ALLIANCE BEHAVIOUR, ABSORPTIVE CAPACITY AND COMPETITIVE ADVANTAGE: A COMPARATIVE STUDY OF BIOPHARMACEUTICAL FIRMS IN EUROPE AND THE US

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THESIS SUMMARY

In this thesis, we explore the relationship between absorptive capacity and alliances, and their influence on firms' competitive advantage in the US and European biopharmaceutical sectors. The study undertaken in this thesis is based on data from a large-scale international survey of over 2,500 biopharmaceutical firms in the US, the UK, Germany, France and Ireland.

The thesis advanced a conceptual framework, which integrated the multi-dimensions of absorptive capacity, exploration-exploitation alliances, and competitive advantage, into a biopharmaceutical firm's new product development process. The proposed framework is then tested in the empirical analysis, using truncated models to estimate firms' sales growth, with zero-inflated negative binominal models capturing the number of alliances in which firms engage, and aspects of realised absorptive capacity analysed by ordinal probit models.

The empirical results suggest that both skill-based and exploitation-based absorptive capacity play crucial roles in shaping firms' competitive advantage, while neither exploratory nor exploitation alliances contribute to the improvement in firms' competitive position. In terms of the interaction between firms' absorptive capacity and alliance behaviour, the results suggest that engagement with exploratory alliances depends more strongly on firms' assimilation capability (skills levels and continuity of R&D activities), while participation in exploitation alliances is more conditional on firms' relevant knowledge monitoring capability.

The results highlight the major differences between the determinants of firms' alliance behaviour, and competitive advantage in the US and Europe - in the US firms' skill levels prove more significant in determining firms' engagment with exploratory alliances, whereas in Europe continuity of R&D proves more important. Correspondingly, while US firms' engagement with exploitation alliances depends on market monitoring capability, that in Europe is more strongly linked to exploitation-based absorptive capacity. In respect of the determinants of firms' competitive advantage - in Europe, market monitoring capability, engagement with exploitation alliances, and continuous R&D activities, prove more important, while in the US, it is firms' market characteristics that matter most. Commonalities are also observed, however, with a negative relationship between firm age and competitive advantage, as well as an inverted U-shaped relationship between firm size and alliance engagement, being important in both areas.

The thesis closes by highlighting some important implications of the study's key findings for future research and management practice. Furthermore, using the US policy as a benchmark, the thesis offers more insights for future European policy in the biopharmaceutical sector.

Key words: Realised Absorptive Capacity, Exploitation Alliances, Exploratory Alliances, Multi-dimensions, Acquisition Capability

DEDICATION

This thesis is dedicated to my parents, in appreciation for their endless love and tremendous support, thousands of miles away; and to my supervisor, Professor Stephen Roper, from whom I have grown, both personally and professionally.

PREFACE

The aim of this thesis is to explore the relationship between different aspects of absorptive capacity, firms' engagement with exploration and exploitation alliances, and competitive advantage. The study is based on data from a large-scale survey of over 2,500 biopharmaceutical firms in the US, the UK, Germany, France and Ireland. For firms, the study draws attention of the R&D managers (especially those from the US and Europe) in respect to the potential for joint value creation through external linkages that may mitigate some of the potential problems biopharmaceutical firms can encounter when pursuing internal development. It also provides recommendations to these managers regarding the management of firms' R&D activities and skills development in facilitating their alliance activities. For researchers, the findings of this study provide important insights into firms' absorptive capacity and alliance management practices across different national contexts, and extend our prior understanding of certain firm behaviours and sources of competitive advantage in this particular industry. For policy-makers, the international comparison between two major economies (the US and Europe) in this study reveals the influence of different institutional regimes and government policies on firms' absorptive capacity, the choices to enter different types of alliances, and their strategies to achieve competitive advantage.

My interest in the new product development process in this particular sector stems from two main reasons. Firstly, the biopharmaceutical sector is a sub-sector of the broader bio-technology sector, where the new product development process is typically long, resource-intensive and risky. Most incumbent firms rely heavily on partnership/alliances with universities or academic institutes, large pharma, and/or outsourcing some of the new product development activities in pursuing new product development. They are narrowly focused on biopharmaceutical R&D and commercialisation. This provides an ideal setting to examine how the new product development and alliance activities of these firms influence their innovativeness.

Secondly, alliances in the biopharmaceutical industry are characterised by their longevity, because the new product development process normally takes ten years or more. Only a small number of biotechnology alliances are terminated (Green, 1997). The open innovation paradigm developed by Chesborough (2003) suggests that valuable ideas can come from inside and outside the company, and also go to the market from inside and outside the company. Given that these intensive alliance activities bring greater availability of external knowledge in this industry, it will be interesting to look at the evolution of the process whereby firms target, absorb and deploy this external knowledge, which is necessary to feed its internal innovation processes, and how this process shapes a biopharmaceutical firm's competitive advantage.

The study conducted in this thesis possesses two unique features when compared with most other studies on the biopharmaceutical industries. Firstly, I integrated the multi-dimensionality of absorptive capacity (ACAP) and the application of the exploration-exploitation framework of organisational learning in firms' strategic alliances within the new product development process of the biopharmaceutical industry. This was achieved by venturing into the contents of relevant theories and literature in innovation, organisational learning, strategic alliances and new product development in the biopharmaceutical industry. In particular, I used the open innovation paradigm (Chesbrough, 2003) as the theoretical context for the study, and extended the conceptual distinction between potential and realised absorptive capacity (Zahra and George, 2002).

The second unique feature of this study is the international comparison of the factors affecting the development of a biopharmaceutical firm's absorptive capacity, alliance activities and competitive advantage, between the US and Europe. To identify the distinctive characteristics of the US and European biopharmaceutical firms, I empirically analysed and compared the R&D, new product development and alliance activities of 349 biopharmaceutical firms across the US and Europe, which responded to a large-scale new product development survey that has been conducted in 2006. The study, therefore, improves our understanding of the different development paths of the biopharmaceutical industries within two unique innovation systems, which are more market-driven in the US, and more policy-orchestrated in Europe. For example, in the US, government plays an

'enabling' role in shaping the industry environment and encouraging entrepreneurship. Policy has limited its involvement to creating a suitable framework. Government programmes funding research and development as well as small firms, have helped the development of biotechnology without being targeted at biotech in particular or a specific region (Wolter, 2003). Policy in Europe, on the other hand, is more strategic and directive. Government acts as a 'co-ordinator' in the sector. Policy has been very actively involved in building the industry through specialised programmes, the most well known being the European framework programmes. I also used the US industry policy as a benchmark, teasing out some implications for the future European policy in the biopharmaceutical sector. Specifically, the empirical analysis presented in my research complemented and reinforced the Lisbon Agenda (2000) and Sapir Report (2003) by suggesting the importance of R&D, skills and other factors, in particular alliances in contributing to firms' competitiveness in the context of the biopharmaceutical industry.

Globally, although the European biopharmaceutical industry is enjoying probably the fastest and most concerted growth in its history, the US remains a formidable competitor and partner, outperforming Europe in nine out of twelve innovation indicators (Taplin, 2007). Europe is still far behind the US in biopharmaceutical innovation performance (Cooke, 2001), size of the working population with tertiary education R&D expenditure, early stage of venture capital, and others (Taplin, 2007). In particular in Europe, the public support and venture capital investment for the biopharmaceutical industry is not as strong as in the US, for example in the UK, most companies hardly access public venture capital except for the R&D tax credit, and nearly all of the initial venture capital sourcing of small start-ups come from private venture capital sourcing companies, or overseas funding programmes/organisations, especially from the US. Meanwhile, the European firms are under-exploiting their existing science base. The exploitation mechanisms in Europe are not as effective as those in the US, which are always stronger and swifter, although the raw ideas for biopharmaceuticals have always been first available in Europe and not in the US (Cooke, 2001). Thus, the learning process by which these European biopharmaceutical firms are seeking to emulate, catch-up and even overtake their US counterparts, is of greater interest in this thesis.

ACKNOWLEDGEMENTS

I would like to express my deep gratitude to my supervisor Professor Stephen Roper for his supervision, valuable suggestions and critical comments. It is his excellent academic guidance and warm-hearted inspiration that enabled me to achieve this undertaking, and made the journey of my PhD become fabulously interesting and enjoyable.

This thesis could not have been completed without the absolute support and co-operation from the survey respondent companies across the US and Europe, as well as the thorough and demanding interaction that I have had with many practitioners from English biopharmaceutical companies during my pilot study. I would like to accord my deep thanks to these companies and practitioners, who kindly shared their experiences and gave me access to some important information, which afforded me greater insights into the development of biopharmaceutical industries in the US and Europe.

I also wish to extend my appreciation to Mrs. Sue Rudd, Mrs. Andrea McCann and Mrs. Jeanette Ikuomola from Aston Academy of Research in Management for their constant support and assistance during my study at Aston. Sue is always there for me at any time, giving me her love, like my mum. Special thanks are due to Professor Sam Aryee, Director of the Research Degree Programme, who helped me to get through the most difficult time towards the end of my PhD, with constructive advice and encouragement.

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Finally, but not the least, I wish to thank for my family, who gave tremendous love and support both financially and emotionally on various occasions while I was in the UK. I also wish to say a big thank you to my closest friends, for supporting me and bringing more happiness into my life.

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CHAPTER 1

BACKGROUND AND OBJECTIVES

1.1 Introduction

The biopharmaceutical industry has been identified as a high technology industry with a relatively long, research-intensive, and protracted new product development process. Additionally, it is an industry characterised by intensive alliance activities. Most biopharmaceutical firms are narrowly focused on biopharmaceutical R&D and commercialisation making a firm's innovativeness and new product development vital to its continued survival and performance.

Globally, although the US has traditionally taken the lead, the European biopharmaceutical industry is enjoying probably the fastest and most concerted growth in its history. However, differences in policy regarding the development of the biopharmaceutical industry mean that the industry is not always conducted in the same way in Europe as in the US. These differences, which include attitudes towards risk, availability and access to different types of venture capital, government support, patent protection issues, stock market exit routes and others, serve to highlight opportunities as well as bottlenecks.

Comparing the US and European experience in developing the biopharmaceutical sector, the US market-driven approach may prove to be superior to the policy-orchestrated one in the Europe. In the US, government plays an 'enabling' role in shaping the industry environment and encouraging entrepreneurship. Policy has limited its involvement to creating a suitable framework. Government programs funding research and development as well as small firms have helped the development of biotechnology without being targeted at biotech in particular or a specific region (Wolter, 2003). On the other hand, policy in Europe is more strategic and directive. Government acts as 'coordinator' in the sector. Policy has been very actively involved in building the industry through specialized programs, the most well known as the European framework programs. In particular, more finance for new business ventures has come from private than public sources in the US,

which is largely absent in Europe. Differences can also be identified in the policy measures aiming at the improving skill levels. Although both Sapir Report (2003) and Lisbon Agenda (2000) lay particular emphasis on the necessity of investment on higher education to achieve better skills in Europe; the US already spends a higher share of GDP on higher education from public sources than the EU average, and the addition of very substantial private sources means that the US spends more than double the EU average on higher education and more than any Member State (Sapir Report, 2003). This suggests a greater productivity of the biopharmaceutical industry in the US than those in Europe

The research setting for my study is the biopharmaceutical sector. We consider it as the most appropriate setting because this sector is extremely active in collaborative strategies (Pisano, 1991), reflecting a strong push toward new product development (Ernst & Young, 2005), and it has extensively used alliances to gain access to necessary technology and knowledge (George et al, 2001). As the majority of the firms operating in the biopharmaceutical sector are involved in the R&D of drugs or diagnostics for humans (DeCarolis and Deeds, 1999; Shan et al, 1994; Zahra, 1996), they are exposed to extensive regulatory requirements (e.g. FDA), which entails detailed reporting of products under development. This makes it an attractive setting for examining the new product development processes (Shan et al, 1994). Furthermore, the size of the US and European samples are quite similar in this sector, representing 55 percent of the industry population in Europe, and 64 percent in the US (Critical I Report, 2006), and this provides an ideal background for international comparison. Meanwhile, the concern associated with the functioning of this sub-sector of biotechnology brings in a broader view of relevant companies, with the target population including dedicated biotechnology firms, service companies[1] and the large pharmaceuticals. This provides a more inclusive picture of inter-firm co-operation. (Hendry and Brown, 2006).

My research will explore the relationship between absorptive capacity and exploratory and exploitation alliances, and their influence on firms' competitive advantage, through a comparative survey-based study of the US and European biopharmaceutical firms.

[1] However, service firms have been excluded from the sample, given that they are not actually engaged in researching and/or developing (including commercialising) any new product and are, therefore, outside the study boundaries.

This chapter introduces the key themes of my research and is structured as follows: Sections 1.2, 1.3 and 1.4 provide a general introduction to the context and aims of the research. It also addresses the research questions and justifies the reasons for the research that will be conducted in this thesis. Section 1.5 focuses on the discussion of the contribution of my research to knowledge and its managerial implications. An overview of the contents that have been covered by the thesis is provided in Section1.6.

1.1.1 Definitions of Biotechnology Vs. Biopharmaceutical

Biotechnology is defined in a number of different ways. Basically, two common approaches are used in defining biotechnology, i.e. a single definition and a list-based definition. For the purpose of this research, a single definition recommended by the Organisation for Economic Co-operation and Development (OECD), which attempts to describe the field broadly, is used, as follows:

The application of science and technology to living organisms as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services. (OECD, 2003)

Following this broad view of biotechnology, biopharmaceuticals in the context of this thesis is defined as:

Pharmaceuticals manufactured by biotechnology methods, with the products obviously having biological sources, usually involving live organisms or their active components (bioprocessing; also usually very obvious; or directly involving surrogates, e.g., protein/gene sequences). (Rader, 2007: 1019)

This broad view has been adopted by "Biopharmaceuticals in the U.S. and European Markets" (Rader, 2007), which includes all recombinant proteins, (monoclonal) antibodies, vaccines, blood/plasma-derived products, non-recombinant culture-derived proteins, and

cultured cells and tissues. This is the definition most used by those within the US and European biopharmaceutical industries, and probably best understood by the public.

1.2 The Biopharmaceutical Sector

The emergence of the biopharmaceutical industry can be interpreted as a technological discontinuity that broke the barriers to entry into the pharmaceutical industry (Tushman and Anderson, 1986). It can take from six to nine years to successfully bring a new drug to the market (Powell and Brantley, 1992). In particular, the drug discovery and development process is fraught with extremely high uncertainty.

"At any step of the way, the drug might fail because it's not safe or just doesn't work; depending on the kind of drug, the failure rate for a product in clinical trials is typically in the 80 percent to 90 percent range ... Even if a drug is approved, success in a competitive market is another challenge"(Chidley, 2000: 49).

The commercialization of biopharmaceutical products is typified by extensive alliance activity. A positive trend in strategic alliance formation has been found in the biopharmaceutical industry (Biotechnology Industry Organisation (BIO), 1999). In fact, biopharmaceuticals itself is the industry with the highest absolute number of strategic alliances and accounts for 20% of all strategic alliances in 1992 (Hagedoorn, 1993). Moreover, biopharmaceutical firms narrowly focus on biotechnology R&D and commercialisation making the motives of alliance partners even clearer (i.e., access to technology/knowledge) (Shan and Song, 1997). These partnerships may be established based on the partners' complementarity of assets, either as a set of resources, capabilities, or knowledge competence (Helfat, 1997; Liebeskind et al, 1996). Alliances may also be formed to develop synergistic relationships through technological complementarity among partners (Hagedoorn, 1993; Hagedoorn and Schakenraad, 1994). Therefore, a better understanding of the role of firms allying along the entire new product development process seems particularly salient when considering that most innovations will either never

reach the market (Griffin, 1997; Stevens and Burley, 1997), or if they do, they are not likely to meet financial expectations (Booz and Hamilton, 1982).

The performance distribution of commercialized products, in particular in the biopharmaceutical industry, is heavily skewed. For instance, one successful blockbuster drug may accrue several billion dollars of revenues for decades, whereas many, if not most drugs, will never be successful enough to cover their research and development cost. Worldwide, the biopharmaceutical sector has experienced cumulative losses because of heavy investments in research and development and long lead times to commercialization (Strategis' Bio-Industries Group, 1999). Thus, the biopharmaceutical industry provides an ideal research setting to study the relationship between a firm's innovation capability and alliance activities, and their influence on the firm's competitive advantage.

1.3 The Biopharmaceutical Industry in the US and Europe

The US and Europe (UK, Germany and France) have been selected for comparison in this research. It is widely acknowledged that the US leads the way in the global biopharmaceutical industry. It outperforms all other countries in the biopharmaceutical sector with more companies, greater funds for R&D, faster approval for new products, and a more efficient public market (Ernst & Young, 2001). The US biopharmaceutical firms are also clearly the world's leaders in biopharmaceutical research and commercialisation (Shan, 1990; Shan and Song, 1997). However, government support for the US biopharmaceutical industry is less direct, with massive support having been provided for basic research in relevant disciplines rather than for the commercialisation of the results in that field of research. A large number of studies have used the US biopharmaceutical industry as one of the samples in their comparison (see Chen and McDermott, 1998; Lavoie and Sheldon, 2000; Giesecke, 2000).

Although the US has traditionally taken the lead, the European biopharmaceutical market is booming very quickly, enjoying probably the fastest and most concerted growth in its history. According to Standard and Poor's survey (2004), Europe was home to 1,976 companies compared to 1,830 biopharmaceutical companies in the US at the end of 2003,

and created significantly more new companies in 2003 (132) than the US (83). It is also proved that the European economies can perform well in emerging technology industries, especially the biopharmaceutical industry (Capsper and Whitely, 2004). However, the development of the biopharmaceutical industry is not always conducted in the same way in Europe as in the US. These differences, which include attitudes towards risk, availability and access to different types of venture capital, government support, patent protection issues, stock market exit routes and others, serve to highlight opportunities as well as bottlenecks. For example, instead of radically altering institutional frameworks to mimic the US liberal economy model, the European biopharmaceutical firms are engaged in seeking sub-segments within which they can develop long-standing comparative institutional advantage. Therefore, it will be interesting to test the research hypotheses on these two well-developed biopharmaceutical industries but within different economic models. This will also increase the generalisability, reliability, validity, and robustness of the research findings. Additionally, most of the existing studies on biopharmaceutical firms have focused on those established in the US; studying the European biopharmaceutical firms will bring new perspectives to this body of research[2].

1.4 Aim and Research Questions

In the context introduced by Section 1.2 and 1.3, my research aims to explore the relationship between absorptive capacity and exploratory and exploitation alliances, and their influence on firms' competitive advantage, through a comparative study of the US and European biopharmaceutical firms. Specifically, the aims are:

[2] In Japan, despite the fact that the biotechnology market is supposed to be the second largest in the world, at a national level, private co-operation hardly occurs at all. This happens because firms regard government-sponsored research consortia as a national necessity, in which they just have to participate and from which they may be able to reap at least some benefits, but to which major commitments should be avoided (Gassel and Pascha, 2000). Although government-sponsored consortia have been set up in Japan with the intention to help the "laggards", the situation in Japan would appear to be sufficiently different to place a discussion of the comparison of international versus national alliances in biotechnology of that country outside the scope of this research.

- To examine how a firm's *potential absorptive capacity* (PACAP) affects its *exploratory alliances* for joint new product development.

- To investigate the influence of *potential absorptive capacity* (PACAP) and *exploratory alliances* on firms' *realised absorptive capacity* (RACAP).

- To illuminate the relationship between *realised absorptive capacity* (RACAP) and *exploitation alliances*.

- To investigate how *exploitation alliances* and *realised absorptive capacity* (RACAP) shape firms' *competitive advantage*.

All these four questions have been generated in the general context of the open innovation theory (Chesbrough, 2003).

1.5 Contribution to Knowledge and Practice

My study will contribute to the development of absorptive capacity and alliance literatures, and advance a better understanding of the relationships between absorptive capacity and alliance, and their influence on firms' competitive advantages in the context of the open innovation paradigm. Specifically, it will extend the existing knowledge of absorptive capacity, and empirically corroborate the conceptual disctinction between PACAP and RACAP that has been identified by Zahra and George (2002). A set of indicators for measuring PACAP and RACAP will be developed in this study. Given that a better theoretical understanding of the different features of absorptive capacity is necessary, it would be equally important to operationalise these different constructs. Previous research however, relates PACAP, RACAP, exploration, and exploitation alliances to a firm's new product development (i.e. George et al, 2001; Rothaermel and Deeds, 2004; Murray and Chao, 2005), technology learning (Kim and Inkpen, 2005; Simonin, 2004), and innovation performance (Fosfuri and Tribo, 2006; Gray, 2006). It is believed that the effort undertaken in this study will shed new light on this body of research by providing one of the few

empirical analyses of the effects of PACAP, RACAP, exploration, and exploitation alliances on a firm's competitive advantage.

The empirical aspect of this research will provide a unique examination of firms' absorptive capacity, exploratory and exploitation alliances, and competitive advantage in the biopharmaceutical industry. It will extend prior understanding of certain firm behaviours and sources of competitive advantage in this particular industry. The findings of the study will provide valuable empirical evidence and support for the few existing studies, which focus on the multi-dimensionality of absorptive capacity and the application of the exploration-exploitation framework of organisational learning to a high technology firm's strategic alliances. Most importantly, it will offer further insight into the problem of why certain aspects of PACAP/RACAP affect exploration alliance/exploitation alliance and competitive advantage more than others. Meanwhile, the empirical results are also aniticipated to highlight some differences and some commonalities between the US and European bio-pharmaceutical industries. The international comparison between these two major economies will reveal the influence of different institutional regimes and government policies on firms' absorptive capacity, the choices to enter different types of alliances, and their strategies to achieve competitive advantage.

The study is expected to provide recommendations for bio-pharmaceutical firms' absorptive capacity and alliance management practices. It will draw the attention of R&D managers (especially those from the US and Europe) to the potential for joint value creation through external linkages that may mitigate some of the potential problems biopharmaceutical firms can encounter when pursuing internal development.

The findings of the study will offer important insights into the development of a firm's absorptive capacity across different national contexts, in particular the roles of different aspects of PACAP and RACAP in relating to each other. It will also shed more light on the management of a firm's internal capabilities and external linkages, from which managers could identify the key factors in contributing to a firm's superior performance. Another potential contribution of this thesis to the managerial practice could be some implications regarding firms' R&D activities and skills development, which are considered as the "spirit" of a high technology firm's innovation management (Colombo and Garrone, 1996;

Deeds, 2001; McCutchen Jr and Swamidass, 1996; Vedovello, 1998; Leiponen, 2005; Vinding, 2005; Freel, 2005; Watanabe et al, 2002).

1.6 Overview of Thesis

The structure of thesis is presented in Figure 1.1. Four main sections are developed in it. Section 1 focuses on the preparatory chapters (i.e. Chapters 1, 2 and 3); Section 2 (i.e. Chapters 4 and 5) describes the survey and provides a description of the data that have been collected; Section 3 (i.e. Chapters 6, 7, 8, 9 and 10) conducts the econometric analysis of the data; a summary of the empirical results, and discussions of their implications for future research, management practice and policy-making are presented in Section 4 (i.e. Chapters 11 and 12).

Chapter 1, as it is presented here, introduces the context and objectives of my research. The remainder of the thesis is organised as follows: Chapter 2 reviews the key literature in my research areas, explains and justifies the conceptual framework selected for the study. It also summarizes the research questions and develops appropriate measures for each of the main themes that have been addressed in these questions.

Chapter 3 elucidates an appropriate research method for the research questions posed. It critically assesses the feasibility of using a survey-based approach to address my research problems, explores, and justifies the relative benefits and problems of employing survey approach in my research area.

Chapter 4 focuses on the fieldwork (i.e. the pilot study and the main survey) that has been conducted in collecting the data. It is devoted to a comprehensive overview of the initial inductive interviews, the pilot postal survey and the main survey. A description of the data collected from the main survey is provided in Chapter 5, which intends to reveal the characteristics exhibited by these data. In particular, a comparison of the US and the European biopharmaceutical firms is presented according to their different features that have been observed in the descriptive results.

The following four chapters (from Chapters 6 to Chapter 9) are devoted to the empirical analysis of the relationships addressed in the research questions. Using data from the main survey of 2,173 biopharmaceutical firms across US and Europe in 2006 which provided detailed information concerning their R&D, new product development and alliance activities, each of the research questions is investigated. These chapters are organised in a similar fashion. Each starts with a general introduction to the theoretical background, contents and contribution of the chapter, followed by an explanation of the hypotheses that have been developed based on a review of the relevant literature. In the sections' forward, a brief description of the data and empirical methods is given. The remaining sections of each chapter summarise the results of the empirical study, and conclude the chapter with a discussion of the relevant findings.

Chapter 10 provides an integrative analysis of the underlying relationships that have been suggested by the conceptual framework advanced in the study. It attempts to integrate the analysis of absorptive capacity, alliances and competitive advantage in previous chapters in a reduced-form model, which will provide more insights into the issue concerning how PACAP, exploratory alliances and exploitation alliances shape a firm's competitive advantage. The relationship suggested by the reduced-form model is tested using data from the main survey of 2,173 biopharmaceutical firms across US and Europe which provided detailed information on their new product development, R&D and alliance activities.

A summary of the empirical results is provided in Chapter 12. Each of the hypotheses postulated in the earlier chapters and the corresponding results are presented, together with a further discussion of the different results obtained from the US and the European biopharmaceutical firms. An integrative comparison of the conceptual framework is then offered, followed by the empirical results.

The thesis closes with a discussion of the implications of the empirical findings in Chapter 11. This includes a discussion of the contributions and the relevant recommendations of my research to future scholars, and the managers of biopharmaceutical firms. The chapter also uses the US policy as a benchmark, and teases out the implications of my research for the future European policy in the biopharmaceutical sector.

Figure 1.1: Structure of the Thesis

Section Rationale	Chapters included
Section 1: **Preparatory Chapters**	**Chapter 1 Background and Objectives** **Chapter 2 Literature Overview** **Chapter 3 Methodology**
Section 2: **Survey and Descriptives**	**Chapter 4 Fieldwork Report** **Chapter 5 Descriptive Overview**
Section 3: **Econometric Analysis**	**Chapter 6 PACAP and Exploratory Alliances** **Chapter 7 PACAP, Exploratory Alliances and RACAP** **Chapter 8 RACAP and Exploitation Alliances** **Chapter 9 RACAP, Exploitation Alliances and Competitive Advantage** **Chapter 10 Integrative Analysis**
Section 4: **Results and Discussions**	**Chapter 11 Summary of Results** **Chapter 12 Implications**

CHAPTER 2

LITERATURE OVERVIEW

2.1 Introduction

The open innovation paradigm developed by Chesbrough (2003) stresses that valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well. From this point of view, knowledge is far more widely distributed today, compared to the 1970s, and this far greater diffusion of knowledge changes the viability and desirability of the traditional innovation approach to accessing and taking new ideas to market. Increasingly, companies cannot expect to warehouse their technologies, waiting until their own businesses make use of them. They must structure themselves to leverage this distributed landscape of knowledge, instead of ignoring it in the pursuit of their own internal research agendas. This paradigm introduces a new logic of innovation, which will exploit the diffusion of knowledge, rather than ignore it. In this context, this research aims to explore the relationship between absorptive capacity and exploratory and exploitation alliances, and their influence on firms' competitive advantage in the process of firms' new product development.

This chapter has been divided into two parts. The first part, comprising Sections 2.2, 2.3, 2.4 and 2.5, is dedicated to a review of the key literature in respect of the several important subjects that emerge from my research area. It critically assesses the strengths and weaknesses of addressing these issues through different viewpoints, and reviews them in relation to each other in the context of my research. The second part of this chapter (Section 2.6) focuses on the research questions that have been identified from this body of literature. It will start from the explanation of, and justification for, the conceptual framework that I intend to use for my research. Thereafter; a detailed discussion concerning each of the research questions that have been generated from this structure is offered. (Key definitions are included in Box 1.)

Box 2. 1: Key Definitions

Potential absorptive capacity **(PACAP) refers to a firm's capability to value and acquire external knowledge (Lane and Lubatkin, 1998).**

Realised absorptive capacity **(RACAP) denotes a firm's capability to transform and exploit the newly acquired and assimilated knowledge and existing knowledge. It reflects the firm's capacity to leverage the knowledge that has been absorbed (Zahra and George, 2002).**

Exploration alliances **are termed as technology-oriented alliances that focus on upstream activities of the value chain, e.g., basic research, drug discovery and development (Rothaermel and Deeds, 2004).**

Exploitation alliances **are defined as market-oriented alliances that focus on the downstream activities of the value chain, e.g., clinical trials, FDA regulatory process, and marketing and sales (Rothaermel and Deeds, 2004).**

2.2 Absorptive Capacity (ACAP)

Researchers have used the absorptive capacity construct to explain organisational phenomena that span multiple levels of analysis by invoking the organisational learning (Huber, 1991; Kim, 1998), industrial economics (e.g., Cockburn and Henderson, 1998), and dynamic capabilities (Mowery et al, 1996) perspectives. The definitions and operationalisations of this structure vary widely; some researchers have used the term absorptive capacity without a definition (e.g., Glass and Saggi, 1998; Keller, 1996), whereas others have invoked the term broadly to indicate a firm's receptivity to technological change (Kedia and Bhagat, 1988) or to gauge the ability of a firm to use external knowledge (Koza and Lewin, 1998).

Cohen and Levinthal (1990) have offered the most widely-cited definition of ACAP, viewing it as the firm's ability to value, assimilate, and apply new knowledge. They look at absorptive capacity as a firm-level construct; an ability, which the firm develops over time

by accumulating a relevant base of knowledge. However, this definition of the structure suggests that a firm has an equal capacity to learn from all other organisations.

Lane and Lubatkin (1998) on the other hand, shift this unit of analysis to the inter-firm level, and label it as student-teacher paring (the learning dyad). They empirically prove that the ability of a firm to learn from another firm is determined by the similarity of both firms rather than a single firm's knowledge bases, lower management formalisation, research centralisation, compensation practices, and research communities.

Nevertheless, their research omits another very important perspective that shapes the inter-organisation learning process, that being the internalisation and conversion of external knowledge (cf. Fichman and Kemeter 1999; Koestler 1966; Smith and DeGregorio, 2002), which is embedded in the process when firms develop and refine the routines that facilitate combining existing knowledge and the newly-acquired and assimilated knowledge. Meanwhile, previous research about absorptive capacity has overlooked a firm's ability to value and assimilate new knowledge, which is termed as 'potential absorptive capacity' (PACAP) by Zahra and George (2002).

Building upon this ground, Zahra and George (2002) further extend the definition, and divide absorptive capacity into 'potential absorptive capacity' and 'realised absorptive capacity', which are characterised as a set of organisational routines and processes followed by firms to acquire, assimilate, transform, and exploit external knowledge. Remarkably, their notions retain the early idea of absorptive capacity as a firm's ability to evaluate, assimilate and exploit the value of new external knowledge, but they also introduce Kim's (1998) (and others') idea of internalisation and conversion of new knowledge as a part of absorptive capacity.

The great contribution of the ideas of Zahra and George to the body of literature is that they bring in another new dimension of absorptive capacity - the 'transformation capability', which denotes a firm's capability to develop and refine the routines that facilitate combining existing knowledge and the newly-acquired and assimilated knowledge. Most importantly, they divide absorptive capacity into potential absorptive capacity and realised absorptive capacity, and highlight the conceptual distinction between

PACAP and RACAP. This reconceptualisation of absorptive capacity corrects past research's overlooking of potential absorptive capacity.

In addition, the work of Zahra and George makes it clear that in the previous studies, researchers fall short by overlooking the contingent conditions under which absorptive capacity could lead to competitive advantage. To remedy this situation, they develop a conceptual model (Figure 2.1) that links the components of absorptive capacity to value creation, highlighting potential sources, reasons, and conditions under which the components of absorptive capacity create and sustain performance differences across firms, which is a fundamental question in the field.

However, neither these capabilities nor the model have been operationalised. In particular, no additional measures have been developed so far, to gauge each of the four independent dimensions that they suggest comprise absorptive capacity.

2.3 Exploration and Exploitation Alliances

In studies of organisational learning, the problem of balancing exploration and exploitation is exhibited in the distinctions made between the refinement of an existing technology and the invention of a new one (Winter, 1971; Levinthal and March, 1981). Obviously, exploration of new alternatives slows down the process of exploiting existing ones. Likewise, improvement in competence at existing procedures makes experimentation with others less attractive (Levitt and March 1988). Therefore, finding an appropriate balance is made particularly difficult by the fact that the same issues occur at levels of a nested system - at the individual level, the organisational level, and the social system level.

In theories of limited rationality, discussions of the choice between exploration and exploitation emphasise the role of targets or aspiration levels in regulating allocations to search (Cyert and March, 1963). Such ideas are also found in theories of satisficing (Simon, 1955) and in prospect theory (Kahneman and Tversky, 1979) respectively. They led to the attempt to specify conditions under which target-oriented search rules are optimal (Day, 1967). Because of the role of targets, discussions of search in the limited rationality tradition emphasised the significance of the adaptive character of aspirations themselves (March, 1988).

March (1991, 1995) links adaptations at firm level to changes occurring at the level of the organisational population through a model of exploration and exploitation in organisational learning. He described exploration as "experimentation with new alternatives" having returns that "are uncertain, distant, and often negative", and exploitation as "the refinement and extension of existing competencies, technologies, and paradigms" exhibiting returns that "are positive, proximate, and predictable" (p. 85). The survival of the firm is assumed to be dependent on the firm's ability to "engage in enough exploitation to ensure the organisation's current viability and engage in enough exploration to ensure its future viability" (Levinthal and March, 1993: 105)

By employing these theories on exploration–exploitation choices, the type of search and the type of alliances firms are pursuing at different stages of the product development process can be characterised. Koza and Lewin (1998) propose a framework which views

strategic alliances in the context of the adaptation choices of a firm. Specifically, in the co-evolution theory of strategic alliances, they argued that alliance intent may be described, at any time, as having either exploitation or exploration objectives. Strategic alliances, in this view, are embedded in a firm's strategic portfolio, and co-evolve with the firm's strategy, the institutional, organisational and competitive environment, and with management intent for the alliances.

A firm's choice of the type of alliances to enter can be distinguished by its motivation to either explore for new opportunities or exploit an existing opportunity (Koza and Lewin, 1998). From this viewpoint, exploration alliances are entered into with the motivation to discover something new and they focus on the 'R' in the research and development process. Alternatively, exploitation alliances focus on the 'D' in the research and development process and are entered into with the goal to join existing competencies across organisational boundaries in order to generate synergies, which are then shared across the partners. In the biotechnology industry in particular, exploratory and exploitation alliances have been extensively employed (George et al, 2001) and play a very crucial role in the process of biotechnology new product development (Deeds and Hill, 1996; Dowling and Helm, 2006; Gerwin, 2004; Gilsing and Nooteboom, 2006; Parker, 2000). This is empirically proved by most of the previous research (i.e., George et al, 2001; Koza and Lewin, 1998; Rothaermel, 2001; Rothaermel and Deeds, 2004). In pursuing new product development, a biotechnology firm might partner with university/academic institution (George et al, 2002; Mohan and Rao, 2005; Streiffer, 2006) or small start-ups (Quintana-Garcı´a and Benavides-Velasco, 2004; Maurer and Ebers, 2006; Whitehead, 2003; Calabrese and Baum, 2000) or license-in/buy-in research service from CROs (Miller, 2004) for basic R&D; and co-operate with large pharmaceutical companies (Rothaermel and Deeds, 2004; Gilsing and Nooteboom, 2006), or other firms (Fosfuri and Tribó, 2006; Rothaerme and Deeds, 2006), or marketing/distribution companies for commercialisation. Otherwise, they might either develop it on their own (Azzone and Dalla Pozza, 2003; Amir-Aslani and Negassi, 2006), or outsource most of their new product development activities.

In the new product development process of the biotechnology industry for example, when the completion of a prototype product creates an immediate need for certain

complementary capabilities (e.g., legal and regulatory competence, manufacturing, marketing and distribution), a start-up/entrepreneurial firm must make the decision to either go it alone or to collaborate with more established firms that then take on the commercialisation of the new product. If forward integration is costly, time-consuming and risky, external funding through capital markets may not be a viable option (Lerner et al, 2003). Alternatively, established firms that have developed competencies in the downstream activities of the value chain are well positioned to collaborate in the commercialisation of new products (Rothaermel and Deeds, 2004). In contrast to the start-up/entrepreneurial firms, established firms, especially, those large pharma-firms, needed to keep up-to-date with a fast changing knowledge base which was diverse, systemic and built up from various disciplines. However, opportunities usually pertained to niches and were also diffuse, making it difficult for more established firms to decide in which fields of knowledge to invest and which to ignore (Ernst & Young, 2001a; 2001b). Therefore, large pharma-firms made use of alliances with various small DBFs, which enabled them to explore various opportunities at the same time, without making substantial specific investment (Gilsing and Nooteboom, 2006).

2.4 Competitive Advantage

Studies about the origin of firms' competitive advantage tend to be surrounded by four main streams of arguments that are typified as the resource-based view, relational view, institutional view, and industry structure view.

The resource-based view argues that competitive advantage lies in the rare, specialised, inimitable resources and resource market imperfections that cause firm heterogeneity, and that successful firms are those that acquire and maintain valuable idiosyncratic resources for sustainable competitive advantage (Barney, 1991; Dierickx and Cool, 1989; Rumelt, 1984).

In contrast, the relational view (Dyer and Singh, 1998) offers a different, but complementary view about a firm's competitive advantage and suggests that a firm's critical resources may span firm boundaries and may be embedded in inter-firm resources

and routines. It stresses that an increasingly important unit of analysis for understanding competitive advantage is the relationship between firms.

In favour of this stream of argument, institutional theory suggests that a firm's tendency toward conformity with predominant norms, traditions, and social influences in their internal and external environments, lead to homogeneity among firms in their structures and activities, and that successful firms are those that gain support and legitimacy by conforming to social pressures (Oliver, 1992; Zukin and DiMaggio, 1990). At the inter-organisational level, these pressures mainly emerge from government, industry alliances and societal expectations (DiMaggio and Powell, 1983). In other words, a firm's ability to manage inter-firm relations is one source of its sustainable advantage.

On the other hand, the industry structure view (Porter, 1980) argues that a firm's competitive advantage depends on its relative bargaining power. The mechanism to sustain this kind of advantage lies in the barriers to entry into an industry.

The resource-based view focuses on how individual firms generate supernormal returns based upon resources, assets, and capabilities that are housed within the firm, whereas the relational view considers the dyad/network as the unit of analysis and the rents that are generated to be associated with the dyad/network. Quite similarly, the industry structure view shifts the unit of analysis from the firm-level to the network-level, but it emphasises that the relationship between a firm and other network members is competition-orientated rather than alliance-orientated.

Although these arguments may be complementary to each other at a certain level, in effect, they are rather contradictory. For example, according to the resource-based view, an individual firm should attempt to protect, rather than share, valuable proprietary know-how to prevent knowledge spillover, which could erode or eliminate its competitive advantage. However, an effective strategy from a relational perspective should be for firms to systematically share valuable know-how with alliance partners (and willingly accept some spillover to competitors) in return for access to the stock of valuable knowledge residing within its alliance partners (Dyer and Singh, 1998). Notably, this strategy only makes sense when the expected value of the combined inflows of knowledge from partners exceeds the

expected loss/erosion of advantages due to knowledge spillovers to competititors. Likewise, consistent with the industry structure view, firms should be eager to increase the number of their suppliers, thereby maximising their bargaining power and profits. In direct contrast, the relational view suggests that firms can increase profits by increasing their dependence on a smaller number of suppliers, thereby increasing the incentives of suppliers to share knowledge and make performance-enhancing investments in relation-specific assets.

Despite the fact that these different views provide a normative prescription to practising managers, and deepen our understanding of competitive advantage, the clear contradictions between these views suggest that existing theories of advantage are not adequate to explain competitive advantage (Dyer and Singh, 1998).

2.5 Integrating ACAP, Alliances and Competitive Advantage - Towards A Conceptual Framework

The different bodies of literature that have been reviewed in the earlier sections are actually complementary to each other and flow in a path-dependent way. Essentially, open innovation theory (Chesbrough, 2003) is the foundation of the rest of these theories, since according to the open innovation theory, with the great international diffusion of technology in the biopharmaceutical industry, firms win by making the best use of internal and external knowledge in a timely way, creatively combining that knowledge in new and different fashions to create new products. Therefore, they are competing on accessing and integrating external knowledge. Undoubtedly, alliances provide good opportunities for firms to access extra external know-how. However, before forming alliances with their partners, firms have to choose an appropriate type of alliances to enter. Co-evolution theories of strategic alliances and organisational theory provide the theoretical background to investigate this decision making process. A firm's choice of the type of alliances to enter can be distinguished by its motivation to either explore new opportunities or exploit an existing opportunity, and co-evolve with the firm's new product development strategy, institutional, organisational and competitive environment (Koza and Lewin, 1998). Exploration generates the discovery of new opportunities and, at the same time, the potential for exploitation. Thus, successful exploration also creates demand for the

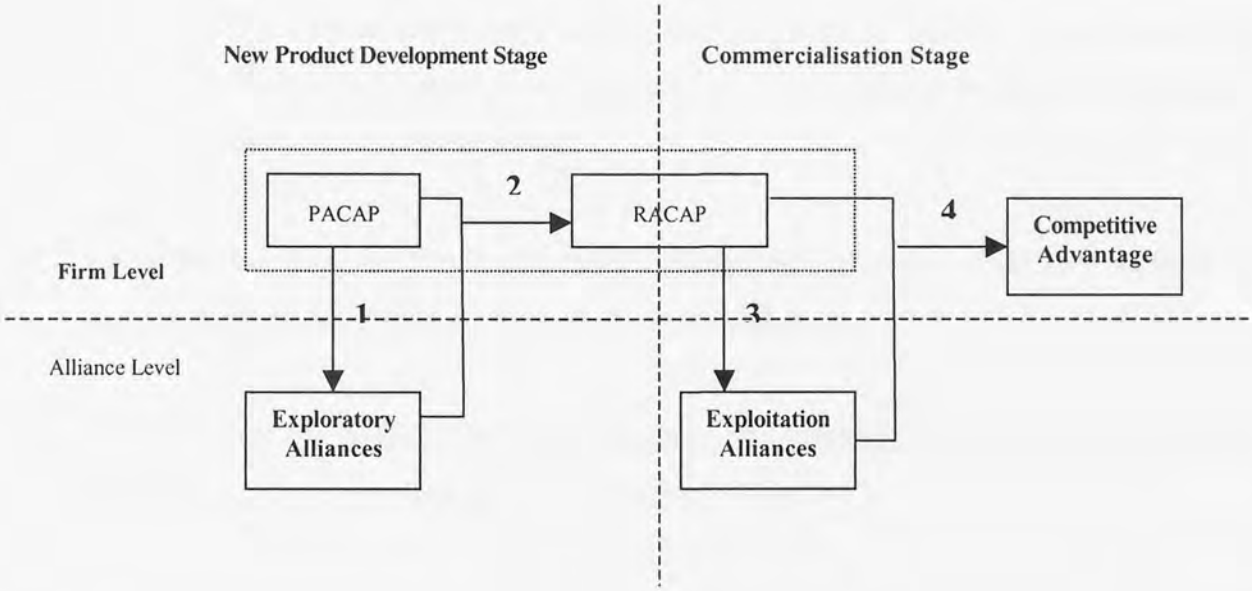
resources required in order to exploit newly-discovered opportunities. Nonetheless, organisational theory argues that exploration of new alternatives slows down the progress of exploiting existing ones. Likewise, improvement in competence at existing procedures makes experimentation with others less attractive (Levitt and March, 1988).

During the alliance process for joint new product development, firms will identify the externally-generated knowledge that is critical to their operations. Once this kind of knowledge is accessible, firms have to develop the special capabilities/competence to assimilate and exploit it. The Zahra and George (2002) model of absorptive capacity is a good conceptual basis on which to build research concerning the development of appropriate absorptive capacity. It connects firms' absorptive capacity with their competitive advantage. In this model, Zahra and George (2002) reconceptualise absorptive capacity as a set of organisational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organisational capability, and differentiate between potential and realised absorptive capacities.

Notably, the open innovation theory and co-evolution theory of strategic alliances provide the pre-requisite for the application of Zahra's and George's (2002) model of absorptive capacity, because the open innovation theory stresses the importance of external source and knowledge complementarities; and experience is the product of alliances with other firms (Lane and Lubatkin, 1998). Meanwhile, the resource-based view, relational view, and institutional view contribute to the clarification of the relationship between absorptive capacity and alliances, and their influence on competitive advantage.

One possible interpretation of these relationships is given in Figure 2.2, which relates absorptive capacity, alliance behaviours and competitive advantage with the process of new product development and commercialisation.

Figure 2. 2:Conceptual Framework



During the new product development stage, for example, potential absorptive capacity affects a firm's choice for exploratory alliances, and is associated with its alliances' intention (see research question 1). Collectively, PACAP and exploratory alliances influence RACAP (see research question 2). At firm level, realised capacity is subject to the potential capacity. Meanwhile, the outcome of exploratory alliances is positively related to the firm's realised absorptive capacity.

When new products come into the commercialisation stage (see research question 4), RACAP and exploitation alliances shape firms' competitive advantage. At the same time, realised absorptive capacity relates to the intention of a firm's exploitation alliances; and engagement with exploitation alliances is a way by which the firm exploits its realised absorptive capacity (see research question 3).

2.6 Research Questions

In this section, we will summarise the research questions that have been developed from the previous conceptual framework. Each of these research questions will be justified and discussed in detail with a brief introduction of the key literature and theoretical background relating to the question. In addition, measures for the variables that have been addressed in our research questions will be developed.

1. To examine how a firm's *potential absorptive capacity* (PACAP) affects its *exploratory alliances* for joint new product development.

2. To investigate the influence of *potential absorptive capacity* (PACAP) and *exploratory alliances* on firms' *realised absorptive capacity* (RACAP).

3. To illuminate the relationship between *realised absorptive capacity* (RACAP) and *exploitation alliances*.

4. To investigate how *exploitation alliances* and *realised absorptive capacity* (RACAP) shape firms' *competitive advantage*.

All these four questions have been generated in the general context of the open innovation theory (Chesbrough, 2003).

2.6.1 Research Question 1: Relating PACAP and Exploratory Alliances

Exploratory alliances are entered into with the motivation to discover something new, and are intended to facilitate learning or prospecting expectations of their parents (Koza and Lewin, 1998). In the biopharmaceutical industry for example, exploration collaborations are motivated by a desire to acquire basic knowledge that can be used to create novel molecular entities which are then entered into the development and regulatory process (Rothaermel and Deeds, 2004). Koza and Lewin (1998) argue that absorptive capacity becomes very important in exploration alliances, and it determines the rate and effectiveness through which knowledge can be internalised. On one hand, potential

absorptive capacity allows a firm to evaluate and assimilate new projects, which can determine the success of the alliances (George et al, 2001). It is also observed that the ability to evaluate external technological information affects a firm's choice of alliance partners (Arora and Gambardella, 1994; Fosfuri and Tribo, 2006). On the other hand, firms with strong potential absorptive capacity could be more inclined to engage in exploratory alliances, since well-developed knowledge acquisition and assimilation capabilities are likely to be more adept at continually revamping their external environment, and internalising externally-assimilated knowledge (Zahra and George, 2001). Hence, this brings to mind question 1:

RQ1: To examine how a firm's *potential absorptive capacity* (PACAP) affects its *exploratory alliances* for join new product development.

Measuring PACAP poses significant empirical challenges and needs to reflect following Zahra and George (2002), firms' capabilities to acquire, assimilate, transform, and exploit external knowledge. However, appropriate measures for each of the four dimensions that address a firms' absorptive capacity is not available. Although the indicators proposed by Zahra and George for these four dimensions provide an important avenue of ideas about the measures for the potential absorptive capacity and realised absorptive capacity, they have never been operationalised. Therefore, a four-stage process has been followed to develope new measures for the dimensions of PACAP and RACAP. First, we reviewed relevant literature and identified a pool of items or measures to capture the domain of transformation capability. These items were then classified according to the relevant implications presented. Only those one of a particular type were selected from this pool of items and are included in the initial scale. In the second, we conducted inductive interviews with R&D managers from several English biopharmaceutical companies to specify the clarity and relevance of each item in the context of this research. This also allowed for extra issues to be identified and explored. During the following stage, we re-phrased some items indicated by these managers as being ambiguous. And issues identified from the interviews were further developed into specified items or measures for the different dimensions of absorptive capacity. Finally, the phrasing of these items was further improved by the author and peers.

Acquisition is measured by *R&D intensity.* It is defined as the absolute value of R&D spending in total turnover. The investments that high technology firms make in maintaining a strong R&D programme allow them to attract and keep talented scientists who follow scholarly developments in the field (Kim, 1997; Zahra, 1996). And this in turn gives the chance to these researchers to acquire and assimilate the knowledge created by alliances. Kim (1997) and Kodama (1995) note the crucial importance of a firm's internal R&D in determining its ability to import external knowledge. R&D funds are also used to employ outside experts who are knowledgeable in emerging fields. The use of such experts can compress the absorption cycle of externally-acquired information (Kim, 1997).

Assimilation is captured by *Relatedness of prior knowledge* and *individual skills* (Schmidt, 2005). *Related prior knowledge* is represented by the continuity (continuous vs. occasional) of their R&D engagement. It is assumed that a firm which is continuously involved in R&D activities, should possess more previously accumulated knowledge related to a specific field than other firms performing R&D occasionally, considering the path dependence nature of absorptive capacity.

Exploration alliances are coded as number of technology-oriented alliances (R&D based alliances) that focus on upstream activities of the value chain, e.g., basic research, drug discovery and development (Rothaermel and Deeds, 2004).

2.6.2 Research Question 2: Relating PACAP, Exploratory Alliances and RACAP

Rothaermel and Deeds (2004) view the new product development process as a knowledge management process. They argue that the outcome of the exploration process is the embodiment of new knowledge learned through exploration into a prototype product. However, firms not only need the learning capabilities to recognise and assimilate the knowledge from their partners, but also the capabilities to transform and exploit the acquired knowledge by incorporating it into the firm's operations, thus improving its performance (Murray and Chao, 2005). A competitive advantage in innovation only materialises if the firm also possesses RACAP (Zahra and George, 2002), since it is the transformation and exploitation capabilities rooted in RACAP that allow the firm to

explore and combine existing and external knowledge absorbed from exploratory alliances and convert knowledge into new products (Kogut and Zander, 1996). In a sense, RACAP is employed to add value to the asset that has been acquired and assimilated from alliances (Newey and Shulman, 2004). Hence, realised absorptive capacity maximises the economic return of exploratory alliances. On the other hand, the complementarities between potential absorptive capacity and realised absorptive capacity imply that firms can acquire and assimilate knowledge (PACAP) but might not have the capability to transform and exploit the knowledge (RACAP) for profit generation (Zahra and George, 2002). The cumulativeness feature of absorptive capacity and its effects on expectation formation (Cohen and Levinthal, 1990) determine that the acquisition and assimilation of new knowledge (PACAP) will affect the development of transformation and exploitation capabilities (RACAP). Therefore, these ideas lead to question 2:

RQ2: To investigate the influence of *potential absorptive capacity* (PACAP) and *exploratory alliances* on firms' *realised absorptive capacity* (RACAP).

In our research, **RACAP** is assessed by the related knowledge *transformation* and *exploitation* capabilities.

Transformation is measured by a four-item scale that assesses the extent to which firms are able to recognise opportunities and consequences of new external knowledge for existing operations, structures and strategies (Zahra and George, 2002). These items are developed partially from existing items regarding realised absorptive capacity (i.e. Jansen et al, 2005) and partly from issues identified by the inductive interviews with R&D managers from several English biopharmaceutical companies. Each of the four items is estimated on a 5-point disagree/agree scale.

Finally, we gauge ***Exploitation*** by *number of patents*. Zahra and George (2002) suggested number of patents as a measure for firms' knowledge exploitation or application capability. In fact, number of patents has been used by previous studies as a proxy of firms' innovation performance (e.g., Austin, 1993; Almeida, 1996; Deeds and Hill, 1996; George et. al, 2001; Mowery et al, 1996). And the outcome of innovation behaviour on the other hand, is suggested as being closely related to the ability to exploit existing internal and

external firm-specific competencies to address a changing environment (Teece et al, 1997; George et al, 2001). For the firm to get a patent approved, it has to demonstrate a certain degree of newness that reflects a change in the firm's basic knowledge structure (George et al, 2001). This is mainly achieved by knowledge exploitation in that systematic exploitation routines guarantee the persistent creation of new knowledge (Spender, 1996). Number of patents, therefore, denotes a certain level of capability to exploit external new knowledge, and reflects firms' ability to incorporate new external knowledge into their operations.

2.6.3 Research Question 3: Relating RACAP and Exploitation Alliances

Exploitation alliances focus on the 'D' in the research and development process and are entered into with the goal of joining existing competencies across organisational boundaries in order to generate synergies, which are then shared across the partners (Koza and Lewin, 1998). According to the Zahra and George's (2002) model of absorptive capacity, the intention of exploitation alliances is related to a firm's realised absorptive capacity, which reflects the firm's capacity to leverage the knowledge that has been absorbed. Exploitation alliances facilitate the firm's successful commercialisation of the more specific knowledge that has been generated by employing its RACAP (Hagedoorn and Schakenraad, 1994). They allow a firm go beyond its boundaries, and leverage the knowledge that has been absorbed from inside or outside without its own resource and environmental constraints. In the biotechnology industry, for example, new ventures often focus on creating new drugs, which are then commercialised by established pharmaceutical companies with well-developed competencies in downstream activities of the value chain (Rothaermel and Deeds, 2004). Therefore, exploitation alliances maximise the return of economic value of realised absorptive capacity. Accordingly, question 3 becomes important:

RQ3: To illuminate the relationship between *realised absorptive capacity* (RACAP) and *exploitation alliances*.

Exploitation alliances are labelled as market-oriented alliances (marketing-based alliances) that focus on the downstream activities of the value chain, e.g., clinical trials, FDA regulatory process, and marketing and sales (Rothaermel and Deeds, 2004) in absolute number terms. Exploitation alliances can be characterised by the union of complementary assets (Teece, 1986). Successful exploitation enables the firm to commercialise the knowledge gained through exploration. New biotechnology firms often focus on creating new drugs, which are then commercialised by established pharmaceutical companies.

2.6.4 Research Question 4: Relating RACAP, Exploitation Alliances and Competitive Advantage

Zahra and George (2002) argue that although PACAP is necessary to identify and filter relevant external knowledge and capture it within the firm's boundaries, a competitive advantage in innovation only materialises if the firm also possesses RACAP. The possession of RACAP becomes very crucial in improving its performance (Murray and Chao, 2005). In particular, using its realised absorptive capacity in developing new products makes a firm's knowledge more complex, specific and systemic because of the inherent variations in the abilities to combine and leverage different kinds of competencies (Zander and Kogut, 1995). The more tacit, complex, specific and systemic the knowledge is, the easier it is for a firm to generate a sustainable competitive advantage (Bou-Llusar and Segarra-Cipres, 2006). Since the heterogeneity implicit in RACAP may be a source of causal ambiguity and create barriers to imitation (Reed and DeFillippi, 1990), it becomes a valuable competitive resource (Barney, 1991).

On the other hand, Dyer and Singh (1998) argue that a pair or network of firms can develop relationships that result in sustained competitive advantage. They highlight that relationships between firms are an increasingly important unit of analysis for explaining supernormal profit returns. From a relational view, Dyer and Singh (1998) stress that the complementary resource endowments are the distinctive resources of alliance partners that collectively generate greater rents than the sum of those obtained from the individual endowment of each partner. Similarly, the co-evolution theory of strategic alliances (Koza and Lewin, 1998) suggests that the greater the exploitation intent of an alliance, the greater the alliance will be organised to produce performance outcomes. In some instances a firm's

ability to generate rents from its resources may require that these resources be utilised in conjunction with the complementary resources of another firm. Notably, Shan and Hamilton (1991) found that the complementarities of both firm and country-specific resources between domestic and foreign firms, was a key factor in the formation of cross-border strategic alliances in biotechnology. The complementarities in the cases they studied consisted of linkages between the strong basic research capabilities of the US firms with the unique local knowledge, and the distribution capabilities of their partners in overseas markets. In these cases, the alliance partners brought distinctive resources to the alliance, which, when combined with the resources of the partner, resulted in a synergistic effect whereby the combined resource endowments were more valuable, rare, and difficult to imitate than they had been before they were combined. In consequence, these alliances produced stronger competitive positions than those achievable by the firms operating individually.

Combining institutional and resource-based views, Oliver (1997) observed that firms need both resource capital and institutional capital for longer-run competitive advantage. Resource capital consists of the value-enhancing resources and capabilities of the firm, and is indicated by the firm's strategic assets (Amit and Schoemaker, 1993), including those developed from realised absorptive capacity, such as superior distribution channels, and R&D capability. In contrast, institutional capital is those contextual factors that enhance optimal use of resource capital (e.g., strategic alliances). In other words, realised absorptive capacity and exploitation alliances are sources of sustainable competitive advantage of firms. Therefore, question 4 arises:

RQ4: To investigate how *exploitation alliances* and *realised absorptive capacity* (RACAP) shape firms' *competitive advantage*.

We measure ***Competitive advantage*** at firm level by *performance*. *Firm performance* is well cited as an important indicator of a firm's competitive advantage, denoting the function of how well managers build their organisations around resources that are valuable, rare, inimitable, and lack substitutes (Barney, 1991).

Firm performance is proxied by *sales growth*, which is widely considered a key indicator of new ventures' performance (Bloodgood et al, 1996; Brush, 1995; Chandler and Hanks, 1993). Sales growth is used extensively to evaluate new venture performance by trade publications, industry experts, and venture capitalists. It is a conventional measure for firm performance in the management, finance economics and accounting literature (e.g. Dyl, 1988; Hambrick, 1983; Larcker, 1983; Lewellen and Huntsman, 1970; Masson, 1971; O'Reilly et al, 1988; Gerhart and Milkovich, 1990; Leonard, 1990; Redling, 1981). Essentially, sales growth rate is especially important given a firm's need to generate cash flow to support future R&D (George et al, 2001). In fact, considering our research questions aiming to investigate the relationship between alliances and competitive advantage, growth rates provide the most effective indicator which could better capture the impact of possessing innovative alliance partners on firms' competitive advantage (Stuart, 2000). On the other hand, measuring the performance of entrepreneurial biopharmaceutical firms using purely financial indicators such as sales growth is always criticised (Brush and Vanderwerf, 1992), because most of these firms do not have any history of revenues or earnings. However, it is observed that around 83.3 percent of our respondent firms have positive sales growth rates. And the average age of these firms is 13.6 years, with 12 years in Europe and 15.9 in the US. In addition, other performance measures such as market share growth may not present firms' performance appropriately, as the definitions of market and industry boundaries are often unclear, especially in young industries (Grant, 1998; Porter, 1980), such as the biotechnology industry that will be examined in our research.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In this chapter, we critically assess the rationale for using a survey-based approach to address my research questions. Previous research in this field is also reviewed, with a view to exploring and justifying the relative benefits and problems of employing the survey approach in my research area. The aim of this chapter is to elucidate an appropriate research method for the research questions introduced in Chapter 2.

3.2 Reasons for Using a Survey-Based Approach

We focus on the entire population of biopharmaceutical firms across the US and Europe, which includes more than 2,000 companies. The time and costs associated with each visit to these biopharmaceutical firms for conducting interviews or case studies are inestimable. A self-completion questionnaire is undoubtedly the most effective and economic way to administer and carry out the survey. Unlike interview and case study approaches, the survey approach eliminates interviewer variability without the problems that may be caused by interviewers asking questions in different orders or in different ways. In this study, the respondent R&D managers were completely open to the questions, and the survey approach dispensed with the concerns whether the participants were likely to exhibit the social desirability bias that is often evident when an interviewer is present. This approach also gave the R&D managers a certain degree of flexibility. However, it is worth noting that previous studies in the biopharmaceutical industry have suffered from the problem of low response rates when using survey approaches to collect data (Li Shaoming, 2004). Also the problem associated with the representativeness of sampling in a survey, may more or less influence the generalisability of the final research findings. However, as the main focus of the research undertaken in this thesis is the entire population of biopharmaceutical firms across the US and Europe, this problem is not believed to exist.

Other methodological approaches such as in-depth company case studies and inductive interviews may help us to develop a better understanding of the behaviour foundation and implications of the relationship between alliances and absorptive capacity, and their relevant impact on a biopharmaceutical firm's competitive advantage. In particular, the interview approach contributes to the design of a quantitative instrument for measuring firms' absorptive capacity and competitive advantage. And in-depth company case-studies of the process of alliance formulation and development are more effective in examining potential links between PACAP and RACAP. On the other hand, the main issue arising from these approaches is the fact that conducting interviews and case studies is costly and time-consuming even in a small case, and given the spread of firms geographically in the US and Europe in this study, such a strategy would be prohibitive in cost terms, and valuable time would be spent on travelling. It is also worth noting that in practice, gaining access to those R&D managers of different biopharmaceutical companies and arranging a mutually convenient time for the interviews can be extremely difficult, considering the status and power held by the respondents, particularly those at senior level. Moreover, the researcher's presence may cause biased responses during the interview situation, and account may need to be taken of the tendency for the interviewees to be more likely to exhibit social desirability bias when an interviewer is present (Bryman and Bell, 2003; Dillman, 1991; McClelland, 1994).

3.3 Advantages of Postal Survey Approaches

Considering the international nature of my research, a mail survey seemed to be the most appropriate data collection method. Given the need to cover the US and Europe, different geographical locations, a self-completion questionnaire is the most effective and economic way to conduct the survey (Dawson and Dickinson, 1988). Such a questionnaire can be sent out quickly without constraints in respect of geographical distance, quantity, and availability of the potential respondents. Self-completion questionnaires can be mailed by post or otherwise distributed in very large quantities at the same time. For example, a thousand questionnaires can be sent out by post in one batch, whereas even with a team of interviewers, it would take a long time to conduct personal interviews with a sample of that size (Bryman and Bell, 2003). Furthermore, according to Bryman and Bell (2003: 142),

"the cheapness of the self-completion questionnaire is especially a advantage if you have a sample that is geographically widely dispersed", so from this viewpoint, a postal questionnaire is much cheaper, taking into consideration the time and the cost of travel for interviewers.

Moreover, the self-completion questionnaire is a non-intrusive way to gather feedback, as opposed to individual interviews, focus groups, and sometimes on-site observations, because respondents can provide their input in a tension- or intimidation-free environment and at their convenience. For instance, self-completion questionnaires eliminate the interviewer variability, and the potential problems that may be caused by interviewers asking questions in different orders or in different ways. Questionnaires also give respondents a certain degree of flexibility, because they can complete a questionnaire when they want and at the speed that they are comfortable with (Bryman and Bell, 2003).

Unlike the answers given in personal interviews, those provided by respondents in self-completion questionnaires are independent from interviewer effects. This is mainly because there is no interviewer present when a self-completion questionnaire is being completed, and respondents are completely open to the questions. More specifically, researchers do not need to take into account the tendency of people being more likely to exhibit social desirability bias when an interviewer is presented. Sudman and Bradburn (1982) suggest that postal questionnaires work better than personal interviews when a question carries the possibility of such bias.

Additionally, questionnaire completion can be relatively simple and straightforward and may not require an excessive amount of time. This depends on the effective design of the questionnaire, however. In this respect, earlier research shows that simplicity will positively affect the rate of return as well as increase overall response accuracy (Long, 1986). In terms of my research, the questionnaire will be administered to the potential respondents by post. However, it is worthy of note that considering the geographic dispersion of the US biopharmaceutical firms included in this study, delivering a postal survey normally takes 7 -10 days, and in this case, questionnaires will be also administered by email and fax at the same time according to the preferences of the potential respondents. During the telephone pre-contact, each potential respondent will be asked regarding the

way they expect the questionnaires to be delivered. Although email surveys are notorious for attaching low response rate when compared with conventional mail survey methods (Dommereyer and Moriarty, 1999; Kent and Lee, 1999; Basi, 1999), and for their lack of anonymity, formal image, incentives and cosmetic features (Ranchhod and Zhou, 2001; Parker, 1992; Kent and Lee, 1999; Mehta and Sivadas, 1995; Simith, 1997; Dommereyer and Moriarty, 1999), it is much quicker and much less expensive to use an electronic questionnaire than traditional mail survey methods, providing all the necessary computing equipment and network connections are in place (Kent and Lee, 1999).

3.4 Criticism of Survey Approaches

One of the primary concerns about mail surveys relates to their high non-response rates (Yu and Cooper, 1983). Indeed, previous studies using survey approaches in the biopharmaceutical industry have suffered from the problem of low response rates (Li, 2004). Most telephone surveys have difficulties achieving response rates higher than 60%, and even the response rates for most major American national surveys have been falling during the last four decades (Brehm, 1993; Steeh, 1981). In particular, the issue of missing data can never be circumvented in the survey, since there are always firms who might not fill in a complete copy of the questionnaire. Therefore, surveys are often discontinued because of lack of the goal of a perfect response rate.

However, having a low response rate does not necessarily mean that a survey suffers from a large amount of non-response errors. Recent studies suggest that surveys with very low response rates can be more accurate than surveys with much higher response rates. Visser et al (1996) compared the accuracy of self-administered mail surveys and telephone surveys forecasting the outcomes of Ohio state-wide elections over a 15-year period. Even if the mail surveys had response rates of around 20%, and the telephone surveys had response rates of about 60%, the mail survey predicted the election outcomes much more accurately with an average error rate of 1.6% than did the telephone survey, which had an average error of 5.2%. In addition to the accuracy of the predicted outcomes, the mail surveys documented voter demographic characteristics more accurately.

Another major concern of the survey approach is associated with the non-respondent bias. Colombo (2000) argued that the quality of a survey not only depends on the response rate, but also on how the response rate is distributed in the population. Non-response bias is a major concern for studies based entirely upon data collected through mailed questionnaires (Van Loon et al, 2001). Although it is always claimed as a major constrain of mail survey, numerous methods exist for eliminating non-response bias, e.g., re-weighting the data, individual-level model of selection, or deriving bounds on the true population parameter. In terms of my research, non-response bias will be corrected by the use of statistical weighting, which is a faster, more economical and simpler method to reduce the bias created by non-response (Diaz de Rada, 2005).

The rest of the issues mostly relate to problems such as representative sampling, self-selection bias and so on. It has been argued that extrapolation from a sample survey may ignore the possible disparities that exist in the 'real world'. Scholars have, for many years, explored various methods for generating samples representative of populations, and the family of techniques referred to as probability-sampling methods do so quite well (e.g. Henry, 1990; Kish, 1965). Many notable inaccuracies of survey findings were attributable to the failure to employ such techniques (e.g. Laumann et al, 1994; Mosteller et al, 1949). Consequently, it is believed that representative sampling is essential to permit generalisation from a sample to a population. In my research, as the sampling frame is the whole population, the problems of representative sampling and self-selection bias do not exist.

3.5 Conclusion

A mail survey is considered as the most appropriate data collection method for my research given the international nature of the study. A self-completion questionnaire is undoubtedly the most effective and economic way to carry out the survey, especially because the geographic distribution of the US and the European biopharmaceutical firms included in my study is so wide. A questionnaire can be distributed without the constraints of geographical distance, quantity and availability of the potential respondents. Comparing with other data collection methods, such as individual interviews, focus groups, and

sometimes on-site observations, self-completion questionnaires give respondents more flexibility, they can provide input in a tension- or intimidation-free environment and at their convenience, without the problem of the interviewer effects, in particular when a question carries the possibility of social desirability bias. In addition, the simplicity of completing questionnaires proves to be an important factor in contributing to the rate of return and overall response accuracy (Long, 1986). Additionally, as mentioned earlier, the methods of email and fax will also be used according to the preferences of the potential respondents, since this strategy will overcome any delays caused by the regular mail services.

On the other hand, mail surveys are always criticised as having problems of lower response rate, non-response bias, representative sampling, self-selection bias and so on. However, having a low response rate does not necessarily mean that a survey suffers from a large amount of non-response errors. Recent studies suggest that the accuracy of predicted outcomes can be higher in surveys with very low response rates than in those with much higher response rates (Visser et al, 1996). Meanwhile, numerous methods exist for eliminating non-response bias, i.e., re-weighting the data, individual-level model of selection, or deriving bounds on the true population parameter. As my research focuses on the entire population of the biopharmaceutical firms across the US and Europe, the problems of the representative sampling and self-selection bias will not exist.

CHAPTER 4

FIELDWORK REPORT

4.1 Introduction

This chapter focuses on the pilot study and main survey that have been conducted to collect the data. The purpose of this chapter is to provide a comprehensive overview of the initial inductive interviews, the pilot postal survey and the main survey.

The chapter is organised as follows:

- In section 4.2, we review the initial inductive interviews that were conducted to help in the development of the initial English version of the postal questionnaire, and the rules that followed to construct the interviews, as well as the issues we identified from the interviews.

- Section 4.3 is devoted to a detailed description of the process for the pilot postal survey, and considers the questionnaire design and survey conduct. Additionally, a further discussion concerning the implications of the pilot survey in contributing to the questionnaire design for the main survey, is provided.

- Section 4.4 provides a clear picture of the main survey. It also addresses the important methods and techniques that have been used to obtain the target group. Discussion concerning the implications of the response rate and its representativeness follows.

4.2 Inductive Interviews

A pilot study was conducted through inductive face-to-face interviews with the R&D managers of several English biopharmaceutical firms in order to inform the questionnaire design. For example, the pilot helped the researcher to deep into the specific questions within each main area that was identified from the previous literature review. It also assisted in determining the clarity, and the relevance of the measures in the context of this research. Particularly those measures that have been developed in the previous literature review, i.e. the measurements for the different dimensions of absorptive capacity, alliance type, competitive advantage, etc.

4.2.1 Interview Conduct

Since the study only focuses on the biopharmaceutical sector with target population including dedicated biotechnology firms (DBFs) and large pharmaceuticals. A more rigorous selection process was required for the pilot interview companies. Usually the major players in this sector are large pharmaceuticals, small start-ups, and other service providers[3]. According to the representativeness of the target population, i.e. size, age, ownership status, etc., six companies were chosen, two of six were independent small start-ups, two were the headquarters of large pharmaceuticals, and the remaining two were subsidiaries of medium-size university spin-off companies. Moreover, in contributing to the design of the questionnaire, it is guaranteed that all the selected interview companies have the following characteristics. Firstly, they are actively involved in new product development activities. Secondly, they either extensively use alliances in developing their new products, or anticipate developing partnerships over the next two to three business years. We approached these companies by mail first, explaining the aims of our research, and enlisting their participation. Then, we contacted each of the companies by telephone or email in order to ask for their availability and arrange an appropriate time for the interviews. Eventually, all except one agreed to participate.

[3] Service firms have been excluded from this study, because they are not actually engaged in researching and/or developing any new product, and are therefore not in the remit of this research.

The pilot interviews lasted between 40 and 90 minutes, subject to the different situation in each company. The interviewees were mostly R&D managers or CEOs of the companies. The senior managers can reasonably be expected to be very knowledgeable about the operations of their firms and this industry sector, and thus, the information obtained in the interviews could be treated as being highly credible.

Seven main areas identified from the literature were discussed with the R&D managers during the interviews. These areas involved firms' background information, new product development and R&D, alliance activities, and competitive advantage. Open-ended questions were asked within each area in order to generate fixed-choice answers. This provided a good opportunity to find out if the issues reflected in the study have already been recognised by some of these firms. Additionally, some issues most likely to be skipped in the questionnaire, were identified in the pilot.

Based on the conceptual framework developed in the previous literature review chapter, the interview questionnaire was divided into seven sections. The first section is designed to acquire some general information about the company's background, as it was appreciated that some of the potential control variables (e.g., number of employees, age, sales growth) might come from here. Sections 3 and 5 target the early and the late stages of firms' new product development process. Our aim in this respect was to map the whole picture of a firm's new product development and alliance activities instead of partially looking at the relationships between potential absorptive capacity (PACAP), realised absorptive capacity (RACAP), exploratory and exploitation alliances, because these two stages are where all the research questions are rooted. This advances an integrative view of the research questions, also issues that might have been missed in the literature review will be identified. All the questions included in both sections were asked as follows:

- Is the company involved in this kind of activity?
- What is the motivation?
- How does it work?
- What are the most important factors in determining the success of this kind of activity?
- How is the success of these activities judged?

- If alliances have not been used, what is the barrier in trying to form alliances in this area?

Sections 2, 4, 6 and 7 of the pilot interview questionnaire, focus on more specific issues concerning firms' new product development, research and development, patents, competitive advantage, and alliances. These sections start by asking specific questions about the company directly, and then come back to the general issues that have been identified from the previous literature. This is believed to help in the generation of some potential indicators for firms' potential absorptive capacity, realised absorptive capacity, innovation performance, competitive advantage, etc.

4.2.2 Results and Key Lessons from the Inductive Interviews

One of the most important issues emerging from the interviews concerned firms' outsourcing activities. As the biopharmaceutical industry itself is a highly regulated industry with a relatively long, resource-intensive, and prolonged new product development process, the majority of the incumbent firms could only afford to compete in certain stages of this process, relying heavily on partnerships or outsourcing the rest of the new product development activities in pursuing new product development. For this reason, we included a special section in the questionnaire to gather information about firms' outsourcing activities. Another important issue is associated with the measures that have been used by these firms to evaluate their business performance, for example, we discovered that goal achievement is a very effective indicator for assessing the success of firms' alliance activities. In addition, the interviews also helped to identify many important factors relating to the motivation of firms' alliance activities, for example, funding the projects, and spreading the risk and costs of new product development, etc.

Although our measures for absorptive capacity almost covered the four dimensions in the main stream, the interviews help to generate the particular indicators for the different dimensions of absorptive capacity from a basket of potential measures. For example, we found that number of patents was not only a most common indicator for these firms to measure their new product development output, but was also considered as a very

important pre-requisite to attract potential partners, as well as a potential source of competitive advantage. It is worth noting that most of the interviewed firms considered patent quality rather than the number of patents as an important source of competitive advantage. Therefore, we changed the number of patents to patent quality as one of the determinants for a firm's source of competitive advantage in the questionnaire design. On the other hand, the interview provides some insights into the research questions regarding the relationship between absorptive capacity, alliances and their influence on firms' competitive advantage. We found that communication plays a very crucial role in knowledge assimilation and transformation between partners, as can be seen by the regular meetings between partners, and the use of joint development teams in terms of staff working with partners, and thus, we include both items as measurements for each of these two dimensions. Another finding is associated with the type of partners, since a few basic types of partners were identified from the interviews, i.e. small start-ups/spin-off companies, large pharma-companies, university/academia institutes, contract research organisations (CROs) and others.

4.3 Pilot Postal Survey

A pilot postal survey was conducted on Irish biopharmaceutical companies prior to the main survey to pre-test the initial design for the English version questionnaire. This also provided a good opportunity to ascertain the approximate response rate for the main survey.

4.3.1 Questionnaire Design for the Pilot Survey

The seven sections developed according to the conceptual framework derived from the literature review were expanded in response to the findings from the initial inductive interviews. For some questions, fixed choice answers were generated, according to the reply of the corresponding open-ended questions. Issues identified from the interviews were further developed into detailed questions and included in the relevant sections. Apart from those generated from the initial interviews, we used the existing scales developed by

previous researchers to measure certain notions in the pilot questionnaire, i.e. competitive advantage, motivation for alliances, R&D constraints. We also re-phrased some items indicated by the R&D managers as ambiguous. And the phrasing of the questions was further enhanced by the author and peers.

In the end, the initial English version postal questionnaire for the pilot survey was produced with seven individual sections covering all the aspects of absorptive capacity, R&D and new product development, alliances/partnerships as well as competitive advantage. The core set of questions for the pilot survey was as follows:

- Company Background
  - Firm age, location, ownership, market segment; employment, sales turnover; etc.
- Research and Development
  - R&D investment, constraints on firms' R&D activities, license in/out intellectual property, etc.
- New Product Development
  - Patenting activities, new product pipeline, factors determining the success in developing new product ideas, etc.
- Early Stage of New Product Development
  - Alliances focusing on basic research, drug discovery and development, motivation of alliances, alliance performance, etc.
- Commercialisation of New Products
  - Alliances focusing on commercialisation activities, alliance motivation, alliance performance, alliance overlap, etc.
- Future Alliances
  - The type of potential partners;
- Competitive Advantage
  - Source of competitive advantage.

4.3.2 Conduct of Pilot Survey

Despite the fact that the companies involved in the pilot survey could not represent exactly the actual sample, the use of these companies did eliminate the risk of ruining some of the potential data sources because of the problems incurred by the questionnaire design or the pilot survey itself. Essentially, considering the industry background (as the typical European biotechnology industry); government policies; development of the financial market; particularly the language and culture environment, Irish biopharmaceutical companies have many commonalities with those companies included in the target group. Furthermore, the specific geographic location and business language used made pilot survey on the Irish biopharmaceutical companies, the most effective and economic strategy.

The list of Irish biopharmaceutical companies was obtained from [BiotechologyIreland.com]. This site is a central source of information on all aspects of biotechnology in Ireland and highlights Ireland as a centre for biotech excellence in basic and applied research as well a location for biotech businesses large and small, indigenous and multi-national. And the same selection procedure was used later on in the derivation of the target group for the study proper. Stage 1 included a population of 253 Irish biotechnology companies. In Stage 2, by browsing the product profiles information provided either by the database or company website, we identified a list of 78 biopharmaceutical companies from this population. Meanwhile, service firms, i.e. consultancies, venture capitalists, incubator centres, and technology transfer organisations were excluded from this list. In the next stage, we made contact with each company included on this list according to the telephone number that was provided. The response proved that this technique was more effective in a sense, at least for the Irish companies, because most of the companies showed great interest in participating in this research after being contacted. However, three companies were filtered out due to their having moved or merged. In the end, this process yielded a group of 75 Irish biopharmaceutical companies.

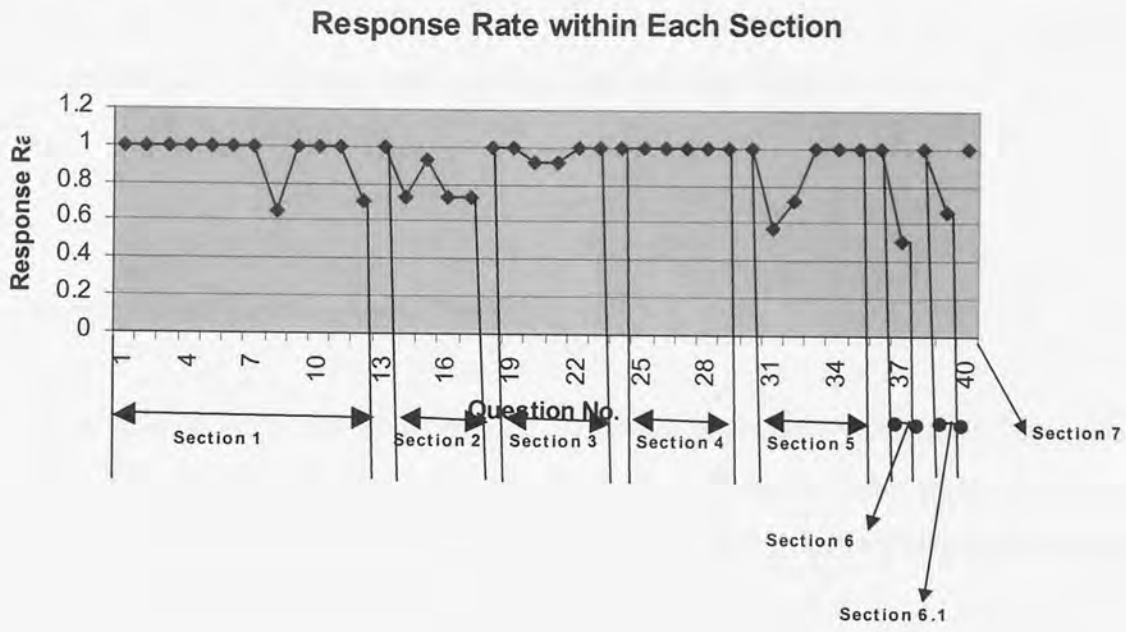
The questionnaire was distributed among these 75 Irish companies by post. A follow-up survey was performed on the non-response companies. At the same time, telephone follow-up was used in order to further raise the response rate.

4.3.3 Results and Key Lessons from the Pilot Survey

Finally, a response rate of 22.7 percent (19 observations) was achieved. The response rate within each section (see Figure 4.1) was calculated. We found that questions regarding the general background information of the companies always gave the highest response rate. One of the reasons might be that this type of question does not ask for any confidential information, and it also applies to all the kinds of firms operating in this sector. In contrast, we also found that questions regarding some sensitive information, in particular, financial data, i.e., sales growth, R&D spending, turnover, etc. had the lowest response rates, compared with the other questions. This is understandable because these questions are normally confidential for the companies. However, this kind of information is crucial for our measurements of absorptive capacity and performance, in particular R&D intensity and market share growth. Therefore, instead of asking for specific figures, we requested an estimated proportion. We also rephrased these questions to make it more concise and easy to understand what was required, in an attempt to further raise the response rate. This made a great difference in terms of the response rate as was seen later on in the main survey. In addition to the main questions of interest, those questions with a relatively low response rate, serving as a supplement in support of the main questions, were eliminated from the questionnaire. Apart from these modifications, the questionnaire was re-ordered, and re-arranged, in order to ensure that it was reader-friendly.

Overall, the pilot survey was not only very helpful in contributing to the final questionnaire design, but also served as good guidance for the main survey. In particular, it accurately predicted the response rate of the main survey, for example the final response rate of the UK survey was 22.7%, which is exactly the same as was achieved in the pilot.

Figure 4. 1: Section Response Rate (Pilot Survey)



4.4 Main Survey

The main survey was administered to 2,173 US and European biopharmaceutical firms that were identified from different data sources. A follow-up was conducted two weeks after through a combination of telephone contact and mail shot. Finally, we obtained a useful response from 349 biopharmaceutical firms, achieved a response rate of 16.06%, representing 10.76% of the total potential population. A dataset with 349 observations was constructed.

Section 4.4.1 provides an overview of the final questionnaire design and translation for the main survey, based on the existing literature and the key results and lessons that were identified from the previous inductive interviews and pilot postal survey. Section 4.4.2 details the process that was followed to derivate our US and European target groups. Important methods and techniques that were used to identify appropriate companies from available data sources are also specified. Section 4.4.3 is devoted to a detailed description of the main survey conducted on the 2,173 US and European biopharmaceutical firms. The

corresponding response rates in general, and response rates within each section are calculated and analysed in Sections 4.4.4 and 4.4.5, and the discussion associated with the representativeness of these response rates is advanced in Section 4.4.6.

4.4.1 Questionnaire Design and Translation

Building upon the existing literature and inductive interviews with R&D managers from several English biopharmaceutical companies, as well as our pilot postal survey on the Irish biopharmaceutical firms, the final version of the questionnaire was designed to include questions regarding the following seven main sections:

- Section 1 focuses on the background information of firms, being designed to obtain firms' general information, i.e., firm age, size, location, ownership, market segment; employment, strategic focus; etc. This information is very important to tease out our control variables (see Appendix 2) and control the effect of factors (i.e. some firm characteristics, market characteristics and strategic focus) other than the independent variables that might influence firms' absorptive capacity, alliance activities and competitive advantage.

- Section 2 concentrates on acquiring information concerning firms' R&D. i.e. R&D investment, constraints on firms' R&D activities, license in/out intellectual property, etc.

- Section 3 draws attention to firms' new product development activities, i.e., patenting activities, new product pipeline, factors determining the success in new product development, etc.

- Sections 4, 5 and 6 target the early and late stages of a firm's new product development process, as well as future alliances. These sections aim to capture the entire new product development process, with the intention of obtaining information

concerning a firm's absorptive capacity, and alliance activities. The core set of questions included in these sections is as follows:

- Section 4. Early Stage of New Product Development
  - Alliances focusing on basic research, drug discovery and development, motivation of alliances, alliance performance, etc.
- Section 5.Commercialisation of New Products
  - Alliances focusing on commercialisation activities, alliance motivation, alliance performance, alliance overlap, etc.
- Future Alliances
  - The type of potential partners;

- Section 7 focuses on a firm's source of competitive advantage, and is designed to help respondent firms to identify the different types of sources they have in this respect.

In particular, the questionnaire included many items aiming to measure the firm's absorptive capacity, which had been developed either through reviewing earlier research in the relevant area, or through the pilot interviews. The questionnaire was four pages long and took about 10-15 minutes to complete. There were 33 items concerning absorptive capacity, 48 items regarding a firm's alliance activities and 13 items relating to competitive advantage, covering approximately three pages of the questionnaire.

Additionally, based on the results and key lessons obtained from pilot surveying the Irish biopharmaceutical companies, the questionnaire was further revised before the data collection phase. The changes made for the final version were as follows:

- For questions regarding sensitive information, i.e. financial data, sales growth, R&D spending, turnover, etc., instead of asking a particular figure, we requested an estimated proportion.

- These particular questions were re-worded to make it more concise and easy to understand them, and hence further improve their response rate.

- Those questions with a relatively low response rate in the pilot survey, serving as a supplement in support of the main questions were eliminated from the questionnaire.

Apart from these modifications, the questionnaire was re-ordered, and re-arranged, in order to ensure that it was reader-friendly. We also made sure that each section followed logically into the next, and the sequence gradually moved from the easy to the complicated questions.

The questionnaire was then translated into French and German. As suggested by Jobber et al (1991), when there are language differences between sender and recipient, questionnaires that are translated into the recipients' native language may generate a higher response than English-version questionnaires. However, considering the time and resource constraints, a cross-translation method was employed instead of back-translation method. The translation work for the German and French-version questionnaires was checked by different translators and recipients' native language speakers to ensure the consistency and accuracy of the translation.

4.4.2 Derivation of Target Group

As we set the research in the context of the biopharmaceutical sector, a further selection process for the derivation of the target group was required. In order to identify a complete list of the US and European biopharmaceutical companies from the potential data sources, we adopted a special procedure followed by three individual stages as follows:

- Stage 1 - The first stage involved the identification of the population of all the companies operating in the biotechnology industry from different data sources.

- Stage 2 - The second stage was dedicated to identifying a list of biopharmaceutical firms from this population by looking at the product profile of each company provided either by the database or the company website. Service firms were eliminated from this list (i.e. consultancies, technology transfer organisations, incubator centres, investor in

biotechnology companies). We also excluded organisations that were active in the biopharmaceutical sector but which were not formal legal entities. Once the final list of biopharmaceutical companies was identified, information regarding the contact detail, i.e. telephone number, email address and postal address, was acquired.

- Stage 3 – The third stage involved approaching each of these companies by telephone to confirm contact details, explain the purpose of the research, and encourage their collaboration. This process also guaranteed that the target companies were within the scope of this research and were operating in the biopharmaceutical sector.

(Table 4.1. shows the output of these procedures for the target group selection in different countries included in this research.)

US

The overall population of biotechnology firm in the US was provided by the BioScan industry directory, which is the most comprehensive, publicly available source covering the global biotechnology industry. Previous research studies have used BioScan as the main source of information on new product development and alliances (cf. Deeds and Hill, 1996; Powell et al, 1996; Rothaermel and Deeds, 2004); co-operative relationships, start-up attributes and innovation output (Shan et al, 1994); firms' financial performance and their various inter-organisational agreements (Zollo et al, 2002); etc. This list of the US biotechnology companies containing 1,205 firms was used in Stage 1. In the next stage, using a combination of desk research and telephone filtering, a population of 1,020 biopharmaceutical companies, excluding service firms, was identified. However, because the situation of some of the sample companies had changed, either because they had moved, merged, taken over by other companies, or faced insolvencies during the time of this research, these had to be excluded from the existing list. Therefore, after stage 3, 999 companies remained, and these were included in the US target group.

Europe

According to Ernst & Young's industry report (2004 and 2005), there were 1,861 private and public biotech companies in Europe in the year 2004. In contrast, the number of biotech companies in Europe decreased slightly in 2005, falling about 3 percent compared to 2004. While the industry continued to bring in new companies through the normal process of company formation, the sector also lost companies through acquisitions and insolvencies.

The European target group selection was also based on BioScan initially. However, the number of European biotech companies included in Bioscan is very limited compared with Ernst & Young's industry statistics at the same time (2005). For this reason, the European sample was reinforced by several other sources, such as Nexis-Lexis, COMPUSTAT, and so on. However no source had a complete list of all the European DBFs. Moreover, some of them could not be publicly accessed. In the end, only Biotechnology-Europe.com was selected, since it is the most comprehensive and freely accessible source for the European biotechnology industry, and the number of companies contained in this directory is close to the number announced by Ernst & Young.

In the next step, three countries – the UK, France and Germany, were selected for the study. These three countries represent different types of European biotechnology. The UK is still one of the three major European players (together with Switzerland, and the Nordics) with a strong emphasis on therapeutics. Germany and France, on the other hand, are more involved in technology platforms. To some extent, this reflects different stages of maturity. Noteworthy is that the number of biotechnology companies in these three countries accounts for 50 percent of the entire population in Europe, with a distribution of 17 percent in the UK, 11 percent in France, and 22 percent in Germany (Ernst & Young, 2006). Moreover, considering the comparability to the US target group (i.e. the strength of research capabilities in life science), it is believed these three countries properly represent the European picture.

The UK target population comes from two complementary sources: the Biotechnology-Europe.com, and the Sainsbury Report (1999). Biotechnology-Europe.com covers the

majority of the UK biotechnology companies, being the most comprehensive, publicly-accessible industry directory for the UK biotechnology industry, in comparison with different biotechnology directories. However one area that was especially drawn on in the Sainsbury Report (1999) is the detailed information regarding to the Wales biotechnology companies, originally obtained from the Welsh Development Agency, a network and regional biotechnology association. This Agency produces a biotechnology directory and has a Centres of Expertise programme to promote HEI Departments with strong industrial links. Whereas Biotechnology-Europe.com does not include any biotechnology companies in Wales, which is identified as one of the three typical biotechnology clustering regions in the UK (Sainsbury, 1999). In order to identify a complete list of target companies in the UK, the same selection process was replicated. The first stage involved the inclusion of all the UK biotechnology companies (with a number of 473 firms in total) from these two data sources. In the second, by browsing the product profile information provided by the data sources, a cut list of biopharmaceutical companies was identified from these 473 companies. Additionally, service companies were ruled out from this list. The final stage yielded a population of 343 such firms, which comprise the UK target group.

The starting point for the French and German target group selection was Biotechnology-Europe.com, and a similar selection process that used before was followed. Nevertheless, the coverage was still far from complete comparing with the industry statistical figure published by Ernst & Young. Potential companies were identified in stage 1 through the online Biotech and Life Sciences company directory, initially created by Venture Valuation, Zurich/Switzerland, a company that is focused on the valuations of life sciences companies, in particular specialised in the Biotech area. This Biotech Database provides free access to a very comprehensive industrial directory and information platform containing data of biotechnology and life sciences companies in France and Germany (i.e. company description, additional information and categorization). It is also available and free of charge for the purposes of obtaining a brief profile of each organisation. The target group was created by performing a key word search on 'drug R&D or human diagnostics' on the two databases, and only those companies with 'description of activities' involved in R&D of drugs or diagnostics for humans were included. In the end, a list consisting of 782 such companies (including 262 French companies and 520 German companies) was identified. In stage 3, all these companies were contacted via email before the main survey,

in order to ask for the contact name, explain the purpose of this research, and encourage their collaboration. At the same time, this ensured that all the firms included in the survey were actually involved in the R&D of drugs or diagnostics for humans. However, out of the 250 French companies, six refused to collaborate, and nine had gone bankrupt or merged, by the time they were contacted. Similarly, out of the 520 Germany companies, eight refused to collaborate, and three were out of business. Therefore, the remaining 247 French companies and 509 German companies form the final list for the French and German target groups.

Table 4. 1: The Output of the Target Group Selection Process in each Country

Country	Main Data Sources	No. of Biotechnology Companies	No. of Bio-pharmaceutical Companies	Proportion of the Population
Ireland (Pilot)	[Biotechnologyireland.com]	253	75	30%
France	[France-biotechnology.com]	312	247	79.2%
Germany	[Germanbiotech.com]	999	509	51%
UK	[Biotechnology-Europe.com] Sainsbury Report (1999)	477	343	72%
Europe		2,041	1,174	58%
US	Bioscan	1,205	999	83%
Total		3,246	2,173	67%

4.4.3 Survey Conduct

The fieldwork took place between 30th June 2006 and 16th October 2006. Figure 4.2 shows the time-scale of the main survey. At the end of June 2006, this final version of the questionnaire was mailed to 2,173 R&D managers or CEOs of the target US and European biopharmaceutical firms. However, as the US and English data source did not include detailed information about the contact persons, typically R&D managers or CEOs, we identified the most suitable respondent through telephone contact with the target companies or from the information provided by the company website before conducting the main survey. This helped to refine the initial version of the mailing list (obtained from the data source) by excluding potential respondents from the same company and potential respondents with inappropriate job titles such as chief financial officer. In addition, considering company policy for the confidentiality issues within the firms, some of the target companies refused to give any contact name, and instead, we were asked to simple use the title, normally, the head of R&D, or CEO. In contrast, for the German and French companies, as the data source already contained the detailed contact information, much more time was available for the main survey.

To enhance the response rate, the main survey was administered in three stages. Firstly, personalised letters along with the questionnaire were mailed to the R&D managers of the target companies, in those firms where that existed, or to the CEOs in other cases. The letter described the purpose and significance of the research, and guaranteed the confidentiality of all information supplied, as well as encouraging co-operation. The postal questionnaire was sent out on 30th June 2006, with the instruction that it could be returned by e-mail, ordinary mail or fax. After the first stage of spontaneous responses, the names of those who responded were then removed from the original mailing list.

Two weeks later, a follow-up letter was mailed to each of the target respondents to remind them of the survey. To further raise the response rate, we made telephone contact with the non-response managers or CEOs of the target companies. However, because of the language constraints, we only sent follow-up letters to the French and German companies in the second stage, and the final response rates were still very competitive (with France 18%, Germany 16%), compared with US 12%, and the UK 25%.

The tool used for gathering the data during the main survey and the follow-up was the questionnaire sent via post, e-mail or fax. R&D managers or CEOs involved in the research were those directly involved in negotiating the partnerships. These senior managers can be reasonably expected to be very knowledgeable about the operations of their firms, in particular in the areas of R&D, new product development activities and partnership. Hence, the information obtained in the questionnaire could be treated as being highly credible.

4.4.4 Response Rates

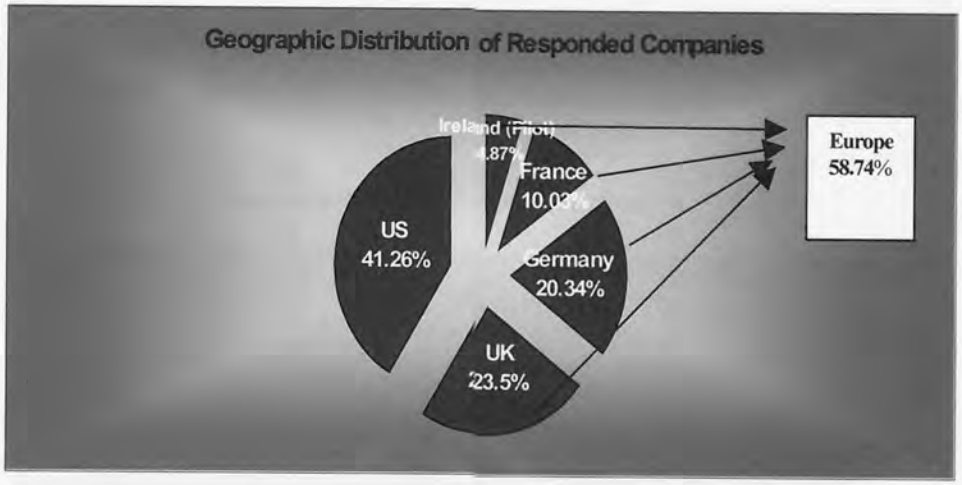
The process of gathering information ended on 16th October 2006. By that date, we had received complete information from 349 of the 2,173 target US and European biopharmaceutical companies, corresponding to a response rate of 16.0% in general (with US 14.4%, Europe 17.5%, UK 23.9%, France 14.2%, Germany 14.0%, and Ireland 22.7%). All these questionnaires were analysed to arrive at requisite observations. Thus, we could build a database with 349 observations. In Table 4.2, it may be observed how the response rates are distributed among different countries. As regards the geographical distribution, 41.3% of the companies were located in the US, and the remainder 58.7% in Europe, with a distribution of 23.5% in the UK, 10.0% in France, 20.3% in Germany, and 4.9% in Ireland (Table 4.3. shows the geographical distribution in detail).

Table 4. 2: Distribution of Responses Rates among Different Countries

Country	No. of Response Companies	No. of Bio-pharmaceutical Companies	Response Rate
Ireland (Pilot)	17	75	22.7%
France	35	247	14.2%
Germany	71	509	14.0%
UK	82	343	23.9%
Europe	205	1,174	17.5%
US	144	999	14.4%
Total	349	2,173	16.0%

Table 4. 3: Geographical Distribution of Respondent Companies

Country	No. of Response Companies	Distribution
Ireland (Pilot)	17	4.9%
France	35	10.0%
Germany	71	20.3%
UK	82	23.5%
Europe	205	58.7%
US	144	41.3%
Total	349	100%

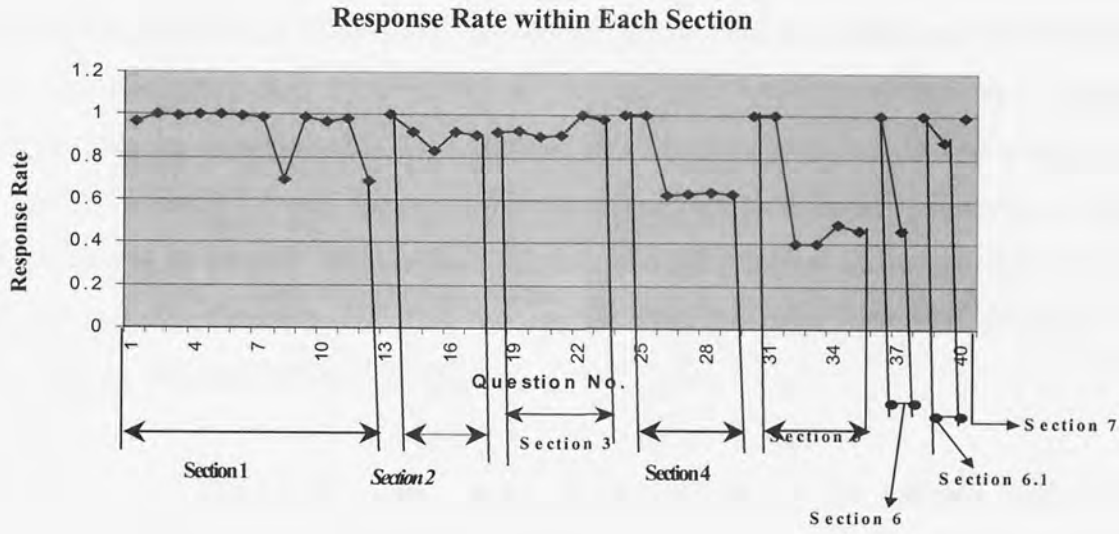


4.4.5 Question Response Rates

Meanwhile, the response rate within each section was calculated, and the distribution is presented in Figure 4.3. Compared with the result obtained from the pilot, the general response rate of the main survey decreased from 22.7% to16.0%. According to the results of the pilot and the main survey, we found that questions regarding to the general background information of the companies always gave the highest response rate. One of the reasons as mentioned before (in the results of the pilot survey) might be that this type of question does not relate to any confidential information about the companies, and applies to all the kinds of firms operating in this sector. We also found that questions regarding to the alliance overlap had the lowest response rate. This is not surprising because the possibility of firms having both types of alliances with the same partners is rather less than the possibility of having either or both type(s) of alliance(s) with different

partners. In addition, it seems that the general trend of the pilot response rates predicted the trend of the response rate in the main survey, although this varies between the response rates for the same question. Moreover, for questions concerning sensitive information, e.g. financial data, in particular sales growth, the response rate was improved by up to 5% in the main survey after we modified the questions by asking for an estimated proportion instead of a particular figure. This outcome is readily observed in the response rate for each section (see Figure 4.3.).

Figure 4. 3:Section Response Rate (Main Survey)



4.4.6 Representativeness

Of the 2,173 questionnaires sent out, 349 were returned, giving a response rate of 16%, and representing 10.8% of the total potential population. The companies taken into consideration were mainly small start-ups and medium-sized companies; in fact 302, out of 86.5% of these companies were founded in the last 25 years, while only 47 were longer-established. Size is consistent with age: it was pointed out that 86.5% of the surveyed companies had less than 200 or 200 employees. This result is reliable given the fact that

the biotechnology industry itself is a emerging industry and only goes back to the early 1970s (Rothaermel and Deeds, 2004; 2006), and the first new biotechnology drugs only reached the pharmaceuticals market in the 1980s. Hence, the majority of the firms were small start-ups and medium size companies. (Of the 52.1% of these companies, 182 were founded in the last 10 years, while only 79 were 20 years older. Size: 57.6% of the companies have less than 30 employees).

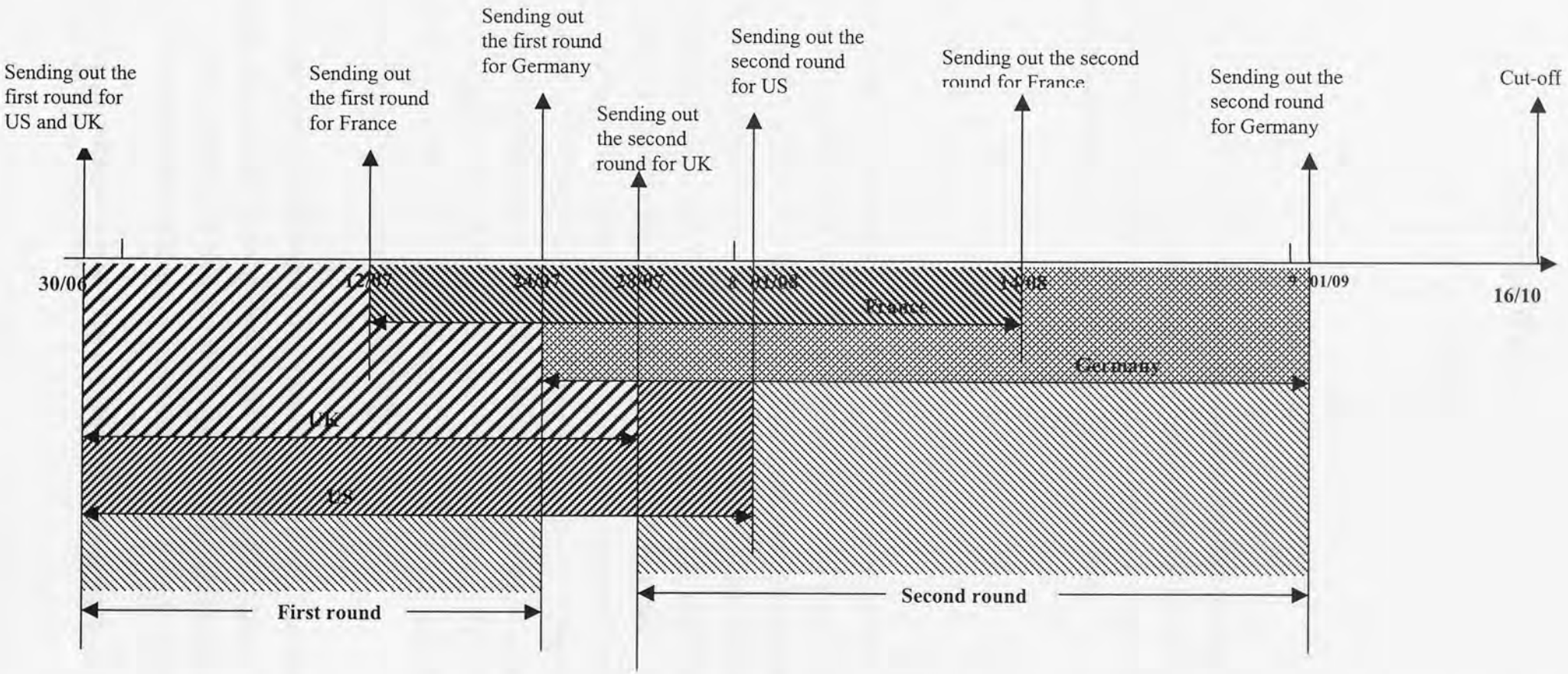
4.5 Conclusion

The main survey was conducted using 2,173 biopharmaceutical firms across the US and Europe. In particular, a three-round data collection process (i.e. initial mail shot, follow-up with questionnaires sent by post, e-mail or fax, and further mailing) was followed to further raise the response rate. This allowed us to receive complete information from 349 of the 2,173 target US and European biopharmaceutical companies, achieving a response rate of 16.0% in general, with individual response rates higher in Europe (17.5%) than in the US (14.4%), and the UK (23.9%) higher than the other countries (France 14.2%, Germany 14.0%, and Ireland 22.7%).

Data collected from the main survey is considered to be reliable and to yield comprehensive information about the new product development, performance, R&D and alliance activities of the target US and European biopharmaceutical companies. Several reasons for this are identified as follows: first and foremost, of the 2,173 questionnaires sent out, 349 were returned, giving a response rate of 16%, representing 10.8% of the total potential population. This provides a solid base for carrying out the empirical analysis of the relationships between absorptive capacity and alliances, and their influence on firms' competitive advantage in the following chapters with a large data set containing 349 observations. Secondly, the geographic distribution of the respondent companies among different countries (see Table 4.3) is similar to the industry structures in the US and Europe. Thus, the information gathered from these firms could reflect a clear picture of the industry landscape in the US and Europe. Thirdly, the questionnaires used in the main survey were designed based on the existing literature and the results and key lessons obtained from the

inductive interviews, and were further tested by the pilot postal survey on the Irish biopharmaceutical companies. To a certain extent, this minimised measurement errors, in terms of inaccurate responses caused by badly-worded questions, which decrease the level of quality of the data (Loosveldt et al, 2004). Finally, as we focused on the whole population of the US and European biopharmaceutical companies in the main survey, the data obtained is not affected by the sampling error which results when observations are made only on a sample and not on the entire population.

Figure 4. 2: Time-Scale for the Main Survey



CHAPTER 5

DESCRIPTIVE OVERVIEW

5.1 Introduction

In this chapter, the results of the descriptive statistics for the data are given in detail. The aim of this chapter is to provide a general description of the characteristics exhibited by the data. In particular, it presents a comparison of the US and European biopharmaceutical firms according to their different features as observed in the descriptive results.

5.2 Background Information

In general, the US respondent biopharmaceutical firms are larger and older than their European counterparts[4], with a higher level of employee skills. The average age of our US respondent firms is 15.9 years, with an average number of 65 employees, 87.0 percent of whom have a degree or higher qualification. In contrast, a typical European respondent biopharmaceutical firm averages 12.1 years old, with 35 employees, and only 66.9 percent possessing a degree or higher qualification (see Table 5.1.). In fact, 90.9 percent of our respondent companies consider the employee's skills as the most important skills in contributing to their success in developing new product ideas (see Table 5.2.). These firm-level characteristics reflect the longer history of the US biopharmaceutical firms, which is supported by the empirical studies which focus on the comparative advantage of the US in biotechnology (Lavoie and Sheldon, 2000; Grossman and Helpman, 1991) and the official industry statistics published by Ernst & Young (1997a; 1997b).

Overall, R&D intensity (see Table 5.3.) is higher in a typical US respondent firm, despite the fact that the average sales growth is not as fast as the European counterparts. This provides broad support for the empirical evidence which suggested that the average level of R&D investment by US biopharmaceutical firms was larger than that for European

[4] The results are consistent with the finding of Critical I Report 2006 (comparative study of European biotechnology) and Ernest & Young Industry Report 2003.

firms (Ernst & Young, 1997a; 1997b; Mowery and Nelson, 1999), reflecting a much tighter supply constraint on the availability of investment capital in Europe as compared to the US, where there are well-tested capital markets such as NASDAQ (Lavoie and Sheldon, 2000).

Meanwhile, it seems that university or research institute spin-off companies are more popular in the US, whereas other types of spin-off, in particular spin-off commercial companies, and spin-off others, are much more common in Europe. The results suggest an intensive use of public sector research results in the US (Cooke, 2001), and a relatively lower level of commercialisation capability of the European biopharmaceutical firms (Lavoie and Sheldon, 2000).

Table 5. 1: Background

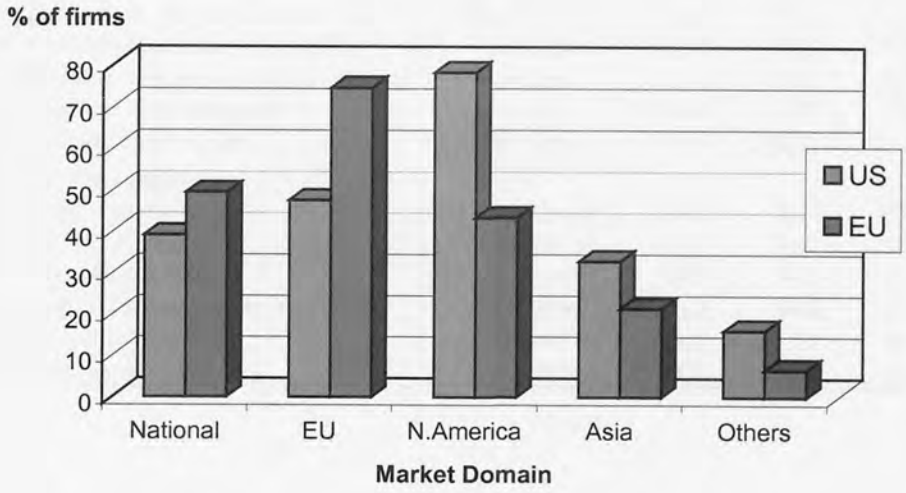
Variable		US n=144	EU n=205	Total n=349	Sig.[5]
A: Firm Characteristics					
Firm age*	(Years)	**15.88**	**12.08**	13.35	p=.006
No. of employees*	(per firm)	**65.0**	**35.0**	46.81	p=.003
Employee skills	(% per firm)	87.0	66.9	75.0	
Sales growth	(% per firm)	51.3	64.5	59.6	
B: Main Markets					
National market*	(% of firms)	**39.2**	**49.5**	45.3	p=.055
European market*	(% of firms)	**47.6**	**74.7**	63.5	p<.000
North American market*	(% of firms)	**78.3**	**43.4**	57.8	p<.000
Asian market*	(% of firms)	**32.9**	**21.4**	26.1	p=.019
Other markets*	(% of firms)	**16.1**	**6.5**	10.4	p=.007
C: Main Activities					
Basic R&D*	(% of firms)	**66.7**	**46.8**	55.1	p<.000
Pre-clinical dev.*	(% of firms)	**60.4**	**37.1**	46.8	p<.000
Clinical phaseI*	(% of firms)	**51.4**	**22.9**	34.8	p<.000
Clinical phaseII*	(% of firms)	**41.7**	**18.3**	28.1	p<.000
Clinical phaseIII*	(% of firms)	**30.8**	**10.2**	18.8	p<.000
Manufactory*	(% of firms)	**58.3**	**46.6**	51.5	p=.031
Regulatory support*	(% of firms)	**61.1**	**18.7**	36.4	p<.000
Marketing & sales*	(% of firms)	**41.0**	**51.9**	47.3	p=.046
D: Type of Spin-off Companies					
Spin-off universities or research institute*	(% of firms)	**31.2**	**21.2**	25.2	p=.042
Spin-off hospitals or healthcare centers	(% of firms)	1.4	2.3	1.9	
Spin-off commercial company*	(% of firms)	**13.8**	**31.4**	24.2	p<.000
Spin-off others*	(% of firms)	**4.3**	**9.6**	7.4	p=.056
E: Financial Support					
Venture capital companies	(% of firms)	47.2	47.0	47.1	
From Government*	(% of firms)	**46.7**	**65.8**	57.7	p=.003
Overseas funding	(% of firms)	14.0	13.0	13.5	
Other financial support*	(% of firms)	**53.3**	**29.9**	39.9	p<.000

[5] Here we only report the significance levels of those variables which are significantly different between the US and Europe in the T-test results.

5.3 Primary Market

Overall, the US and European respondent firms focus on different primary markets. As we can easily see from the following chart, in contrast to the European firms, the US firms focus more on North American, Asian, and other markets[6]; the European firms, on the other hand, focus much more on their national and European markets rather than the rest of the world. In particular, we found the regional market was still the main focus for both the US and the European firms which responded to our survey. As Table 5.1 illustrates, 78.3 percent of the US companies reported having North American markets as part of their market domain, and similarly, 74.4 percent of the European companies are participating in the European Market.

Figure 5. 1: Primary Market



5.4 Average Number of Patents and New Product Development Cycle

Table 5.2 presents a description of the new product development activities of the respondent firms. As shown in Table 5.2, the average US respondent biopharmaceutical

[6] The finding is supported by the industry statistics published by Ernst and Young (2005).

firm has 91 products in the market, and nine products in development, holding 53 patents; the average new product development cycle is 6.2 years. However, in Europe, the situation is completely different, although a typical respondent biopharmaceutical firm has 110 products in the market, and four products in development, it only holds 20 patents. And the average new product development cycle is 4.3 years, which is relatively shorter than that of the average US firms. The results vividly illustrate the increased maturity of the European biopharmaceutical industry with greater number of new products in the market and a relatively shorter new product development cycle (Ernst & Young, 2006).

Table 5. 2: New Product Development

Variable		US n=144	EU n=205	Total n=349	Sig.[7]
No. of patents currently*	(per firm)	**53.10**	**20.21**	33.79	p=.003
New product development cycle*	(Year)	**6.21**	**4.27**	5.08	p=.008
A: Product Pipeline					
No. of products in basic R&D*	(per firm)	**6.49**	**3.36**	4.77	p=.081
No. of products in pre-clinical dev.*	(per firm)	**2.05**	**0.72**	1.32	p<.000
No. of products in clinical PhaseI*	(per firm)	**0.67**	**0.25**	0.44	p<.000
No. of products in clinical PhaseII*	(per firm)	**0.59**	**0.19**	0.37	p<.000
No. of products in clinical PhaseIII*	(per firm)	**0.38**	**0.09**	0.22	p<.000
No. of products awaiting regulation approval	(per firm)	0.30	0.37	0.34	
No. of products in development*	(per firm)	**9.660**	**4.97**	7.41	p=.005
No. of products in the market	(per firm)	91.08	110.55	101.67	
B: Other Capabilities					
Internal R&D capability	(% of firms)	84.2	83.3	83.7	
Internal communication	(% of firms)	85.5	90.4	88.3	
Good project management	(% of firms)	79.7	84.0	82.2	
Awareness of leading edge research*	(% of firms)	**76.1**	**60.3**	67.1	p=.002
Effective partnerships*	(% of firms)	**61.6**	**75.5**	69.6	p=.008
Employees' skills	(% of firms)	91.2	90.7	90.9	

Despite the fact that the European firms have a greater number of products in development in general, the actual number of products in pre-clinical and clinical Phase I, II, III development is less than their US counterparts. This indicates a stronger product pipeline and commercial exploitation capability of the US biopharmaceutical firms (BioWorld Phase III Quaterly Report, 2005; Ernst & Young, 2005; 2006; Yeoh and Roth, 1999). It is also worth noting that although there is no great difference in the number of products awaiting regulation approval in both groups, the average number of products in the market

[7] Here we only report the significance levels of those variables which are significantly different between the US and Europe in the T-test results.

in Europe is far ahead of the US figure. The US firms, on the other hand, with a smaller number of products under development and in the market, hold more patents than the European firms. This is consistent with the earlier study which reported that the European biopharmaceutical industry is far behind in terms of the patenting activities in comparison to the US (Taplin, 2007; Thumm, 2001). One of the reasons might be associated with the difference between the length of the new product development cycle in the US and European biopharmaceutical firms, which is relatively shorter in Europe and longer in US. In support of this, our correlations analysis shows that there is a certain association between a firm's new product development cycle and number of patents (r=.144, p=.017). Moreover, we found that the US firms have more licensing activities in comparison to the European firms (see Table 5.3). One possible reason for this could be that the US firms hold a higher number of patents than their European counterpart. And our results of the correlation analysis further confirm that there is an association between licensing activities and number of patents. (License-in r=.120, p=.042; License-out r=.245, p=.000). The result, therefore, provides evidence for the prior findings that suggested a continued growth of the intensive licensing activities in the US biopharmaceutical industry (Recombinant Capital, 2005).

Table 5. 3: Research and Development

Variable		US n=144	EU n=205	Total n=349	Sig.[8]
A: R&D Activities					
Whether or not carry out R&D*	(% of firms)	**95.0**	**90.1**	92.1	p=.085
License in*	(% of firms)	**72.2**	**59.7**	65.0	p=.021
License out*	(% of firms)	**62.4**	**42.3**	50.9	p<.000
R&D Intensity	(% per firm)	45.1	41.7	43.2	
B: Constraints					
Lack of capital	(% of firms)	55.6	58.9	57.5	
Lack of suitable managerial staff	(% of firms)	17.7	19.1	18.5	
Lack of suitably-qualified research and technical staff	(% of firms)	19.8	17.2	18.3	
Lack of suitably-experienced research and technical staff*	(% of firms)	**26.5**	**18.2**	21.8	p=.088
Lack of research data and/or information	(% of firms)	13.7	11.9	12.7	
Difficulty in accessing appropriate technology	(% of firms)	15.4	16.7	16.1	
Lack of information about markets	(% of firms)	16.0	21.7	19.3	
Problems caused by market or research regulation*	(% of firms)	**14.1**	**22.9**	19.1	p=.049
Lack of development partners*	(% of firms)	**32.6**	**20.0**	25.4	p=.015

[8] Here we only report the significance levels of those variables which are significantly different between the US and Europe in the T-test results.

Additionally, it seems that there is a great difference in their attitudes towards the role of other capabilities, i.e. awareness of leading edge research, effective partnership as the most important internal capabilities in contributing to the success in developing new product ideas. As Table 5.2 shows, the US firms consider awareness of leading edge research as the most important internal capability, whereas the European firms tend to believe that effective partnership is most important internal capability.

5.5 Alliances

Overall, the US respondent firms show greater interest in engagement with exploratory and exploitation alliance activities than the European firms. Similar results were also found in prior research which suggested a continued growth of intensive alliance activities in the US biopharmaceutical sectors (Recombinant Capital, 2005). As shown in Tables 5.4, 5.5 and 5.5.1, the average US respondent biopharmaceutical firm has 3.0 exploratory alliances and 2.2 exploitation alliances, making 5.2 alliances in total. In Europe, however, the average biopharmaceutical firm has only 4.6 alliances in total, these being 2.6 exploratory alliances and 2.0 exploitation alliances. In particular, it is worth mentioning that the total number of alliances in the UK is greater than any of the other countries included in the survey target group. A typical UK respondent biopharmaceutical company averages 5.1 alliances in total with 2.3 exploratory alliances and 2.8 exploitation alliances.

Table 5. 4: Exploratory Alliances

Variable		US n=144	EU n=205	Total n=349	Sig.[9]
No. of exploratory alliances	(per firm)	3.036	2.579	2.778	
A: Type of Partner					
Small start-ups	(per firm)	0.736	2.082	1.461	
Large pharma	(per firm)	0.878	0.792	0.831	
Univ. or other academia	(per firm)	1.578	1.788	1.692	
Government research organisations	(per firm)	0.411	0.466	0.441	
Private research institutes	(per firm)	0.222	0.159	0.188	
Commercial laboratories/R&D enterprises	(per firm)	0.582	0.364	0.464	
B: Alliance Motivations					
To access partners' intellectual capital	(% of firms)	56.0	56.2	56.1	
To expand the range of products offered to customers	(% of firms)	44.1	50.1	47.2	
To Increase the speed of new product dev.	(% of firms)	63.7	77.4	71.1	
To access infrastructure	(% of firms)	50.5	49.1	49.7	
To achieve operational flexibility	(% of firms)	44.3	39.6	41.7	
To access finance, e.g. project-funding*	(% of firms)	**56.0**	**41.8**	48.3	p=.046
To access larger projects	(% of firms)	26.7	37.2	32.4	
To spread R&D risks/costs of new equipment	(% of firms)	46.7	35.9	40.8	
To respond to customers	(% of firms)	31.5	36.3	34.1	
To improve financial and market credibility*	(% of firms)	**66.7**	**36.0**	50.2	p=.045
C: Alliance Performance					
Made little progress towards objectives *	(% of firms)	**4.3**	**0.0**	2.0	p<.000
Partially-achieved objectives	(% of firms)	38.3	46.5	42.7	
Achieved progress	(% of firms)	53.2	50.4	51.7	
Surpassed progress	(% of firms)	5.3	5.6	5.4	

[9] Here we only report the significance levels of those variables which are significantly different between the US and Europe in the T-test results.

Table 5. 5: Exploitation Alliances

Variable		US n=144	EU n=205	Total n=349	Sig.[10]
No.of exploitation alliances	(per firm)	2.178	2.034	2.096	
A: Type of Partner					
Partner with small start-ups	(per firm)	0.683	1.591	1.123	
Partner with large pharma	(per firm)	0.683	0.763	0.721	
Partner with manu. outside the industry	(per firm)	0.333	0.336	0.335	
Partner with government research organisations	(per firm)	1.000	0.613	0.815	
Partner with regulatory/patents/intellectual property consultancies	(per firm)	0.603	0.798	0.696	
Partner with marketing/distribution companies	(per firm)	1.429	0.789	1.120	
Partner with PR companies*	(per firm)	**0.444**	**0.212**	0.332	p=.019
B: Alliance Motivations					
To access complementary knowledge	(% of firms)	76.2	67.2	71.9	
To increase the speed of new product dev	(% of firms)	69.8	71.8	70.8	
To achieve Operational flexibility*	(% of firms)	**66.1**	**48.3**	57.6	p=.050
To access finance	(% of firms)	50.8	46.2	48.6	
To access larger projects	(% of firms)	28.6	24.9	26.9	
To access new markets	(% of firms)	32.3	21.7	27.2	
To access overseas markets*	(% of firms)	**41.9**	**65.1**	53.2	p=.010
To improve financial and market credibility	(% of firms)	64.5	48.3	56.7	
To respond to customers	(% of firms)	32.3	42.8	37.3	
C: Alliance Practice					
Communicate monthly	(% of firms)	62.5	49.6	55.7	
Communicate quarterly	(% of firms)	50.0	52.9	51.5	
Include partners in the management team	(% of firms)	22.2	14.1	18.0	
Staff working with partners as a joint development team*	(% of firms)	**73.6**	**43.1**	57.6	p=.000
D: Alliance Performance					
Made little progress towards objectives	(% of firms)	2.9	3.4	3.2	
Partially achieved objectives	(% of firms)	44.1	37.4	40.6	
Achieved progress	(% of firms)	54.4	54.9	54.6	
Surpassed progress	(% of firms)	2.9	6.0	4.6	
E: Alliance Overlap					
Alliance overlap*	(% of firms)	**56.9**	**31.6**	44.2	p=.002
Small start-ups	(% of firms)	43.6	52.4	47.2	
Large pharma	(% of firms)	51.3	52.7	51.9	
Universities or other academic institutes	(% of firms)	61.5	50.0	57.2	
Government research organisations	(% of firms)	30.8	19.4	26.5	
Private research institutes*	(% of firms)	**12.8**	**0.0**	8.0	p=.023
Commercial laboratories/R&D enterprises	(% of firms)	38.5	22.3	32.3	
Manufacturers	(% of firms)	35.9	39.0	37.1	
CROs*	(% of firms)	**51.3**	**27.9**	42.4	p=.065

Table 5.5. 1: Alliances

Variable		US n=144	EU n=205	Total n=349
Total No. of alliances	(per firm)	5.244	4.603	4.883

[10] Here we only report the significance levels of those variables which are significantly different between the US and Europe in the T-test results.

It is also observed that for typical US respondent biopharmaceutical firms, the most common type of exploratory alliance is formed with universities or academic institutes. In contrast, for the European firms, in particular the UK biopharmaceutical firms, it seems like this kind of exploratory alliance is most commonly formed with small start-up companies. However, in France and Germany, the most common type of alliance partner for the average biopharmaceutical firms is a university or other academic institute, which is the same as in the US. The results confirm an earlier finding of strong university-industry relations in biopharmaceuticals in the US (Owen-Smith et al, 2002), reflecting a closer integration of basic science and clinical development of the US biopharmaceutical industry. On the other hand, a lower level of connectivity between public research organisations and the industry is identified in Europe, which is considered as one of the main reasons for Europe's under exploitation of its existing science base in biotechnology (de Looze et al, 2001; Lemarie et al, 2000; Sharp, 1995; Orsenigo, 1989; Owen-Smith et al, 2002). For the major partners of exploitation alliances, the results show that the US firms seem to be more inclined to collaborate with marketing/distribution companies, while in Europe, major partners in the commercialisation stage are mostly other small companies within the industry. In addition, our t-test result shows that there is significant difference in their preferences of partnering with PR companies ($t=-2.380$, $p=.019$). Table 5.5 shows that the US biopharmaceutical firms have more alliances with PR companies in the commercialisation stage in comparison to the European firms.

With reference to alliance performance, 51.7 percent of our respondent companies think that their alliances in the early stage achieved the objectives. However, 57.1 percent of the German firms think that their alliances in the early stage only partially achieved their objectives. For the alliances in the commercialisation stage, 54.6 percent of the respondent companies, and especially 73.0 percent of the UK companies believe that their alliances formed at this stage achieved their objectives. This is in contrast with 50 percent of the German firms that think their alliances in the commercialisation stage only partially achieved their objectives.

Moreover, 73.6 percent of the US firms reported having staff working with their partners as a joint development team, while only 43.1 percent of the European respondent firms had experiences of using joint development teams. It seems that the European firms are more

inclined to have a formal communication with their partners regularly rather than any other alliance practice.

5.5.1 Alliance Motivation

According to our results in Tables 5.4.and 5.5, we found that the US firms consider access to finance and improving financial and market credibility as the motivation to co-operate in basic research, drug discovery and development, more than the European firms do. They are also more concerned about achieving operational flexibility and this form the motivation to co-operate in commercialisation activities. On the other hand, the European firms, in particular 72.7 percent of French biopharmaceutical firms, are more interested in accessing overseas markets when co-operating with their partners in the commercialisation of new products (see Tables 5.4. and 5.5.).

It is worth noting that the majority (more than 64.5 percent) of the US firms are aiming to improve their access to complementary knowledge, increase their speed of new product development, achieve operational flexibility and improve financial and market credibility when co-operating with their partners in the commercialisation activities. However, for the majority (more than 65.1 percent) of the European firms, co-operation in commercialisation activities is mainly motivated by the ability to access complementary knowledge, increase the speed of new product development, and gain access to overseas markets. Specifically, it seems that the US firms are more interested in achieving operational flexibility in participation in exploitation alliances, while the European firms are more inclined to favour the ability to access overseas markets.

In contrast, increasing new product development speed is considered by the majority of the US (63.7 percent) and EU firms (77.4 percent) as one of their main reasons for co-operating in basic research, drug discovery and development. Meanwhile, our results also highlight some differences between these US and European biopharmaceutical firms in their motivations for exploratory alliances. In particular, we found that the US firms are more likely to use exploratory alliances as a means to access external finance, and/or to improve financial and market credibility, than their European counterparts.

5.5.2 Alliance Overlap

In respect of our questions estimating the chance of alliance overlap, 56.9 percent of the US firms reported that they had alliance overlap, which means, they co-operated with the same partners in the different stages, or say in both exploratory and exploitation alliances, whereas this situation was only reported by 31.6 percent of the European respondent firms. Moreover, 51.3 percent of our US respondent firms co-operated with CROs in both types of alliances, whereas only 27.9 percent of the European respondent firms had this kind of partnership. In addition, we found that these European firms have no interest in partnering with private research institutes in either type of alliances at the same time (see Table 5.5).

5.5.3 Distribution of Alliance Types

From the observations, we found that more than half (around 58 percent) of our respondent firms do not have any exploitation alliance, including 63 percent of the European firms and 51.4 percent of the US firms. This is completely opposite to our previous findings on exploration alliances, which suggests that the majority (more than 65 percents) of our respondent firms have at least one exploration alliance. In particular, these results show that around 68.9 percent of the US firms have at least one exploration alliance, and even in the European case, only less than 39.3 percent of the firms do not have any exploration alliance. In comparison to exploration alliance activities, 40.5 percent of our respondents registered having exploitation alliances, the proportions being 35.1 percent in the European category, and 47.4 percent in the US category.

We also found that 34.0 percent of the respondent firms have both types of alliances at the same time, with a distribution of 28.2 percent in Europe, and 41.5 percent in the US. However, 36.6 percent of the companies responding to the survey, only have one type of alliance in their alliance portfolios, the proportions being 39.1 percent of the European firms and 33.3 percent of the US firms. Furthermore, 30.1 percent of these companies only have exploration alliances, accounting for 32.2 percent of the European category, and 27.4 percent of the US category. By contrast, only 6.5 percent of these firms reported having

exploitation alliances, comprising 6.9 percent of the European population and 5.9 percent of the US population (see Table 5.6. and Figure 5.2.).

These results suggest that European firms are more inclined to capitalise on only exploration alliances, while the US firms are expert in employing both types of alliances at the same time. In general there is a tendency toward exploration alliances in the US and the European biopharmaceutical industry. This finding is completely opposite to the earlier finding of Rothaermel (2001), who discovered that incumbent pharmaceutical firms prefer exploitation alliances over exploration alliances (Rothaermel, 2001). Alternatively, our results provide strong empirical support for the notion that this trend might reverse over time as incumbents shift their attention towards exploration alliances or in-house development (Zucker and Darby, 1997).

Table 5. 6: Combination of Alliance Types (%)

(%)	No alliance	Both types	Only 1 type				
			Exploration	Exploitation	Either type	Exploration	Exploitation
General	29.4	34	30.1	6.5	36.6	64.1	40.5
EU	32.8	28.2	32.2	6.9	39.1	60.3	35.1
US	25.2	41.5	27.4	5.9	33.3	68.9	47.4

Table 5. 7: Combination of Alliance Types (Numbers)

Numbers	No alliance	Both types	Only 1 type				
			Exploration	Exploitation	Either type	Exploration	Exploitation
General	57	49	12	68	56	105	61
EU	34	56	8	45	37	93	64
US	91	105	20	113	93	198	125

Figure 5. 2: Combination of Alliance Type (%)

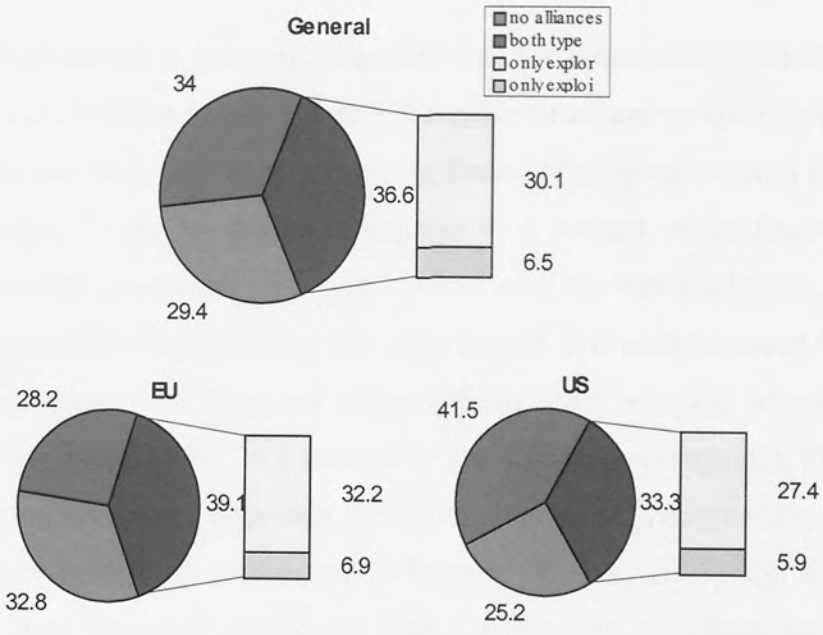
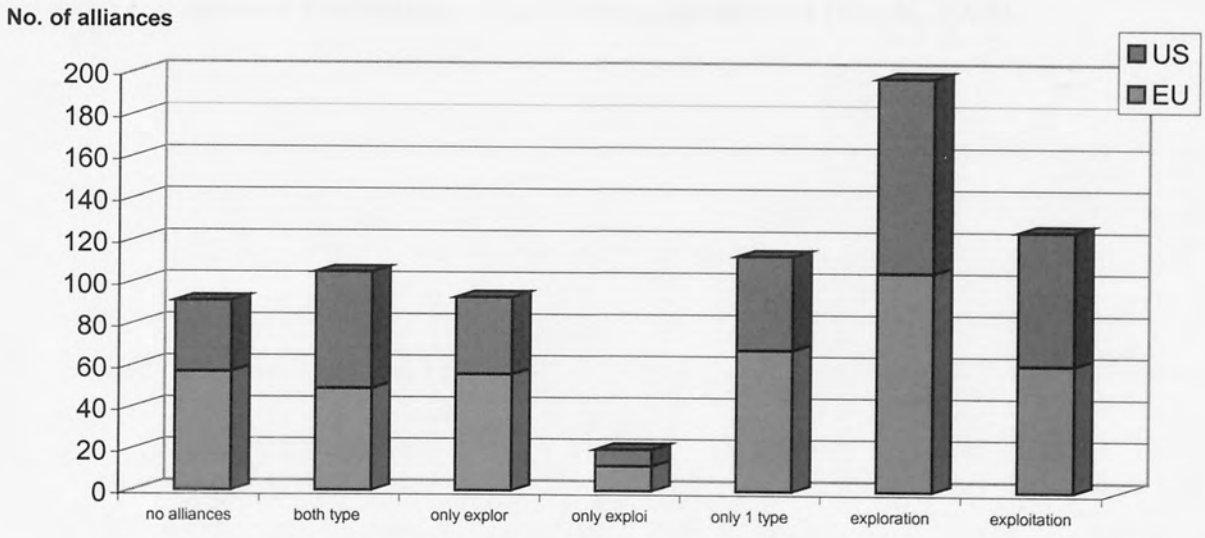


Figure 5. 3: Exploration Vs. Exploitation Alliances



5.6 Government and Other Financial Support

Although lack of capital is generally considered as the major constraint on R&D activities in both cases (see Table 5.3), the US and European firms are completely different in their venture capital sourcing, and in particular the financial support received from government and other sources. Table 5.1 demonstrates that 65.8 percent of the European respondent firms have obtained government financial support over the last three years, while the figure is only 46.7 percent in the US during the same period. It is also observed that 53.3 percent of the US companies had financial support from other sources, whereas this kind of support was only received by 30.0 percent of the European companies. On the one hand, this reflects a market-driven approach in the developing biopharmaceutical industry in the US and a policy-orchestrated approach in Europe (Wolter, 2003). On the other hand, it suggests that these European companies find it difficult to raise large amounts of private funding (Wolter, 2003), a problem which is well-documented in previous empirical studies (Fazeli, 2004; 2005; Bains, 2006; Cooke, 2001; Critical I Report, 2006). In fact for many years, Europe had very poor availability of venture capital compared with the US, which had the largest equity capital market in the world, with a dedicated band of biotech venture capitalists who had a higher-risk appetite and liberal attitude to fundraising and thus supported and nurtured biopharmaceutical companies early on (Fazeli, 2004).

5.7 Absorptive Capacity

Table 5. 8: Measures of Absorptive Capacity

Variable		US n=144	EU n=205	Total n=349	Sig.[11]
1. Potential absorptive capacity					
1.1 Acquisition dimension					
R&D Intensity	(% per firm)	45.1	41.7	43.2	
1.2 Assimilation dimension					
Employee skills	(% per firm)	87.0	66.8	75.0	
Continuously	(% of firms)	88.1	85.9	86.8	
2. Realised absorptive capacity					
2.1 Transformation dimension					
Market monitoring capability	(% of firms)	68.6	62.4	65.0	
Knowledge management capability	(% of firms)	63.3	63.3	63.3	
Knowledge monitoring capability	(% of firms)	87.9	86.8	87.2	
Internal communication capability	(% of firms)	78.4	73.1	75.4	
2.2 Exploitation dimension					
No. of patents currently*	(per firm)	**53.10**	**20.21**	33.79	p=.003

As Table 5.8 illustrates, within all of our measures of absorptive capacity, apart from number of patents as we mentioned before, there are no variables which are significantly different between the US and the European firms. The average number of patents held by the European respondent firms is relatively smaller in comparison to their US counterparts, less than half of the number of patents held by the US respondent firms. This supports the prior findings that Europe is far behind in patenting activities when compared with the US (Taplin, 2007; Thumm, 2001), and provides empirical evidence for the argument that European firms are under-exploiting their existing science base (e.g. de Looze et al, 2001; Lemarie et al, 2000; Sharp, 1995; Orsenigo, 1989). As for the indicators of transformation dimension, the majority (more than 60 percent) of our respondent firms have well-developed market monitoring knowledge management, knowledge monitoring and international communication capabilities. And the proportion of firms with well-developed knowledge transformation capabilities in the US and Europe is very similar. In terms of our three measures of PACAP we see relatively similar mean values across our samples of the US and European firms. Average R&D density in each case (i.e. the proportion of the workforce engaged in R&D) was around 42-43 per cent in each area with around 86-88 per cent of firms engaging in R&D on a continuous basis. Around 70 per cent of firms' employees had a degree or its equivalent.

[11] Here we only report the significance levels of those variables which are significantly different between the US and Europe in the t-test results.

CHAPTER 6

PACAP AND EXPLORATORY ALLIANCES

6.1 Introduction

In this chapter we explore the extent to which firms' internal capabilities to absorb external knowledge or technology influence their utilisation of exploratory alliances. The context for the study is the new product development process in the biopharmaceutical sector, vivo therapeutics, a sub-sector of the broader bio-technology sector, where the new product development (NPD) process is typically long, resource-intensive and risky. Previous studies have suggested that alliances play a central role in NPD in this sector (e.g. Deeds and Hill, 1996; Parker, 2000; Gerwin, 2004; Dowling and Helm, 2006; Gilsing and Nooteboom, 2006) as firms seek external technology, expertise of risk-sharing partners. Firms with strong internal capabilities, and therefore the ability to readily absorb new knowledge, i.e. high levels of potential absorptive capacity are, we argue, more likely to make use of wider networks of exploratory alliances.

Our evidence on the relationship between internal capabilities and external linkages in NPD relates to two broader debates in the innovation literature. First, discussion of the 'open innovation' model has suggested the importance for firms across industrial sectors of combining internal and external knowledge as part of their innovation strategy (Chesborough, 2003; 2006). Key elements of this approach the organisation of firms' NPD activities are usually argued to be boundary-spanning linkages and internal mechanisms for effective knowledge sharing such as cross-functional teams (Rosenberg, 1982; Song et al, 1997). Both are intended to allow external knowledge to be effectively accessed by firms and applied internally. Cross-functional teams may, for example, facilitate knowledge integration and information exchange (Grabher, 2001), the development of trust and mutual learning (Creed and Miles, 1996), and may be a way of overcoming hierarchical and spatial barriers to project success (Zeller, 2002). The evidence presented here sheds some light on the extent of the adoption of an open innovation approach to NPD in the US

and European biopharmaceutical sectors, and on the profile of firms adopting the open innovation approach.

Our study in this chapter also relates to the growing literature on complementarities between firms' internal characteristics and firms' boundary spanning linkages. For example, a number of studies have examined potential complementarities between firms in-house and extra-mural R&D, reflecting firms choice between conducting in-house R&D, external R&D, or both (Veugelers and Cassiman, 1997; Love and Roper, 2001, 2002; Cassiman and Veugelers, 2006). Cassiman and Veugelers (2006) also suggest that complementarities may arise between in-house and external R&D due to firms' improved scanning ability for external knowledge sources, the ability to exchange internally generated for externally sourced knowledge, enhanced absorptive capacity, or increased appropriation capacity. Similarly, Griffiths et al (2003) stress the dual role of firms' in-house R&D activity in directly generating knowledge and increasing firms' absorptive capacity[12]. Here, evidence of a positive relationship between firms' potential absorptive capacity and exploratory alliances would provide further evidence of such complementarities in NPD.

The rest of the chapter is organised as follows. Section 6.2 reviews recent literature on the nature of potential absorptive capacity and the role of exploratory alliances and considers their potential relationship. This leads to hypotheses related to aspects of PACAP linked to both R&D and human resources. Section 6.3 describes our econometric approach and Section 6.4 summarises the main empirical results. Section 6.5 discusses the main strategic and policy implications. Our results do emphasise the positive relationship between PACAP and firms' use of exploratory alliances but also suggest significant differences in the nature of this relationship in the US and European firms.

[12] Other studies have, however, suggested the potential limits of such complementarities as the degree of managerial complexity involved increases (Roper et al, 2007).

6.2 Literature and Hypotheses

While the general context for our study can be said to be the open innovation model (Chesbrough, 2003 and 2006), it also reflects more specific debates about the nature of firms' alliances and their objectives. Radner and Rothschild (1975) and Hey (1982), for example, argue that the balance between firms' investments in exploratory and exploitation alliances will reflect firms' evaluation of the relative returns. Others have argued, however, that this type of choice-based approach may be misleading due to the potential for new investment alternatives to emerge or for the probability distributions of outcomes to change or be dependent on the choices made by other firms. An alternative approach, derived from models of organisational learning, relates the choice between exploration and exploitation more directly to the strategic or learning goals of the firm (Winter, 1971; Levinthal and March, 1981), or more precisely to firms' objectives at different stages of the NPD process (Cyert and March, 1963; Day, 1967; Kahneman and Tversky 1979; March, 1988; Simon 1955). A firm's choice of the type of alliances to enter can be distinguished by its motivation to either explore for new opportunities or exploit an existing opportunity (Koza and Lewin, 1998). In biotechnology in particular, exploratory alliances are widely observed (George et al, 2001), and are seen as playing an important role in the NPD process (Deeds and Hill, 1996; Dowling and Helm, 2006; Gerwin, 2004; Gilsing and Nooteboom, 2006; Parker, 2000), a role supported by much empirical evidence (e.g. George et al, 2001; Koza and Lewin, 1998; Rothaermel, 2001; Rothaermel and Deeds, 2004). One of the most widely cited motives for collaboration is the acquisition of new technical skills or technological capabilities from partner firms (Mariti and Smiley, 1983; Hamel et al, 1989; Shan, 1990; Hamel, 1991; Powell and Brantley, 1992; Mody, 1993; Khanna, 1996). Specifically, Rothaermel and Deeds (2004) indicate that exploration alliances as a way by which firms gain access to external knowledge, and they find broad support for this contention from a sample of 325 biotechnology firms that entered 2565 alliances over a 25-year period. Exploratory alliances might therefore involve links to university or other academic institutions (George et al, 2002; Mohan and Rao, 2005; Streiffer, 2006), small start-ups (Quintana-Garcı´a and Benavides-Velasco, 2004; Maurer and Ebers, 2006;Whitehead, 2003; Calabrese et al, 2000) or the licensing or buying in of research services from CROs (Miller, 2004).

The value of such exploratory alliances to a firm will, however, depend on the firm's absorptive capacity, or following Cohen and Levinthal (1990) its ability to value, assimilate, and apply new knowledge. However, in the literature, definitions and operationalisations of the concept of absorptive capacity vary widely, with some researchers using the concept without a definition (e.g. Glass and Saggi, 1998; Keller, 1996), some invoking the term to explain organisational phenomena that span multiple levels of analysis by invoking the organisational learning (Huber, 1991; Kim, 1998), industrial economics (e.g., Cockburn and Henderson, 1998), and dynamic capabilities (Mowery et al, 1996) perspectives. Common to each approach, however, is the central idea that absorptive capacity is an organisational capability reflecting firms' receptivity to technological change (Kedia and Bhagat, 1988) and the ability of a firm to effectively use outside knowledge (Koza and Lewin, 1998)[13]. Zahra and George (2002) offer a useful refinement on the broad notion of absorptive capacity, developing the separate notions of 'potential absorptive capacity' and 'realised absorptive capacity'. This retains the idea of absorptive capacity as a firm's ability to evaluate, assimilate and exploit the value of new, external knowledge. It also incorporates Kim's (1998) notion of the transformation capability, i.e. firms' capability to develop and refine the routines that facilitate combining existing knowledge and the newly acquired and assimilated knowledge.

In summary then, potential absorptive capacity determines the rate and effectiveness through which the knowledge acquired through firms' exploratory alliances can be internalised (Koza and Lewin, 1998). Firms' R&D investments are an important element of the creation of absorptive capacity (Mowery et al, 1996; Griffiths et al, 2003). Indeed, both Cohen and Levinthal's original test and Arora and Gambardella (1994)'s subsequent examination of the issue use R&D intensity as a proxy for absorptive capacity. However, recent studies have used R&D intensity not only as a measure of internal learning, but also as a requirement for external learning as firms seek to exploit potential complementarities between internal and external knowledge (Bierly and Chakrabarti, 1996; Cohen and Levinthal, 1990; Kim, 1997; Kodama, 1995). We therefore anticipate that:

[13] A notable weakness of much of the literature on absorptive capacity is the implicit assumption that a firm has an equal capacity to learn from all other organisations regardless of their institutional or organisational form. Lane and Lubatkin (1998) overcome this to some extent by focusing attention on the learning dyad as the unit of analysis rather than the individual firm, and demonstrate that the ability of a firm to learn is greater where firms share some common characteristics.

Hypothesis 1.1: In both the US and Europe, biopharmaceutical firms' engagement with exploratory alliances will be positively associated with R&D intensity.

R&D intensity is only one dimension of firms' R&D activity and others have argued that other aspects of R&D behaviour – notably the continuity of firms' R&D activity – may also be important in determining firms' skills and knowledge in their specific fields of research and contributing positively to absorptive capacity (Schmidt, 2005). We therefore anticipate that:

Hypothesis 1.2: In both the US and Europe, biopharmaceutical firms' engagement with exploratory alliances will be positively associated with continuous R&D.

Another dimension of absorptive capacity which has received much attention in the literatures on organisational learning (e.g. Holmqvist 2003; March 1991), innovation (Ahuja and Lampert, 2001; Burgelman, 1983) and alliances (e.g. Hagedoorn, 2002; Osborn et al, 1998; Rohtaerme and Deeds, 2004) are levels of employee skills[14]. Higher skill levels enhance absorptive capacity, but may themselves be the beneficiary of inter-organisational learning (Child, 2001; Ciborra, 1991; Hamel, 1991; Ingram, 2002; Lane and Lubatkin, 1998; Larsson et al, 1998; Liebeskind,1996; Miner and Andersson, 1999). Most recently, for example, Schoenmakers and Duysters (2006) demonstrate the importance of learning alliances as a vehicle for competence development through a study of 171 high technology firms in different sectors. Therefore we anticipate that:

Hypothesis 1.3: In both the US and Europe, biopharmaceutical firms' engagement with exploratory alliances will be positively associated with employee skill levels.

[14] The presence within a firm of a high level of skilled workers or specific or unique competencies, however, may also play an 'attractor' or 'signalling' role attracting potential alliance partners (Powell et al, 1996).

6.3 Data and Methods

Table 6.1 presents the descriptive statistics of all variables included in our empirical modelling. In terms of our three measures of PACAP we see relatively similar mean values across our US and European respondent firms. Average R&D density in each case (i.e. the proportion of the workforce engaged in R&D) was around 42-43 per cent in each area with around 86-88 per cent of firms engaging in R&D on a continuous basis. Around 70 per cent of firms' employees had a degree or its equivalent.

Our main variable of interest here is firms' number of exploratory alliances (A_i) which we model using a simple linear formulation:

$$A_i = \alpha + \beta_1 RDINT_i + \beta_2 RDCONT_i + \beta_3 EMSKILLS_i + \delta_1 FC_i + \delta_2 MC_i + \delta_3 SP_i + \varepsilon_i$$

Here the β_j coefficients capture the potential for a relationship between PACAP and the number of exploratory alliances and the δ_j the impact of three groups of control variables relating to firm characteristics (FC), market characteristics (MC) and firms' strategic profile (SP). The number of exploratory alliances itself is a count variable taking on discrete non-negative integer values but including zero with our respondent firms having an average of 2.8 exploratory alliances (Table 6.1). Firms' number of exploratory alliances are strongly skewed to the right (Figure 6.1), however, and diverge widely having a coefficient of variation of nearly five times of its mean value[15] (Table 6.1). In other words, the distribution of the number of exploratory alliances displays marked signs of over-dispersion relative to the Poisson distribution. This suggests the potential value of the negative binomial model for count data rather than the standard Poisson model. In addition, as around 36 per cent of our respondent firms have no exploratory alliances there is the possibility that a zero inflated model may be relevant. To test this we perform a Vuong (1989) test to compare the zero inflated negative binominal model with the standard negative binominal model[16]. The results suggest a significant difference between the two models suggesting the appropriateness of the zero inflated negative binomial formulation.

[15] Variance of No.of exploratory alliance = 16.059

[16] In a Vuong test of the zero inflated negative binomial vs. standard negative binomial: z = 19.29 Pr>z = 0.0000.

We use three groups of control variables in the econometric analysis relating to firms' background characteristics (e.g. age, size, ownership status), the geographic market orientation of the firm and its strategic focus (Table 6.1). On average the US respondent firms are marginally older, larger and more likely to be independent firms than those European respondents. They are also more likely to be engaged in the early stages of the discovery process but less likely than the EU firms to be engaged in sales or marketing activities (Table 6.1). Moreover, we further weight our response rates between US and those within Europe in order to adjust for the non-response bias and some of the estimates and standard errors[17].

6.4 Empirical Results

Zero inflated negative binomial estimates of equation (1) are given in Table 6.2 for all of our US and European respondent firms. In the model we differentiate between those values of each independent variable relating to the US and Europe to allow coefficients to be compared. Table 6.3 reports Wald tests for the equality of the EU and US coefficients. In terms of the parameters of interest, we find a positive but insignificant relationship between R&D intensity and the number of exploratory alliances in which firms are engaged, a result which is consistent in both the US and Europe. The suggestion is that firms' acquisition capability does not contribute to its engagement with exploratory alliances in either the US or Europe. More significant effects are identified for the other aspects of PACAP – firms' engagement in continuous R&D and employee skills – providing some support for Hypotheses 1.2 and 1.3 which both reflect firms' assimilation capability. In both cases, however, we find a significant difference between the size and significance of each effect in the US and Europe (Table 6.3). In particular continuous R&D proves an important determinant of firms' engagement in exploratory alliances in the EU but not in the US; while skill levels are only significant in the US. The suggestion is that in the US firms' engagement in exploratory alliances is not conditional on either internal R&D intensity or continuity, i.e. on any aspect of internal knowledge creation. Instead, participation depends more strongly on skill-based absorptive capacity. In Europe, on the

[17] The absolute weights among different countries have been calculated as US 6.938, UKI3.636, France 7.057, and Germany 7.169.

other hand, participation in exploratory alliances depends more strongly on continuous R&D, suggesting that both firms internal knowledge creation capability and absorptive capacity are more important determinants of engagement in exploratory alliances.

These results are confirmed by separate ZINB models estimated for the US and European subgroups (Table 6.4). In both cases R&D intensity – representing the acquisition dimension of ACAP – proves insignificant again suggesting little support for Hypothesis 1.1. In terms of the assimilation dimension of PACAP, however, continuous R&D proves important in Europe only while employee skills prove important in the US. Marginal values in the models in Table 6.4 suggest that a one percent increase in employee skills in the US will increase firms' number of exploratory alliances by 0.16, while a move from undertaking discontinuous to continuous R&D in Europe increases firms number of alliances by 1.7.

In addition to the main variables of interest, we also find some interesting results from the set of control variables included in our model (see Table 6.2 and 6.4). First, we find both in the US and Europe an inverted U-shape relationship between firm size (employment) and the number of exploratory alliances. Holding all the other variables constant at their mean values, we illustrate this effect in Figure 6.2 which suggests that the number of exploratory alliances peaks around 220 employees in both the US and Europe. Second, although weak in statistical terms we find a marked difference between Europe and the US in the relationship between firm age and the number of exploratory alliances (Table 6.4). In the US older plants have more alliances while in Europe we find the opposite effect (Figure 6.3) (Rothaermel and Deeds, 2004). Third, in Europe we find no ownership effect on alliance behaviour but in the US independent companies tend to have 4.2 fewer exploratory alliances than those firms which are part of multi-plant or multi-site groups (Table 6.4). Finally, in terms of firms' market and strategic focus the key determinant of firms' engagement with exploratory alliances, perhaps unsurprisingly, proves to be a strategic focus on the initial stages of the discovery process, i.e. R&D and pre-clinical development (Table 6.4).

6.5 Empirical Conclusions

Our aim in this charpter is to investigate the relationship between a firm's potential absorptive capacity and its number of exploratory alliances. Our results suggest that employee skills, and continuous R&D activities are significantly and positively associated with firms' number of exploratory alliances, suggesting that firms' assimilation capability (employee skills, and continuous R&D activities) plays a crucial role in determining their engagement in exploratory alliances. This reflects the results of previous studies which have suggested the importance of firm's internal R&D in determining their ability to import, comprehend, and assimilate external knowledge (Kim 1997; Kodama 1995) as well as the need for well-educated technicians, engineers and technological specialists to enable firms to access knowledge from outside their boundaries (Rothwell and Dodgson, 1991), or attract potential alliance partners (Porac et al, 2004).

Our results also suggest that ongoing R&D activities are extremely important for biopharmaceutical firms (Coombs and Deeds, 2000), activities which have previously been related both to innovative activity (Acs and Audretsch, 1989; Scherer, 1980) and productivity (Comanor, 1965). Firms engaging in continuous R&D activities may have stronger innovative capabilities and more products in development than those involved in R&D occasionally or infrequently. This may provide substantive incentives for firms to engage in exploratory alliances with firms which have an established pipeline of R&D outputs (i.e., patents, products in development) from their R&D activities (Coombs and Deeds, 2000). In addition, exploratory alliances, as we have defined them previously, are formed with the explicit purpose of learning (Koza and Lewin, 1998). Both alliance partners must see some potential for learning from each other (Sen and Egelhoff, 2000). Hence, firms which engage in R&D only occasionally or infrequently, with relatively weak innovative capabilities, may find fewer firms willing to enter alliances with them (Sen and Egelhoff, 2000).

The other aspect of this chapter which is of interest is the differences it highlights in the determinants of exploratory alliance behaviour in the US and Europe, with previous US and European comparative studies in biotechnology focusing instead on industry-university relations (Owen-Smith et al, 2002), the role of government (Giesecke, 2000),

and sources of comparative advantage (Lavoie and Sheldon, 2000). In particular, we find that while US firms' engagement with exploratory alliances depends on skills, that in Europe is more strongly linked to on-going R&D (Becker and Peters, 2000)[18]. One possibility is that this profile reflects greater investment and support for bio-technology companies in the US than in Europe and European firms under-exploitation of the existing science base (e.g. de Looze et al, 2001; Lemarie et al, 2000; Sharp, 1995; Orsenigo, 1989). In this scenario, public investments in biotechnology R&D in the US may be substituting for firms' own investments, with exploratory alliances then more dependent on skills-related aspects of ACAP rather than in-house R&D. In Europe, lower levels of public support (e.g. Bains, 2006) and investment in publicly funded R&D (Fazeli, 2004; Wolter, 2003; Cooke, 2001) may be increasing the relative importance of firms' own R&D investments.

Additionally, our results show that some of our control variables, firm characteristics (i.e. firm size, ownership status), market characteristics (i.e. foreign market segment), and strategic focus, in particular on basic R&D, pre-clinical development and regulatory support have significant effects on the number of exploratory alliances. Specifically, we find an inverted U-shape relationship between firm size and number of exploratory alliances in both our US and EU subgroups (Table 6.4). This result differs markedly from previous findings of a monotonic positive relationship between firm size and alliance participation (i.e. Rothaermel, 2001; Rothaermel and Deeds, 2004; Gomes-Cassere et al, 2006) but reflects wider results from the innovation literature of an inverted U shape relationship between firm size and innovation activity. One possible explanation for the inverted 'U' shape relationship suggested by Schmidt (2005) is that as a firm grows and approaches the technological frontier it may have less incentive to seek external knowledge.

Our results provide broadly-based support for the argument that the assimilation dimension of potential absorptive capacity (proxied by employee skills, and continuous R&D activities) plays a important role in determining firms' exploratory alliance activities. Our results also show that the acquisition capability (proxied by R&D intensity) has no influence on firms' number of exploratory alliances in both the US and Europe. In other

[18] Our results also emphasise the importance of skills to the US industry, a factor which has been highlighted as one of the barriers to growth in the sector (Bagchi-Sen et al, 2004; Zucker et al, 1998).

words, R&D investment itself is not enough to make exploratory alliances work. Rather, firms need a certain level of employee skills to internalise the external knowledge that has been acquired, or at least to facilitate the external learning process. In strategic terms, this suggests the need for continuity in R&D within a firm and also relevant investments in skills to facilitate external knowledge gathering.

One potential issue with these conclusions is that our analysis is based only on biopharmaceutical firms – albeit both in Europe and the US – an industry which is often regarded as having distinct characteristics and being heavily regulated. However, recent studies have shown that research results from the biotechnology industry are generalizable to other high technology industries such as telecommunication and semiconductors industry at least (Almeida, 1996). Before being confident about any generalization, however, other studies could usefully be undertaken in an attempt to generalize our results to other high technology industries, e.g. data processing and telecommunications.

Finally, our results suggest some differences and some commonalities between the US and European bio-pharmaceutical industries. The most interesting difference is clearly that it is the skills aspect of the assimilation dimension of PACAP which seems to matter in the US while it is the R&D aspect which matters most in Europe. Further investigation to both confirm this result and explore its behavioural foundations and implications is clearly needed. In particular, it may be worth undertaking more in-depth company case-studies of the process of alliance formulation and development to highlight potential links to skill development and R&D. In addition, the relationship between R&D intensity and number of exploratory alliances may worth to be further examined, using data from different countries and industries.

Table 6. 1: Variable Descriptives

Variables		All Firms (n=349)		EU (n=205)		US (n=144)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
No. of exploratory alliances	(per firm)	2.78	4.01	2.58	3.87	3.04	4.18
PACAP Measures							
R&D intensity	(% per firm)	43.20	0.34	41.70	0.34	45.10	0.34
Employee skills	(% per firm)	68.80	0.28	66.90	0.29	71.40	0.26
Continuous R&D	(% of firms)	86.90	0.34	86.00	0.35	88.10	0.33
Firm Characteristics							
Firm age	(year)	13.60	12.41	12.10	11.53	15.90	13.30
No. of employees	(per firm)	47.00	84.04	35.00	68.01	65.00	101.25
Independent company	(% of firms)	83.50	0.37	80.30	0.40	88.10	0.33
Market Characteristics							
Regional market	(% of firms)	76.10	0.43	74.50	0.44	78.30	0.41
Foreign market	(% of firms)	47.30	0.50	47.10	0.50	47.60	0.50
External market	(% of firms)	32.10	0.47	26.80	0.44	39.60	0.49
Strategic Focus							
Basic R&D and preclinical dev.	(% of firms)	67.30	0.47	60.00	0.49	77.80	0.42
Clinical trials (Phase I, II, III)	(% of firms)	38.10	0.49	26.30	0.44	54.90	0.50
Manufactory	(% of firms)	51.60	0.50	46.80	0.50	58.30	0.50
Regulatory support	(% of firms)	38.00	0.49	21.40	0.41	61.10	0.49
Marketing & sales	(% of firms)	47.50	0.50	52.20	0.50	41.00	0.49

Source: Author's Survey

Figure 6. 1: The Distribution of No. of Exploratory Allianc(s)

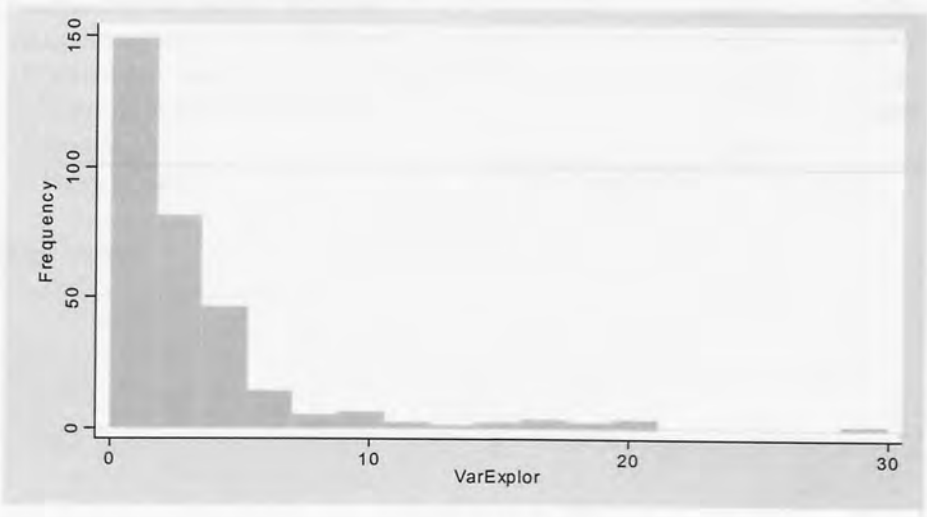


Table 6. 2: The Influence of Potential Absorptive Capacity on Exploratory Alliances: Zero-inflated Negative Binominal Regression (Zinb)

Independent variables	Coef.	dy/dx
PACAP Indicators		
R&D Intensity for EU firms	0.318	1.203
R&D Intensity for US firms	0.616	2.328
Employee skills for EU firms	-0.427	*-1.613*
Employee skills for US firms	0.041**	*0.154*
Continuous R&D for EU firms	0.526*	*2.041*
Continuous R&D for US firms	-0.039	*-0.148*
Firm Characteristics		
Firm age for EU firms	-0.008	*-0.029*
Firm age for US firms	0.019	*0.070*
No. of employees for EU firms	0.014**	0.051
No. of employees for US firms	0.005	0.018
No. of employees Square for EU firms	0.000*	0.000
No. of employees Square for US firms	0.000~	0.000
Independent company for EU firms	0.267	*1.017*
Independent company for US firms	-0.776*	*-2.767*
Market Characteristics		
Regional market for EU firms	0.049	0.186
Regional market for US firms	0.318	1.267
Foreign market for EU firms	-0.372	*-1.284*
Foreign market for US firms	0.558~	*2.521*
External market for EU firms	0.182	0.735
External market for US firms	0.024	0.092
Strategic Focus		
Basic R&D and preclinical dev. for EU firms	0.290~	1.145
Basic R&D and preclinical dev. for US firms	0.475**	1.941
Clinical trials (Phase I, II, III) for EU firms	0.134	0.530
Clinical trials (Phase I, II, III) for US firms	0.020	0.075
Manufactory for EU firms	-0.354	-1.241
Manufactory for US firms	-0.052	-0.193
Regulatory support for EU firms	-0.626**	-1.881
Regulatory support for US firms	-0.215	-0.776
Marketing & sales for EU firms	0.325	1.322
Marketing & sales for US firms	0.204	0.825
Constant	0.590~	
Number of obs = 237	Wald chi2(18) = 93.43***	

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 6. 3: Wald Tests for the Equality of Coefficients: US Versus Europe

	DF	χ^2
Hypothesis 1: R&D Intensity	2	3.13
Hypothesis 2: Employee skills	2	9.07*
Hypothesis 3: Continuous R&D	2	5.41~
Firm Characteristics		
Age	2	3.97
Firm size (No. of employees)	2	10.49**
Employee square	2	10.12**
Ownership status (independent company)	2	8.10
Market Characteristics		
Regional market	2	1.30
Foreign market	2	5.52~
External market	2	0.73
Strategic Focus		
Basic research and pre-clinical development	2	9.42**
Clinical trials	2	0.72
Manufacture	2	3.18
Regulatory support	2	10.12**
Marketing & sales	2	2.89

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

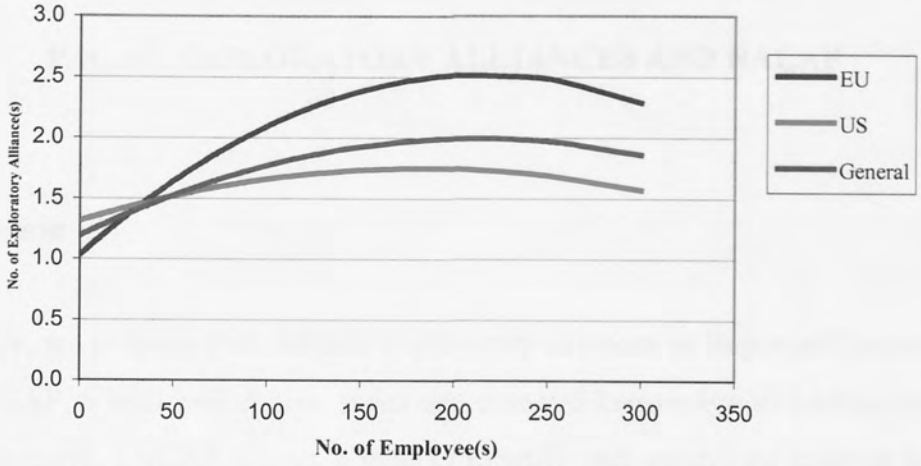
Table 6. 4: The Influence of Potential Absorptive Capacity on Exploratory Alliance: US and Europe Models

	US		EU	
Robust	**Coef.**	**dy/dx**	**Coef.**	**dy/dx**
Potential Absorptive Capacity				
R&D Intensity	0.619	2.43239	0.324	1.185
Employee skills	0.041**	0.16163	-0.414	-1.514
Continuous R&D	-0.056	-0.22634	0.536*	1.656
Firm Characteristics				
Firm age	0.018	0.07231	-0.008	-0.028
No. of employees	0.005	0.01881	0.014**	0.051
No. of employees square	0.000~	-0.00005	0.000**	0.000
Independent company	-0.778*	-4.28638	0.290	0.961
Market Characteristics				
Regional market	0.310	1.11927	0.058	0.210
Foreign market	0.553~	2.24581	-0.374	-1.340
External market	0.029	0.11251	0.181	0.694
Strategic Focus				
Basic R&D and preclinical dev.	0.470*	1.60765	0.296~	1.045
Clinical trials (Phase I, II, III)	0.019	0.07612	0.130	0.492
Manufactory	-0.052	-0.20563	-0.359~	-1.314
Regulatory support	-0.221	-0.89444	-0.641**	-1.955
Marketing&sales	0.203	0.81481	0.333	1.220
Constant	0.629		0.531	
	Number of obs = 102		Number of obs = 135	
	Wald chi2(15) =118.41***		Wald chi2(15) = 30.26*	

Source: Author's Survey

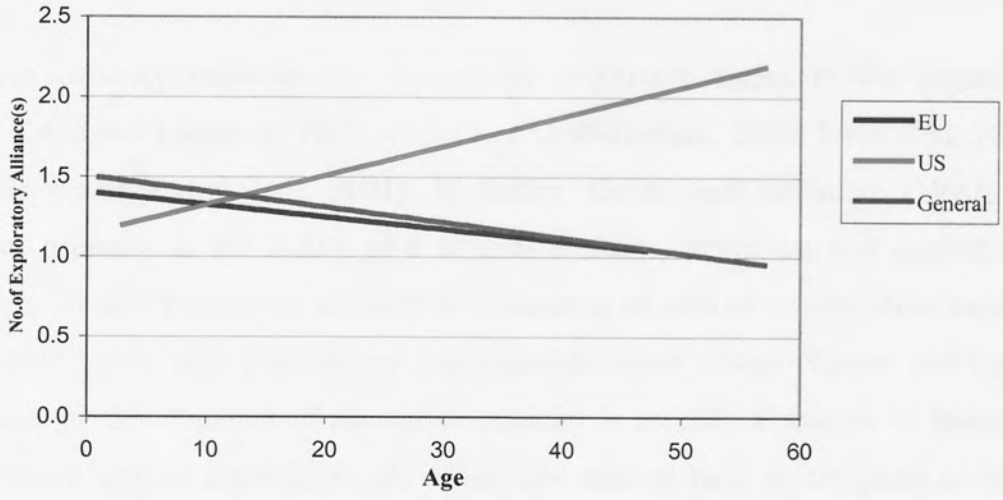
~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Figure 6. 2: Predicted Number of Exploratory Alliances: By Firm Size



Notes: Computed from the marginal coefficients in Tables 5.2 and 5.4. Variables at mean values.

Figure 6. 3: Predicted Number of Exploratory Alliances: By Firm Age



Notes: Computed from the marginal coefficients in Tables 5.2 and 5.4. Variables at mean values.

CHAPTER 7

PACAP, EXPLORATORY ALLIANCES AND RACAP

7.1 Introduction

In this chapter, we propose PACAP and exploratory alliances as important determinants of a firm's RACAP, which reflect how firms use external knowledge to address the internal innovation demand. PACAP allows a firm to identify and assimilate external knowledge that is necessary for its innovation process. Exploratory alliances on the other hand, facilitate the generation of new insights that provide a fit between new external knowledge and existing practice. We empirically test our hypotheses using data from a large-scale survey of 2,173 biopharmaceutical firms across the US and Europe in 2006. The survey provides detailed information concerning these firms' R&D, new product development and alliance activities.

Absorptive capacity becomes an increasingly important theme in the organisational learning (Lane and Lubatkin, 1998; Gupta and Govindarajan, 2000; Lane et al, 2001) and innovation research (i.e. Tsai, 2001). In theory, Cohen and Levinthal (1990) defined absorptive capacity as the ability of a to firm evaluate, assimilate and exploit external knowledge. In fact absorptive capacity is composed of sets of combinative capabilities, characterised by its path dependence and cumulativeness nature (Cohen and Levinthal, 1990). And the development of absorptive capacity is actually a process of interaction of these different sets of capabilities. However, few studies have investigated in depth the problem of how these combinative capabilities affect each other. Zahra and George (2002) shift the level of analysis of absorptive capacity from a single organisational capability to a range of multidimensional capabilities. They identified two sub-sets of absorptive capacity: potential and realised. Potential absorptive capacity captures a firm's receptiveness to external knowledge; realised absorptive capacity, in contrast, reflects the firm's capacity to leverage the knowledge that has been absorbed. These dynamic capabilities affect the efficiency and quality of firms' external knowledge sourcing behaviour.

On the other hand, strategic alliances as an important strategy tool for external knowledge sourcing have been cited intensively in the organisational learning literature (i.e. Holmqvist, 2003; March, 1991). A number of studies have revealed the importance of the use of external linkages in facilitating the flow of knowledge and technology-based capabilities (i.e. Kogut, 1988; Hamel et al, 1989; Hamel, 1991). Koza and Levin (1998) move this a step forward by considering strategic alliances in a framework of exploration-exploitation in organisational learning (March, 1991). In this view, a firm's choice to enter an alliance can be distinguished in terms of its motivation to explore for new opportunities (exploratory alliance) or to exploit existing capabilities (exploitation alliance).

Our study in this chapter sheds new light on the development of absorptive capacity and alliance literatures. Firstly, we empirically operationalised the Zahra and George constructs of PACAP and RACAP, and advanced previous understanding of the evolution of ACAP by looking at the different dimensions of ACAP and developing relevant measures for each of these dimensions. Secondly, our findings in this chapter provide valuable empirical evidence and support for the few studies, which focus on the multi-dimensionality of ACAP and the application of the exploration-exploitation framework of organisational learning to a high technology firm's strategic alliances. Last, but not the least, we further generalised the open innovation paradigm in the context of the biopharmaceutical industry, by highlighting the important role of external linkages in contributing to a firm's internal capability development.

The remainder of this chapter is organised as follows: Section 7.2 reviews the relevant literature on absorptive capacity and strategic alliances, and develops some hypotheses based on these bodies of knowledge. This section is followed by a brief description of the data and empirical methods. The following section presents our empirical results. A concluding discussion of these results is given in Section 7.5, and the corresponding implications are addressed in Chapter 12.

7.2 Literature and Hypotheses

Realised Absorptive Capacity and Exploratory Alliances

According to Koza and Lewin (1998), exploration alliances are entered into with the motivation to discover something new; they focus on the 'R' in the research and development process. Faems et al (2006) define an explorative R&D alliance as an agreement between otherwise independent firms that pool their capabilities for the purpose of discovering new technological opportunities. The outcome of the exploration process is documented by most of the existing literature as codification of new knowledge, or in other words, the embodiment of new knowledge learned through exploration into a prototype product that can be extended into the testing and development process (e.g., Gilsing and Nooteboom, 2006; Koza and Lewin, 1998; Murray and Chao, 2005; Rothaermel and Deeds, 2004). In the biopharmaceutical industry, for example, exploration collaborations are motivated by a desire to acquire basic knowledge that can be used to create novel molecular entities which are then entered into the clinical development and regulatory process. It is argued that "the intent behind entering an exploration alliance involves a desire to discover new opportunities" (Koza and Lewin, 1998: 257). From this point of view, exploratory alliances are more likely formed to discover new insights, or recognise new opportunities, which provide a fit between new knowledge and existing practice rather than accessing external knowledge itself.

Transformation is defined by Zahra and George (2000) as a firm's capability to develop and refine the routines that facilitate combining existing knowledge and the newly-acquired and assimilated knowledge. Two factors arising from this are very important in determining a firm's transformation capability; one is the external new knowledge, and the other is the ability to combine two apparently incongruous sets of information to arrive at a new schema. The latter is also called the "bisociation" process, which occurs when a situation or idea is perceived in "two self-consistent but incompatible frames of reference" (Koestler, 1966:35). It yields new insight, facilitates the recognition of opportunities, and at the same time, alters the way a firm sees itself and its competitive advantage (Zahra and George, 2000). For most biopharmaceutical firms, exploratory alliances not only offer access to external new knowledge, but also provide opportunities for these firms to

discover new insights, or recognise new opportunities which fit existing practice. Therefore, we argue

> Hypothesis 2.1a: Biopharmaceutical firms' engagement with exploratory alliances will positively affect the transformation dimension of RACAP.

Exploitation reflects a firm's ability to harvest and incorporate acquired and transformed knowledge into its operations (Tiemessen et al, 1997; Van den Bosch et al, 1999). It requires retrieving knowledge that has already been created and internalised for use (Lyles and Schwenk, 1992). The outcome of the exploration process is documented by most of the existing literatures as codification of new knowledge, or in other words, the embodiment of new knowledge learned through exploration into a prototype product that can be extended into the testing and development process (e.g., Gilsing and Nooteboom, 2006; Koza and Lewin, 1998; Murray and Chao, 2005; Rothaermel and Deeds, 2004). According to the cycle of discovery (Nooteboom, 2000), exploitation starts when variety of content (of a concept, technology, product or practice) that emerges from exploration is reduced, in consolidation, into a dominant design, as suggested in the innovation literature. Exploratory alliances are more likely formed to discover new insights, or recognise new opportunities which provide a fit between new knowledge and existing practice. Gilsing and Nooteboom (2006) suggest that exploration provides insights concerning the potential of novel elements, and concerning the constraints imposed by existing designs on the realisation of that potential. It entails more radical architectural change (Nooteboom, 2004) in novel structures of old and new elements. In particular, this stage of exploration involves a radical reconfiguration of old systems of exploitation that are no longer consistent with emerging novelty (i.e., Callon, 2002) in order to open up to new variety of content. The new systems of exploitation are the basic principles for firms' incorporating acquired and transformed knowledge into their operations. Thus, we propose that exploitation alliances will positively affect the exploitation of acquired and transformed knowledge.

> Hypothesis 2.1b: Biopharmaceutical firms' engagement with exploratory alliances will positively affect the exploitation dimension of RACAP.

Acquisition Capability and Realised Absorptive Capacity

The previous literature which defines absorptive capacity as firms' abilities to value, assimilate and apply external new knowledge (Boynton et al, 1994; Cohen and Levinthal, 1989 and 1990; Cockburn and Henderson, 1998; Mowery et al, 1996; Szulanski, 1996), suggests that absorptive capacity is composed of a set of combinative organisational capabilities (Kogut and Zander, 1992) that enable firms to synthesise and apply current and newly-acquired external knowledge (Eisenhardt and Martin, 2000; Kogut and Zander, 1992). Zahra and George (2002) took this a step further, and divided this concept into four individual dimensions - acquisition capability, assimilation capability, transformation capability, and exploitation capability. These combinative organisational capabilities are path-dependent in their emergence and idiosyncratic in detail; however, they exhibit common features (Eisenhardt and Martin, 2000). As a firm's ultimate goal is to put acquired knowledge to good use – i.e. turn it into new and innovative products and processes – it has to ensure that all four components of absorptive capacity (and not only a single one) are built up (Schmidt, 2005). Therefore, accumulating absorptive capacity in one period will permit its more efficient accumulation in the next. By having already developed some potential absorptive capacity in the early stage, a firm may more readily accumulate what additional knowledge it needs in the subsequent periods in order to exploit any critical external knowledge that may become available. This further indicates that these four dimensions are built upon each other, co-exist at all times, and fulfil a necessary but not sufficient condition to improve firm performance (Zahra and George, 2002). A classical example for this is the fact that firms cannot possibly transform and exploit knowledge without first acquiring it. Therefore, we posit:

> Hypothesis 2.2a: The acquisition dimension of PACAP is a pre-requisite (*necessary but insufficient condition*) of the transformation dimension of RACAP.

> Hypothesis 2.2b: The acquisition dimension of PACAP is a pre-requisite (*necessary but insufficient condition*) of the exploitation dimension of RACAP.

On the other hand, despite the fact that the complementarity between potential absorptive capacity and realised absorptive capacity implies that firms can acquire and assimilate knowledge (PACAP), they might not have the capability to transform and exploit the knowledge (RACAP) for profit generation (Zahra and George, 2002). The cumulativeness feature of absorptive capacity and its effects on expectation formation (Cohen and Levinthal, 1990) determine that acquisition and assimilation of new knowledge (PACAP) will affect the extent to which this knowledge has been transformed and exploited (RACAP). Strong support has been found by Lane and Lubatkin (1998) who showed from their study of 69 bio-pharmaceutical alliances, that the efficiency of knowledge absorption between two firms depends on their degree of familiarity with one another's practices. It is also suggested by Cohen and Levinthal (1990) that better understanding of external new knowledge, facilitates firms' evaluation of the import of intermediate technological advances that provide signals as to the eventual merit of a new technological development. Thus, potential absorptive capacity (acquisition capability and assimilation capability) affects the expectation formation, and a firm can predict more accurately, the nature and commercial potential of the technological advances. In other words, the way new knowledge has been analysed, processed, interpreted, and understood will shape the way firms combine it with its existing knowledge. Consequently, this will affect the way firm incorporates newly-acquired and transformed knowledge into its operations (Tiemessen et al, 1997; Van den Bosch et al, 1999). Hence, we propose that the assimilation of newly-acquired knowledge will influence the efficiency of knowledge transformation and exploitation (that is realised absorptive capacity) in the subsequent period.

Hypothesis 2.3a: The assimilation dimension of PACAP will positively affect the transformation dimension of RACAP.

Hypothesis 2.3b: The assimilation dimension of PACAP will positively affect the exploitation dimension of RACAP.

7.3 Data and Methods

Information concerning firms' PACAP, exploratory alliances and RACAP, was gathered from our main survey. A basic description of the data relating to these three main areas or used as control variables is provided in Table 7.1. Overall, we have not found any significant difference between the US and EU in the variables that have been constructed to capture these three main concepts, apart from exploitation capabilities, (which is captured by number of patents). The average number of patents held by our European respondent firms is relatively smaller, and less than half the number of the US respondent firms. In terms of our independent variables, the number of exploratory alliances is a count variable taking on discrete non-negative integer values but including zero with our respondent firms having an average of 2.8 exploratory alliances (Table 7.1). We aslo see relatively similar mean values across our US and European respondent firms in the three measures of PACAP (Table 7.1). Average R&D intensity in each case (i.e. the proportion of the workforce engaged in R&D) was around 42-43 percent with around 86-88 per cent of firms engaging in R&D on a continuous basis. Around 70 percent of firms' employees had a degree or its equivalent (Table 7.1).

Our first dependent variable, transformation capability is measured by a pool of ordinal variables measured on a 5-point disagree/agree scale (coded from 1 to 5), where 1 means strongly disagree and 5 means strongly agree. However, the psychological "distances" between these points are not equal. For example, the "distance" between "strongly disagree" and "disagree" may be shorter than the distance between "disagree" and "neutral", so we recoded the scale "strongly disagree" and "disagree" as 0, neutral as 1, "strongly agree" and "agree" as 2. As these dependent variables take on only non-negative integer ordered category values, we decided to use ordered probit regression (Mckelvey and Zavoina, 1975) to test the proposed relationship between PACAP, exploratory alliances and the transformation dimension of RACAP by the following formulation:

$$A_{ij} = \alpha_1 + \beta_{11} RDINT_{ij} + \beta_{12} RDCONT_{ij} + \beta_{13} EMSKILLS_{ij} + \gamma_1 EXPLOR_{ij} + \delta_{11} FC_{ij} + \delta_{12} MC_{ij} + \delta_{13} SP_{ji} + \varepsilon_{ij}$$

(i=1, 2, ...4)

Where A_{ij} stands for the transformation capability of firm j, i denotes the sub-dimensions of firms' transformation capabilities. The β_{1j} coefficients capture the potential for a relationship between PACAP and the transformation capability, the γ_j indicates the effect of exploratory alliances on the transformation capability and the δ_{1j} the impact of three groups of control variables relating to firm characteristics (FC), market characteristics (MC) and firms' strategic profile (SP). In terms of the indicators of transformation dimension, the majority (more than 60 percent) of our respondent firms have well-developed capabilities in market monitoring, knowledge management, knowledge monitoring and international communication. And the proportion of firms with well-developed knowledge transformation capabilities in the US and Europe is very similar (Table 7.1).

Our second dependent variable is a firm's exploitation capability (A_j), proxied by number of patents. The basic linear formulation for the relationship between PACAP, exploratory alliances and a firm's exploitation dimension of RACAP can be specified as:

$$A_j = \alpha_2 + \beta_{21} RDINT_j + \beta_{22} RDCONT_j + \beta_{23} EMSKILLS_j + \gamma_2 EXPLOR_j + \delta_{21} FC_j + \delta_{22} MC_j + \delta_{23} SP_j + \varepsilon_j$$

Here β_{2j} coefficients capture the potential for a relationship between PACAP and the transformation capability, the γ_j indicates the effect of exploratory alliances on the transformation capability and the δ_{2j} the impact of three groups of control variables relating to firm characteristics (FC), market characteristics (MC) and firms' strategic profiles (SP). The dependent variable, number of patents, is a count variable and takes only nonnegative integer values including zero. On the one hand, the distribution is skewed to the right. On the other hand, it has a coefficient variation of nearly 130 times of its mean value[19], a marked sign of over-dispersion, indicating that the Poisson regression is not a good choice for our data, albeit that it is widely used in studies of patent output (e.g., Graves and Langowitz, 1993; Hausman et al, 1984; Henderson and Cockburn, 1996). Under this circumstance, a common approach is to employ the negative binominal regression analysis (e.g. Hausman et al, 1984). However, considering 18.69 percent of the data valued at zero, there is another possibility of using the zero-inflated negative binominal regression. To test this we perform a Vuong (1989) test in comparing the zero-inflated negative binominal

[19] Variance of No. of Patent (s) = 3968.361

model to the standard negative binominal model[20]. The result highlights a significant difference between these two models, and confirms the appropriateness of the zero-inflated negative binominal estimates.

We further control those variables relating to a firm's background characteristics (e.g. age, size, ownership status), the geographic market orientation of the firm and its strategic focus (Table 7.1) in the econometric analysis. On average, the US respondent firms are marginally older, larger and more likely to be independent firms than the European respondents. They are also more likely to be engaged in the early stages of the discovery process but less likely than the EU firms to be involved in sales or marketing activities (Table 7.1). Additionally, sample weights[21] are derived according to the different response rates within Europe, and those between the US and Europe, for ajusting the non-response bias and some of the estimates and standard errors.

7.4 Empirical Results

7.4.1 All-Respondent Results (Hypotheses 2.1, 2.2 and 2.3)

Table 7.4A shows the results for all the respondents from the analysis of the ordinal probit models and the zero-inflated negative binominal model for patents. We found a significant and positive relationship between exploratory alliances and knowledge monitoring capability, suggesting that engagement with exploratory alliances facilitates firms' identification of the usefulness of new external knowledge to existing knowledge. More significant results are identified for the different aspects of PACAP - R&D intensity, employee skills and firms' engagement with continuous R&D, providing support for Hypothesis 2.2a and 2.3b which are related to the acquisition and the assimilation dimensions of PACAP, respectively. We observe that R&D intensity becomes a significant factor in determining firms' number of patents. In particular, skills level is significant and positively related to firms' internal communication capability on one hand;

[20] Vuong test of zero-inflated negative binominal vs. standard negative binomial: $z = 6.95$ $Pr>z = 0.0000$

[21] The absolute weights among different countries have been calculated as US 6.938, UKI 3.636, France 7.057, and Germany 7.169.

on the other hand, it negatively affects firms' number of patents. Moreover, on-going R&D activities proves an important determinant of the firms' capabilities in market monitoring and knowledge management. These results provide several suggestions for developing firms' RACAP. First, a firm's capability in knowledge transformation depends strongly on the assimilation dimension of PACAP. Second, the possession of skill-based ACAP within a firm does not contribute to the exploitation of new external knowledge. Instead, the development of a firm's knowledge exploitation capability is much more conditional on the related investment in R&D or the firm's equivalent knowledge acquisition capability, say the acquisition dimension of PACAP.

7.4.2 Europe

The empirical results for the European respondents firms are presented in Table 7.4B. The number of exploratory alliances has mixed results in the estimation of different dimensions of RACAP. We observed that in Table 7.4B, the number of exploratory alliances positively affects knowledge monitoring capability on the one hand, but on the other hand, it is negatively related to internal communication capability. A similar relationship is also found between firms' engagement with continuous R&D and the different aspects of transformation capability. For example, on-going R&D activities proves a significant and positive determinant of firms' market monitoring capability. While at the same time, it has a significant but negative effect on firms' knowledge monitoring capability. The suggestion is that for the different aspects of transformation capability, the influences from engagement with exploratory alliances and continuous R&D activities vary in the European case. Additionally, our results reveal a significant but negative relationship between number of exploratory alliances and number of patents. This suggests that for those European firms without any existing alliances, participation in exploratory alliances will negatively affect the exploitation of their external knowledge. Hence Hypothesis 2.1 is rejected. For the other aspects of PACAP - R&D intensity and employee skills, we find that R&D intensity proves an important determinant of firms' market-monitoring capability and number of patents, whereas employee skills again have a significant but negative effect on firms' number of patents. The suggestion is that the possession of skill-based PACAP does not facilitate the development of firms' knowledge exploitation

capability in Europe, adding little support for Hypothesis 2.3b; on the other hand, successful exploitation of a firm's new external knowledge depends strongly on its related R&D investment or knowledge acquisition capability (acquisition dimension of PACAP), therefore providing support for Hypothesis 2.2b. The results also suggest that well-developed knowledge acquisition capability improves firms' understanding of the impact of market changes for new products in the European case.

7.4.3 US

Table 7.4C summarizes the empirical results for the US respondent biopharmaceutical firms. We find mixed results in the relationship between engagement with exploration alliances and firms' RACAP. In particular, exploratory alliances proves positive and a significant determinant of firms' capabilities in market monitoring and knowledge management on one hand; on the other hand, it has a significant but negative effect on firms' number of patents. The suggestion is that engagement with exploratory alliances contributes to the transformation rather than the exploitation of firms' newly-acquired and assimilated knowledge in the US. In terms of the different aspects of PACAP, only continuous R&D proves an important factor in determining firms' number of patents, thereby giving partial support to Hypothesis 2.3b. The suggestion is that the development of the US firms' knowledge exploitation capability depends on its continuity in R&D or the R&D aspect of assimilation dimension of PACAP only.

7.4.4 US Vs. Europe ---Key findings

The difference between the European and the US bio-pharmaceutical firms becomes apparent after we disaggregate the value of each independent variable into the US and the European components in the models. In the ordinal probit models shown in Table 7.2, R&D intensity becomes a significant determinant of the transformation capabilities in Europe but not in the US, adding support to Hypothesis 2.2a. The suggestion is that investment in R&D contributes to the development of firms' transformation capability only in the European case. More significant effects are revealed for the other aspects of PACAP

- firms' engagement with R&D and employee skills---providing support for Hypothesis 2.3a which relates to firms' assimilation capability. In particular, continuous R&D activities proves an important factor in determining firms' transformation capability only in Europe, while skills level becomes significant in the US but not Europe. These results suggest that skills-based PACAP seems to be of greater importance to the transformation capability of the US firms, while it is the R&D aspect of PACAP (internal R&D intensity and continuity) and internal knowledge creation, which matter most to the European firms.

In the results obtained from the zero-inflated negative binominal estimates illustrated in Table 7.3, we find a significant but negative relationship between number of exploratory alliances and number of patents, a result which is consistent across the US and Europe but only with those firms without any existing exploratory alliances. The suggestion is that engagement with exploratory alliances negatively affects the knowledge exploitation capability of those firms that are not currently involved in any exploitation alliance in both the US and Europe, providing little support for Hypothesis 2.1b. In terms of the different aspects of PACAP - R&D intensity, continuous R&D and skills level - we observe that in Table 7.3 continuous R&D activities proves a significant factor in contributing to the exploitation of new knowledge in the US firms, but not in the European ones. Quite differently, R&D intensity becomes positive and highly significant (at $p<.001$ level) only in the European case. Even the value of the coefficient of skills level (in absolute terms) and its related significance level are greater in the European case than in the US case when the exploitation capability is examined. These findings indicate that the development of exploitation capability relies on the different aspects of potential absorptive capacity in the US and Europe, thus giving support to Hypotheses 2.2b and 2.3b which both reflect firms' potential absorptive capacity. Investment in R&D and skills may be more effective in contributing to the development of exploitation capability for the European firms. Whereas, in order to achieve this; the US firms may benefit more by continuously involving in R&D activities.

7.5 Empirical Conclusions

In this chapter, we attempt to extend our understanding of the influences of potential absorptive capacity and exploratory alliances on firms' realised absorptive capacity, as it has been proposed previously in our conceptual framework. Our study in this chapter provides more insights into the evolution of firms' absorptive capacity. The findings offer important empirical implications to the management of firms' realised absorptive capacity across the US and Europe, and give implicit support to the research on absorptive capacity (Jansen et al, 2005; Lim, 2004; Schmidt, 2005), in particular to those studies focusing on the absorptive capacity of the European and the US biopharmaceutical firms (Fosfuri and Tribo, 2006; Bierly and Chakrabarti, 1996; Castellani and Zanfei, 2002; Hall and Bagchi-Sen, 2007; Halmenschlager, 2006). We find that for those firms without any existing exploratory alliances, participation in exploratory alliances does not contribute to the exploitation of new external knowledge either in the US or Europe, providing little evidence for Hypothesis 2.1b. This is probably because although exploratory alliances generate the discovery of new opportunities, and at the same time the potential for exploitation (Rothaermel and Deeds, 2004), exploration of new alternatives slows down the process of exploiting existing ones (Levitt and March 1988). Thus, exploratory alliances might hinder the development of firms' knowledge exploitation capability. Equally, improvement in competence at existing procedures makes experimentation with others less attractive (Levitt and March 1988). Thus, there exists a trade off between exploration of new alternatives and exploitation of existing knowledge base. This suggests that firms might need to find an appropriate balance between their exploration and exploitation activities, at which they could maximise the benefits obtained from both.

Our results reveal that investment in R&D contributes to the development of firms' exploitation capability. As documented extensively in previous innovation studies, R&D expenditure is expected to have a positive effect on patents (Ahuja and Katila, 2001; Hagedoorn and Cloodt, 2003). Our results empirically confirmed the positive and significant effect of R&D intensity on the number of patents (Nooteboom et al, 2006). This provides broad support for the argument suggested by Hypothesis 2.2b that the acquisition dimension of potential absorptive capacity is the pre-requisite of the exploitation dimension of realised absorptive capacity. Accumulating absorptive capacity in one period

will permit its more efficient accumulation in the next. By having already developed some potential absorptive capacity in the early stage, a firm may more readily accumulate what additional knowledge it needs in the subsequent periods in order to exploit any critical external knowledge that may become available. In addition, the result also gives implicit support to the argument regarding to the path-dependent nature of absorptive capacity (Cohen and Levinthal, 1990; Eisenhardt and Martin, 2000; Schmidt, 2005; Zahra and George, 2002).

However, our results suggest that the existence of acquisition capability is the necessary but not the sufficient condition of successful knowledge transformation. Investment in R&D facilitates a firm's external knowledge gathering, and plays a crucial role in determining the firm's ability to import external knowledge. However, having already acquired a certain amount of new knowledge does not necessarily mean a firm could be able to assimilate and transform or exploit this knowledge for profit generation later on (Zahra and George, 2002). Therefore, a better understanding of the new knowledge is still necessary, because it contributes to firms' evaluation of the import of intermediate technological advances that will provide signals to the eventual merit of a new technological development. Strong evidence for this can be found in the study of Lane and Lubatkin (1998) on 69 bio-pharmaceutical alliances, in which it was shown that the efficiency of knowledge absorption between two firms depended on their degree of familiarity with one another's practices.

Another interesting aspect of the results is the differences it highlighted in the determinants of firms' realised absorptive capacity in the US and Europe. We find that in Europe the development of a firm's realised absorptive capacity depends on its relevant investment in R&D - providing empirical support for the earlier findings of R&D intensity as an important factor in determining firms' ability to transform and exploit new knowledge (Schmidt, 2005); whereas for the US firms, this is not the case. In particular, while the exploitation of new knowledge relies on firms' R&D investment in Europe, the development of the US firms' exploitation capability is much more related to the continuity in R&D activities, or the R&D aspect of the assimilation capability. This is consistent with prior findings which reveal that on-going R&D activities is a significant determinant of firms' knowledge exploitation capability (Schmidt, 2005). A Possible

explanation could be that the profile of companies included in this research reflects greater investment and support for biopharmaceutical companies in the US than in Europe. Under this circumstance, lower levels of public support and investment in publicly funded R&D in Europe may be increasing the relative importance of firms' own R&D to the development of the firms' realised absorptive capacity. In the US, public investments in biotechnology R&D might be substituting for firms' own investments. This makes on-going R&D activities play an important role in contributing to the efficient internal knowledge flows within firms, which may help reduce the distance between the assimilation dimension (PACAP) and exploitation dimension (RACAP) (Fosfuri and Tribo, 2006).

In addition, our results suggest that skills level has a significant but negative impact on firms' knowledge exploitation capability in Europe. One possibility is the fact that skills and knowledge embedded in individuals can turn into core rigidities because they are less amenable to change (Grant, 1991; Leonard-Barton, 1992), particularly in the case of knowledge exploitation. Another possible explanation is associated with our measurement of skills, which focuses on the educational/academic skills; however, to exploit new external knowledge, firms might need other skills, such as management skills and commercialisation skills (Bagchi-Sen et al, 2004), apart from advanced technology skills.

Table 7. 1: Variable Descriptives

Variables		All Firms (n=349)		EU (n=205)		US (n=144)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
No. of exploratory alliances	(per firm)	2.78	4.01	2.58	3.87	3.04	4.18
PACAP Measures							
R&D Intensity	(% per firm)	43.20	0.34	41.70	0.34	45.10	0.34
Employee skills	(% per firm)	68.80	0.28	66.90	0.29	71.40	0.26
Continuous R&D	(% of firms)	86.90	0.34	86.00	0.35	88.10	0.33
RACAP Measures							
Market monitoring capability	(% of firms)	65.03	0.48	62.37	0.49	68.57	0.47
Knowledge management capability	(% of firms)	63.30	0.48	63.30	0.48	63.31	0.48
Knowledge monitoring capability	(% of firms)	87.23	0.33	86.77	0.34	87.86	0.33
Internal communication capability	(% of firms)	75.38	0.43	73.12	0.44	78.42	0.41
No. of patents currently*	(per firm)	33.79	86.15	**20.21**	54.78	**53.10**	114.63
Firm Characteristics							
Firm age	(year)	13.60	12.41	12.10	11.53	15.90	13.30
No. of employees	(per firm)	47.00	84.04	35.00	68.01	65.00	101.25
Independent company	(% of firms)	83.50	0.37	80.30	0.40	88.10	0.33
Market Characteristics							
Regional market	(% of firms)	76.10	0.43	74.50	0.44	78.30	0.41
Foreign market	(% of firms)	47.30	0.50	47.10	0.50	47.60	0.50
External market	(% of firms)	32.10	0.47	26.80	0.44	39.60	0.49
Strategic Focus							
Basic R&D and preclinical dev.	(% of firms)	67.30	0.47	60.00	0.49	77.80	0.42
Clinical trials (Phase I, II, III)	(% of firms)	38.10	0.49	26.30	0.44	54.90	0.50
Manufactory	(% of firms)	51.60	0.50	46.80	0.50	58.30	0.50
Regulatory support	(% of firms)	38.00	0.49	21.40	0.41	61.10	0.49
Marketing & sales	(% of firms)	47.50	0.50	52.20	0.50	41.00	0.49

Source: Author's Survey

* p=0.003

Notes: Mean values in bold format represent the existence of significant difference between the US and Europe regarding the same variable.

Table 7. 2: Ordinal Probit Regression Model of Transformation Dimension of RACAP

Table 7.2. 1: Market Monitoring Capability

Dependent Variable (Market Monitoring Capability)	Coef.
No.of exploratory alliances of EU firms	-0.034
No.of exploratory alliances of US firms	0.013
EU firms without exploratory alliances	-0.532
US firms without exploratory alliances	0.868*
Log (R&D intensity of EU firms)	0.756~
Log (R&D intensity of US firms)	-0.083
Level of employee skills of EU firms	-0.231
Level of employee skills of US firms	0.752
Continuous R&D activities of EU firms (Zero)	-0.207
Continuous R&D activities of EU firms (Non-Zero)	1.190~
Continuous R&D activities of US firms (Non-Zero)	0.697
Firm Characteristics	
Firm age	0.000
No. of employees	-0.010
No. of employees Square	0.000
Ownership status (Independent Company)	-0.334
Market Characteristics	
Regional market	0.142
Foreign market	-0.120
External market	0.217
Strategic Profile	
Basic R&D and preclinical dev.	-0.810
Clinical trials (Phase I, II, III)	-0.052
Manufactory	-0.267
Regulatory support	0.283
Marketing&sales	0.222
_cut1	-1.151
_cut2	-0.106
No. of obs = 209	Wald chi2(23) = 71.82***

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 7.2.1. 1: Wald Tests for the Equality of Coefficients: US Versus Europe[22]

Dependent Variable (Market monitoring capability)	dy/dx outcome(0)	dy/dx outcome(1)	dy/dx outcome(2)
No.of exploratory alliances of EU firms	0.002	0.006	-0.008
No.of exploratory alliances of US firms	-0.001	-0.002	0.003
EU firms without exploratory alliances	0.036	0.111	-0.147
US firms without exploratory alliances	-0.023	-0.122*	0.146*
Log (R&D intensity of EU firms)	-0.036	-0.144	0.180
Log (R&D intensity of US firms)	0.004	0.016	-0.020
Level of employee skills of EU firms	0.011	0.044	-0.055
Level of employee skills of US firms	-0.036	-0.143	0.179
Continuous R&D activities of EU firms (Zero)	0.012	0.042	-0.054
Continuous R&D activities of EU firms (Non-Zero)	-0.066	-0.214~	0.280
Continuous R&D activities of US firms (Non-Zero)	-0.031	-0.124~	0.154

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

[22] Pr(oacap1==0) = .01970192
Pr(oacap1==1) = .13540248
Pr(oacap1==2) = .84489559

Table 7.2. 2: Knowledge Management Capability

Dependent Variable (Knowledge Management Capability)	Coef.
No.of exploratory alliances of EU firms	-0.043
No.of exploratory alliances of US firms	0.064*
EU firms without exploratory alliances	-0.083
US firms without exploratory alliances	0.314
Log (R&D intensity of EU firms)	0.016
Log (R&D intensity of US firms)	-0.124
Level of employee skills of EU firms	-0.035
Level of employee skills of US firms	-0.388
Continuous R&D activities of EU firms (Zero)	-0.090
Continuous R&D activities of EU firms (Non-Zero)	0.458
Continuous R&D activities of US firms (Non-Zero)	0.210
Firm Characteristics	
Firm age	-0.010
No. of employees	-0.001
No. of employees Square	0.000
Ownership status (Independent Company)	-0.158
Market Characteristics	
Regional market	0.371
Foreign market	-0.404
External market	0.296
Strategic Profile	
Basic R&D and preclinical dev.	0.502
Clinical trials (Phase I, II, III)	-0.119
Manufactory	-0.029
Regulatory support	0.442
Marketing&sales	-0.106
_cut1	-0.690
_cut2	0.086
No. of obs = 212	Wald chi2(23) = 36.00*

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 7.2.2. 1: Wald Tests for the Equality of Coefficients: US Versus Europe[23]

Dependent Variable (Knowledge management capability)	dy/dx outcome(0)	dy/dx outcome(1)	dy/dx outcome(2)
No.of exploratory alliances of EU firms	0.008	0.006	-0.008
No.of exploratory alliances of US firms	-0.012*	-0.002	0.003
EU firms without exploratory alliances	0.016	0.111	-0.147
US firms without exploratory alliances	-0.051	-0.122*	0.146*
Log (R&D intensity of EU firms)	-0.003	-0.144	0.180
Log (R&D intensity of US firms)	0.023	0.016	-0.020
Level of employee skills of EU firms	0.007	0.044	-0.055
Level of employee skills of US firms	0.073	-0.143	0.179
Continuous R&D activities of EU firms (Zero)	0.018	0.042	-0.054
Continuous R&D activities of EU firms (Non-Zero)	-0.086	-0.214~	0.280
Continuous R&D activities of US firms (Non-Zero)	-0.038	-0.124~	0.154

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

[23] Pr(oacap2==0) = .10984063
Pr(oacap2==1) = .21610645
Pr(oacap2==2) = .67405293

Table 7.2. 3: Knowledge Monitoring Capability

Dependent Variable (Knowledge Monitoring Capability)	Coef.
No.of exploratory alliances of EU firms	0.492**
No.of exploratory alliances of US firms	0.045
EU firms without exploratory alliances	0.946~
US firms without exploratory alliances	-0.281
Log (R&D intensity of EU firms)	0.398
Log (R&D intensity of US firms)	-0.220
Level of employee skills of EU firms	0.044
Level of employee skills of US firms	-0.275
Continuous R&D activities of EU firms (Zero)	-1.705
Continuous R&D activities of EU firms (Non-Zero)	-1.970~
Continuous R&D activities of US firms (Non-Zero)	-0.020
Firm Characteristics	
Firm age	0.001
No. of employees	-0.003
No. of employees Square	0.000
Ownership status (Independent Company)	0.181
Market Characteristics	
Regional market	0.390
Foreign market	-0.195
External market	0.225
Strategic Profile	
Basic R&D and preclinical dev.	0.734
Clinical trials (Phase I, II, III)	0.284
Manufactory	0.307
Regulatory support	-0.255
Marketing&sales	0.108
_cut1	-1.710
_cut2	-0.609
No. of obs = 212	Wald chi2(23) = 42.87**

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 7.2.3. 1: Wald Tests for the Equality of Coefficients: US Versus Europe[24]

Dependent Variable (Knowledge monitoring capability)	dy/dx outcome(0)	dy/dx outcome(1)	dy/dx outcome(2)
No. of exploratory alliances of EU firms	-0.005	-0.047***	0.052***
No. of exploratory alliances of US firms	0.000	-0.004	0.005
EU firms without exploratory alliances	-0.006	-0.063**	0.068**
US firms without exploratory alliances	0.004	0.032	-0.035
Log (R&D intensity of EU firms)	-0.004	-0.038	0.042
Log (R&D intensity of US firms)	0.002	0.021	-0.023
Level of employee skills of EU firms	0.000	-0.004	0.005
Level of employee skills of US firms	0.003	0.026	-0.029
Continuous R&D activities of EU firms (Zero)	0.121	0.317	-0.438
Continuous R&D activities of EU firms (Non-Zero)	0.042	0.219~	-0.261
Continuous R&D activities of US firms (Non-Zero)	0.000	0.002	-0.002

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

[24] Pr(oacap3==0) = .0031506
Pr(oacap3==1) = .04833281
Pr(oacap3==2) = .94851659

Table 7.2. 4: Internal Communication Capability

Dependent Variable (Internal Communication Capability)	Coef.
No.of exploratory alliances of EU firms	-0.050*
No.of exploratory alliances of US firms	0.013
EU firms without exploratory alliances	-0.570~
US firms without exploratory alliances	-0.257
Log (R&D intensity of EU firms)	-0.017
Log (R&D intensity of US firms)	-0.258
Level of employee skills of EU firms	0.401
Level of employee skills of US firms	0.960
Continuous R&D activities of EU firms (Zero)	0.065
Continuous R&D activities of EU firms (Non-Zero)	0.065
Continuous R&D activities of US firms (Non-Zero)	-0.208
Firm Characteristics	
Firm age	-0.010
No. of employees	0.001
No. of employees Square	0.000
Ownership status (Independent Company)	-0.387
Market Characteristics	
Regional market	0.102
Foreign market	-0.210
External market	-0.261
Strategic Profile	
Basic R&D and preclinical dev.	0.039
Clinical trials (Phase I, II, III)	0.067
Manufactory	0.154
Regulatory support	-0.077
Marketing&sales	-0.012
_cut1	-2.122
_cut2	-1.040
No. of obs = 209	Wald chi2(23) = 19.98

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 7.2.4. 1: Wald Tests for the Equality of Coefficients: US Versus Europe[25]

Dependent Variable (Internal communication capability)	dy/dx outcome(0)	dy/dx outcome(1)	dy/dx outcome(2)
No.of exploratory alliances of EU firms	0.004*	0.011*	-0.015*
No.of exploratory alliances of US firms	-0.001	-0.003	0.004
EU firms without exploratory alliances	0.058	0.132~	-0.190~
US firms without exploratory alliances	0.023	0.060	-0.083
Log (R&D intensity of EU firms)	0.001	0.004	-0.005
Log (R&D intensity of US firms)	0.019	0.058	-0.078
Level of employee skills of EU firms	-0.030	-0.091	0.121
Level of employee skills of US firms	-0.071	-0.217	0.289
Continuous R&D activities of EU firms (Zero)	-0.005	-0.014	0.019
Continuous R&D activities of EU firms (Non-Zero)	-0.005	-0.015	0.019
Continuous R&D activities of US firms (Non-Zero)	0.016	0.047	-0.064

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

[25] Pr(oacap4==0) = .03347003
Pr(oacap4==1) = .19289505
Pr(oacap4==2) = .77363491

Table 7.3: Zero-inflated Negative Binominal Regression Model of Exploitation Dimension of RACAP: Split EU/US Explanatory Variables

Dependent Variable (No. of Patents)	Coef.	dy/dx
No.of exploratory alliances of EU firms	0.005	0.068
No.of exploratory alliances of US firms	-0.015	-0.196
EU firms without exploratory alliances	-0.580~	-6.352
US firms without exploratory alliances	-0.726*	-7.196
Log (R&D intensity of EU firms)	1.704**	21.631
Log (R&D intensity of US firms)	-0.383	-4.867
Level of employee skills of EU firms	-1.148*	-14.573
Level of employee skills of US firms	-0.548	-6.959
Continuous R&D activities of EU firms (Zero)	0.221	3.086
Continuous R&D activities of EU firms (Non-Zero)	0.274	3.500
Continuous R&D activities of US firms (Non-Zero)	1.127**	17.253
Firm Characteristics		
Firm age	0.000	-0.003
No. of employees	0.013	0.168
No. of employees Square	0.000	0.000
Ownership status (Independent Company)	-0.236	-3.291
Market Characteristics		
Regional market	-0.209	-2.807
Foreign market	-0.485	-6.039
External market	0.614	8.775
Strategic Profile		
Basic R&D and preclinical dev.	0.517	5.961
Clinical trials (Phase I, II, III)	0.662	9.379
Manufactory	0.082	1.036
Regulatory support	0.110	1.417
Marketing&sales	-0.310	-3.913
Nationality (euus)	2.017***	
_cons	24.128	
No. of obs = 214	Wald chi2(23) = 272.82***	

Source: **Authors' Survey**

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 7. 4: Table of Results

A: Results for All the Respondents[26]

Table of Results						
Independent Variables / Dependent variables			Exploratory Alliances	PACAP		
				Acquisition Dimension	Assimilation Dimension	
				R&D intensity (log)	Employee Skills	Continuous R&D activities
RACAP	Transformation Dimension	Market monitoring capability	-	+	-	(+)
		Knowledge management capability	-	-	-	(+)
		Knowledge monitoring capability	(+)	-	+	-
		Internal communication capability	-	+	(+)	+
	Exploitation Dimension	No. of Patents	+	(+)	(-)	+

Notes: "+" represents positive sign.
"-" represents negative sign.
"(+)", "(-)" represent significant at 5% level

Sources: Results from Appendix 4.

[26] Based on the results obtained from the general models shown in Appendix 4.

B: Europe

Table of Results

Dependent variables / Independent Variables			Exploratory Alliances		PACAP: Acquisition Dimension	PACAP: Assimilation Dimension	
					R&D intensity (log)	Employee Skills	Continuous R&D activities
RACAP	Transformation	Market monitoring capability	-/0	-/N	(+)	-	(+/**N**)
		Knowledge management capability	-/0	-/N	+	-	+/N
		Knowledge monitoring capability	(+/**0**)	(+/**N**)	+	+	(**-**/**N**)
		Internal communicati on capability	(**-**/**0**)	(**-**/**N**)	-	+	+/N
	Exploitation Dimension	No. of Patents	(**-**/**0**)	+/N	(+)	(**-**)	+/N

Notes: "+" represents positive sign.
"-" represents negative sign.
"+/0", "-/0" means the influence of an independent variable on the dependent variables is positive or negative in the US or Europe, when the independent variable is defined in dummy terms.
"+/N", "-/N" means the influence of an independent variable on the dependent variables is positive or negative in the US or Europe, when the independent variable is defined in continuous terms.
"(+)", "(**-**)", "(+/**0**)", "(**-**/**0**)", "(+/**N**)", "(**-**/**N**)" represent significant at 5% level.

Sources: Results from Table 7.2

C: US

Table of Results

Dependent variables \ Independent Variables			Exploratory Alliances		PACAP		
					Acquisition Dimension	Assimilation Dimension	
					R&D intensity (log)	Employee Skills	Continuous R&D activities
RACAP	Transformation	Market monitoring capability	**(+/0)**	+/N	-	+	+/N
		Knowledge management capability	+/0	**(+/N)**	-	-	+/N
		Knowledge monitoring capability	-/0	+/N	-	-	-/N
		Internal communicatio n capability	-/0	+/N	-	+	-/N
	Exploitation Dimension	No. of Patents	**(-/0)**	-/N	-	-	(+/N)

Notes: "+" represents positive sign.
"-" represents negative sign.
"+/0", "-/0" means the influence of an independent variable on the dependent variables is positive or negative in the US or Europe, when the independent variable is defined in dummy terms.
"+/N", "-/N" means the influence of an independent variable on the dependent variables is positive or negative in the US or Europe, when the independent variable is defined in continuous terms.
"", "-", "**(/0)**", "**(-/0)**", "**(/N)**", "**(-/N)**" represent significant at 5% level.

Sources: Results from Table 7.2

CHAPTER 8

RACAP AND EXPLOITATION ALLIANCES

8.1 Introduction

The previous chapter has already examined the impact of PACAP and exploratory alliances on firms' RACAP. In this chapter, the relationship between RACAP and exploitation alliance is explored. Based on an overview of the key literature in the areas of alliance and absorptive capacity, a positive relationship between RACAP and exploitation alliances is assumed. The proposed relationship is tested using data from 349 US and European biopharmaceutical firms that completed a questionnaire on their new product development, R&D and alliance activities during the period of the main survey conducted in 2006.

The theoretical context of this chapter relates to the two broad debates in innovation literature that have been addressed in Chapter 6: the open innovation paradigm which emphasises the importance for firms across industrial sectors of combining internal and external knowledge as part of their innovation strategies (Chesborough, 2003; 2006), and the discussion concerning the complementarities between firms' internal characteristics and their boundary spanning linkages, which suggests complementarities may arise between in-house and external R&D due to firms' improved scanning ability for external knowledge sources, the ability to exchange internally-generated for externally-sourced knowledge, enhanced absorptive capacity, or increased appropriation capacity.

Several contributions have been made to the existing literature in the following ways: firstly, as mentioned in the earlier chapters, this study enhances and extends the previous understanding of absorptive capacity by empirically corroborating its distinctive characters in terms of PACAP and RACAP which have been identified by Zahra and George (2002). Secondly, after reviewing the relevant literaturs of absorptive capacity, and conducting inductive interviews with R&D managers from a few English biopharmaceutical companies, a set of indicators for measuring aspects of RACAP were developed. Given

that a better theoretical understanding of the different features of absorptive capacity is necessary, it would be equally important to operationalise the constructs addressing these features. Finally, the study relates a firm's internal capability deveopment to its external knowledge flow by concpetualising RACAP as a determinant of firms' exploitation alliance activities, thus providing more insights into the capability and alliance management practices.

In the section that follows, the relevant literature on RACAP and exploitation alliances is surveyed, and the theoretical underpinnings of the relationship between RACAP and exploitation alliances then follows. Section 8.3 describes the data used to test the study's hypotheses, and the empirical method for estimating the proposed relationship is developed. The remaining sections of the chapter summarise the results of the empirical study, and ultimately a conclusion provides a discussion of the empirical results. The implications of the empirical investigation are addressed in Chapter 12.

8.2 Literature and Hypotheses

8.2.1 Transformation Capability and Exploitation Alliances

Exploitation alliances are entered into with the goal of joining existing competencies across organisational boundaries in order to generate synergies, which are then shared between the partners (Koza and Lewin, 1998). The ability of firms to recognise two apparently incongruous sets of information and then combine them to arrive at a new schema represents a transformation capability (Zahra and George, 2002). It allows the firms to develop and refine the routines that facilitate combining existing knowledge with newly-acquired and assimilated knowledge from external partners. In exploitation alliances in particular, the presence of organisational routines facilitate the combination of existing knowledge, and external knowledge provides structural, systemic, and procedural mechanisms that allow firms to integrate different types of knowledge together according to their complementarities (Teece, 1986).

On the other hand, it is well documented in previous studies (i.e. Teece 1984 and 1992) that exploitation alliances focus on the complementarities among the allied partners as they exchange explicit knowledge. In the biopharmaceutical industry for example, the most common cases are the new entrant biotechnology firms that provide new technology, while the incumbent pharmaceutical companies commercialise it. Accordingly, transformation capability bridges a connection between technology advancement in basic research, drug discovery and development, and commercialisation advancement in clinical trials, FDA regulatory management, and marketing and sales. And this in turn yields new insights, facilitates the recognition of opportunities, and at the same time alters the way a firm sees itself and its competitive landscape (Zahra and George, 2002). Thus, the transformation dimension of realised absorptive capacity facilitates the goal achievement of exploitation alliances. It fosters the growth of firms' exploitation alliance activities, and improves the efficiency of the process of exploitation alliances. Hence, Hypothesis 3.1 follows:

> Hypothesis 3.1: In both the US and Europe, biopharmaceutical firms' engagement with exploitation alliances will be positively associated with the transformation dimension of RACAP.

8.2.2 Exploitation Capability and Exploitation Alliances

Exploitation reflects a firm's ability to harvest and incorporate knowledge that has already been created and internalised for use (Lyles and Schwenk, 1992) in its operations (Tiemessen et al, 1997; Van den Bosch et al, 1999). It is argued that the outcomes of systematic exploitation routines are the persistent creation of new goods, knowledge, or new organisational forms (Spender, 1996).

In contrast, research into exploitation alliances highlights their importance as predictors of firms' new products on the market (Rothaelmel, 2001; Rothaermel and Deeds, 2004), since successful exploitation alliances enable the firm to commercialise the knowledge gained through exploration (Rothaermel and Deeds, 2004).

From the perspective of organisational learning (Levitt and March, 1988; March 1991), pressures for exploitation often derive from organisational inertia (Lavie and Rosenkopf,

2006). This encourages firms to rely on organisational routines for selecting partners, establishing alliance governance mechanisms, allocating resources, and co-ordinating and monitoring alliances (Kale et al, 2002). According to Rowley et al (2000), inertia pressures to reduce technical uncertainty and organisational risk further limit firms' engagement with exploratory alliances because these alliances entail much more interaction, collaboration, and exchange of tacit knowledge, than do exploitation alliances. Furthermore, inertia also reduces structure exploration and favours existing partners despite the potential merits of new partners, resulting in structure exploitation (Lavie and Rosenkopf, 2006), since it impels firms to enhance the predictability, stability and reliability of their partners by forming recurrent alliances with prior partners that are instituted on familiarity, trust and established collaboration practices (Gulati, 1995). In addition, inertia reinforces attribute exploitation because even when partner selection routines fail to yield relevant partners, firms may still leverage established routines to identify partners that match a certain profiles (Lavie and Rosenkopf, 2006).

On the other hand, the organisational inertia intensifies as established routines and skills become embedded in decision-making processes and are applied almost automatically in response to external stimuli (Nelson and Winter, 1982). And these routines are pursued by firms to ensure that inputs are transformed into outputs (Perrow, 1967). Jansen et al (2005) empirically confirmed that routinisation was positively related to the transformation and the exploitation of new external knowledge (that is, to realised absorptive capacity) based on their research on 220 branches of a large European, multi-unit financial services firm. This is because that routinisation provides efficient structures for collective action and decreases efforts spent on decision-making and implementation (Cohen and Bacdayan, 1994). Thus, units that routinise organisational behaviours are able to efficiently transform new external knowledge into existing sets of tasks (Cohen and Bacdayan, 1994). Moreover, routine tasks are well practised and predictable, they permit closely co-ordinated exploitation of knowledge in pursuing collective objectives (Adler et al, 1999; Gersick and Hackman, 1990; Grant, 1996). Therefore, Hypothesis 3.2 follows:

> Hypothesis 3.2: In both US and Europe, biopharmaceutical firms' engagement with exploitation alliances will be positively associated with the exploitation dimension of RACAP.

8.3 Data and Methods

Data on RACAP and exploitation alliances that are featured in the hypotheses were obtained from the main survey. A valid response from 349 biopharmaceutical firms (corresponding to a response rate of 16.0 percent) was achieved. The respondent firms have a mean company tenure of 13.6 years, with an average number of 47 full-time employees.

The descriptive statistics in Table 8.1 show no significant differences (except number of patent) between the US and European respondent firms. The average number of patents held by the European firms is relatively smaller (20.2), and less than half amount of the US firms (50.1). In terms of the measures of transformation dimension, a majority (more than 63.3 percent) of the respondent firms have well-developed market monitoring knowledge management, knowledge monitoring, and internal communication capabilities. And the proportion of respondent firms with well-developed knowledge transformation capabilities in the US and Europe is very similar (Table 8.1).

The dependent variable number of exploitation alliances (A_k) - is a count variable taking on discrete non-negative integer values, including zero with the respondent firms having an average of 2.1 exploratory alliances (Table 8.1). The distribution is strongly skewed to the right, and having a coefficient variation of nearly 18.9 times of its mean value[27], an obvious sign of over-dispersion. A preponderance of zeros in the distribution of the number of exploratory alliances is also found. As Table 4 shows, over 59 percent of the counts are zeros. However, the cause of these excessive zeros itself is ambiguous; it could be a result of either unobserved heterogeneity (Long, 1997; Cameron and Trivedi, 1998) or over-dispersion, or both. Thus, neither the zero-inflated poisson model nor the negative binominal model is appropriate for our data, since they could not cover both the over dispersion and excessive zeros in the raw data. Alternatively, we decide to use zero inflated negative binominal model. To further confirm our decision, a Vuong (1989) test was performed to compare the zero- inflated negative binominal model with the standard negative binominal model[28]. The result of the Vuong test shows that the zero inflated negative binominal model (ZINB) is significantly different from the negative binominal

[27] Variance of No. of Exploitation alliance(s) = 16.059

[28] Vuong test of zero-inflated negative binominal vs. standard negative binomial: z = 1.98 Pr>z = 0.024

model (NBREG), and hence indicates that the zero-inflated negative binominal model (ZINB) is the most appropriate model for our data.

In addition to the main variables of interest, we include three groups of control variables in the econometric analysis, these relating to firms' background characteristics (e.g. age, size, ownership status), the geographic market orientation of the firm and its strategic focus (Table 8.1). On average the US respondent firms are marginally older, larger and more likely to be independent firms than those in Europe. They are also more likely to be engaged in the early stages of the discovery process but less likely than the EU firms to be engaged in sales or marketing activities (Table 8.1). Meanwhile, to adjust the non-response bias, we further weight the response rates within Europe, and those between US and Europe[29].

The relationship between RACAP and exploitation alliance (A_k) is specified by a simple linear formulation as follows:

$$A_k = \alpha + \beta_1 TransformC_k + \beta_2 ExploiC_k + \delta_1 FC_k + \delta_2 MC_k + \delta_3 SP_K + \varepsilon_k$$

where the β_i coefficients capture the potential for a relationship between RACAP and the number of exploitation alliance(s) and the δ_i is the impact of the three groups of control variables relating to firm characteristics (FC), market characteristics (MC) and firms' strategic profiles (SP).

[29] The absolute weights among different countries have been calculated as US 6.938, UKI3.636, France 7.057, and Germany 7.169.

8.4 Empirical Results

Table 8.2 presents the results from the zero-inflated negative binominal estimation (ZINB) of the influence of RACAP on exploitation alliances for the whole sample. In terms of parameter of interest, a significant and positive relationship is found between the number of exploitation alliances and knowledge monitoring capability. The suggestion is that the ability of a firm to recognise the usefulness of new external knowledge contributes to its engagement with exploitation alliances. This supports the claim of a meaningful relationship between transformation capability and number of exploitation alliances, and adds support to our Hypothesis 3.1. Another significant result is identified from the exploitation dimension of RACAP in terms of the number of patent(s) firms hold, providing support for Hypothesis 3.2, which reflects firms' exploitation capability. As Table 8.2 illustrates, although it is marginally positive, number of patents proves a significant determinant of firms' engagement with exploitation alliances at $p<0.01$ level. This suggests that firms' engagement with exploitation alliances depends on the exploitation dimension of RACAP.

However, considering the fact that more than 58 percents of our respondent firms do not have any exploitation alliances, it is worthwhile to study those firms which are currently engaging in the exploitation alliances. We test our two hypotheses on firms with existing exploitation alliances, using the negative binominal regression model (NBREG). The results given in Table 8.3 are fully consistent with the previous results from our zero-inflated negative binominal estimation of the same relationship for the whole sample (in Table 8.2). Therefore, it is suggested that for firms with or without existing exploitation alliances, improving knowledge monitoring capability and increasing number of patents, are important factors in fostering the growth of their exploitation alliances.

The most interesting results are achieved after differentiating between those values of each independent variable relating to the US and Europe to allow coefficients to be compared. Table 8.4.1 reports the results from our Wald tests for the equality of the EU and US coefficient. We find a significant and positive relationship between number of exploitation alliances and firms' knowledge monitoring capability, a result which is consistent across the US and Europe. The suggestion is that in both the US and European cases, firms'

engagement with exploitation alliances relays strongly on their abilities to recognise the usefulness of new external knowledge. We also find that the exploitation capability proves a significant determinant of firms' engagement with exploitation alliances in the European but not the US, thus providing some support for Hypothesis 3.2. The result suggests that in Europe, firms' engagement with exploitation alliances depends on their relevant knowledge-exploitation capabilities or exploitation dimension of RACAP.

To further investigate the differences between them, we estimate the influence of RACAP on firms' exploitation alliance activities by separate ZINB models for each case (Table 8.5). However, because there were insufficient observations for our separate ZINB estimation for the US and European subgroups, the results achieved might not be as reliable as our previous results. Despite this, knowledge monitoring capability proves a significant determinant of exploitation alliances in both cases, thereby suggesting some support for Hypothesis 3.2, while number of patent(s) – representing the transformation dimension of RACAP- proves significant in Europe only. This confirms the strong explanatory power of knowledge monitoring capability, and the results from Wald test in Table 8.5 suggest that biopharmaceutical firms well-developed knowledge monitoring capability will gain at least 2.3 of exploitation alliances in both the US and Europe.

Additionally, we have some interesting findings from the three sets of control variables. Firstly, we find an inverted U-Shape relationship between firm size and number of exploitation alliances in both the US and Europe. This result provides partial support for earlier research which reported firm size as being significant in predicting a firm's number of exploitation alliances (Rothaermel and Deeds, 2004). The net effect of firm size on number of exploitation alliances is demonstrated in Figure 8.1 with all the other variables evaluated at their mean value. Overall, the maximum increase in number of exploitation alliances is achieved when firm size is between 150 and190 employees. Secondly, although insignificant, we find a marked difference between the US and Europe in the relationship between firm age and number of exploitation alliances (Table 8.5). In Europe, older firms have less exploitation alliances, while in the US, the effect of age on firms' engagement with exploitation alliances is completely the opposite (Figure 8.2). Finally, in terms of firms' strategic focus, the most important determinant of firms' engagement with exploitation alliances, perhaps unsurprisingly, proves to be a strategic focus on the

commercialisation stage of the new product development process, in particular the marketing and sales activities.

8.5 Empirical Conclusions

The purpose of the study in this chapter is to investigate the relationship between a firm's realised absorptive capacity and its engagement with exploitation alliances. Prior theoretical work has emphasised the importance of realised absorptive capacity and exploitation alliances in contributing to inter-firm learning, and creating and sustaining firms' competitive advantage in the biotechnology industry (Zahra and George, 2002; Koza and Lewin, 1998). Our findings contribute to the development of this body of research by providing empirical evidence for the theoretical studies focusing on RACAP (Zahra and George, 2002) and exploitation alliances (Koza and Lewin, 1998), and specifically for those investigating their relationships. In particular, the consistent results (particularly those for knowledge monitoring capability and number of patents) across our ZINB estimation for the whole sample and NBREG estimation for firms with existing exploitation alliances, enhance the level of reliability and robustness of our empirical findings.

Our results suggest that for firms with or without any existing exploitation alliances, knowledge exploitation capability (gauged by number of patents) plays an important role in determining their exploitation alliance activities. This reflects the results of previous research which discovered a firm's number of patents as a significant positive predictor of the number of its exploitation alliances (Rothaermel and Deeds, 2004). A well-developed knowledge-exploitation capability facilitates the exploitation of public research results (Wolter, 2003), and increases the level of networking among private and public research funders, universities and specialist firms (Owen-Smith et al, 2002), thereby fostering the growth of market-based alliances (exploitation alliances). Our results also suggest that knowledge monitoring capability is extremely important for firms' engagement with exploitation alliances. The ability of a firm to recognise the usefulness of new external knowledge, advances a good understanding of the potential commercial exploitation

opportunities of this type of knowledge (Cooke, 2001; Fazeli, 2005), and therefore, increases the firm's chances of forming alliances focusing on the commercialisation of new products.

Another important aspect of this chapter which is of greater interest, is the differences it highlights in the factors affecting firms' exploitation alliance behaviours in the US and Europe. We find that firms' engagement with exploitation alliances depends on the exploitation-based RACAP in Europe but not in the US. This probably relates to the fact that the European biopharmaceutical industry has been under-exploitating its existing science base (e.g. de Looze et al, 2001; Lemarie et al, 2000; Sharp, 1995; Orsenigo, 1989), and although it has been "decisively back on track" in recent years (Ernst & Young, 2006), most of the incumbent firms are not properly aware of the commercial advantage of their new technologies. This situation arised, as a result of the lower level of market-based alliance activities in Europe, which is also the main way to promote the commercialisation of public research in Europe (Europe Biotechnology Innovation System Report, 2001). Meanwhile, the exploitation mechanisms in Europe are not as effective as those in the US, which are always stronger and swifter (Cooke, 2001), because of lower level of public support and less amount of venture capital investment received (Bains, 2006; Fazeli, 2004). In addition, recent research shows that this private exploitation advantage of the US biopharmaceutical industry has been significantly enhanced with a new round of more aggressive search and selection by a powerful venture capital system, typified as Kleiner Perkins, Caufield & Byers (Cooke, 2001), which is largely absent in Europe.

In addition to the main parameters of interest, we find that some of our control variables, namely, firm characteristics (i.e. firm age, firm size), strategic focus, particularly basic R&D and preclinical development, marketing and sales significantly affect firms' engagement with exploitation alliances. In particular, an inverted U-shape relationship between firm size and number of exploitation alliances is observed in general, and the same result holds across our US and European respondent firms (Figure 8.1). This kind of relationship might arise because the effectiveness with which a firm can select and manage partners is subject to the effectiveness of internal communication and information processing requirements. As firm size increases, so do organisational redundancies, and this in turn prolongs the process of internal communication and information processing,

therefore limiting the efficiency of knowledge exchange throughout units (Galunic and Rodan, 1998), and increasing the likelihood of conflict regarding corporate goals and implementation (Rindfleisch and Moorman, 2001). In this way, the growth of exploitation alliances will decline, after firm size increases past a certain critical point, thus impeding the growth of firms' exploitation alliances.

Table 8. 1: Variable Descriptives

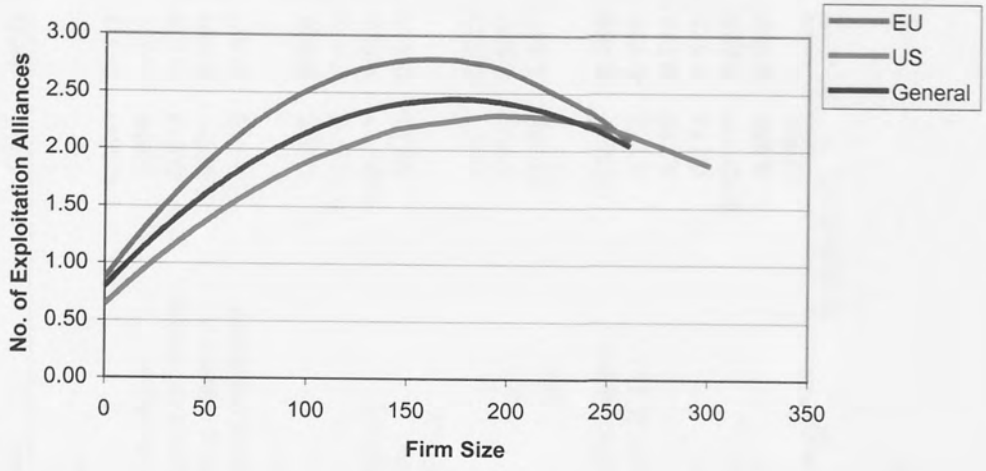
Variables		All Firms (n=349)		EU (n=205)		US (n=144)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
No. of exploitation alliances	(per firm)	2.10	6.467	2.03	7.049	2.18	5.643
RACAP Measures							
Market monitoring capability	(% of firms)	65.03	0.48	62.37	0.49	68.57	0.47
Knowledge management capability	(% of firms)	63.30	0.48	63.30	0.48	63.31	0.48
Knowledge monitoring capability	(% of firms)	87.23	0.33	86.77	0.34	87.86	0.33
Internal communication capability	(% of firms)	75.38	0.43	73.12	0.44	78.42	0.41
No. of patents currently*	(per firm)	33.79	86.15	**20.21**	54.78	**53.10**	114.63
Firm Characteristics							
Firm age	(year)	13.60	12.41	12.10	11.53	15.90	13.30
No. of employees	(per firm)	47.00	84.04	35.00	68.01	65.00	101.25
Independent company	(% of firm)	83.50	0.37	80.30	0.40	88.10	0.33
Market Characteristics							
Regional market	(% of firms)	76.10	0.43	74.50	0.44	78.30	0.41
Foreign market	(% of firms)	47.30	0.50	47.10	0.50	47.60	0.50
External market	(% of firms)	32.10	0.47	26.80	0.44	39.60	0.49
Strategic Focus							
Basic R&D and preclinical Dev.	(% of firms)	67.30	0.47	60.00	0.49	77.80	0.42
Clinical trials (Phase I, II, III)	(% of firms)	38.10	0.49	26.30	0.44	54.90	0.50
Manufactory	(% of firms)	51.60	0.50	46.80	0.50	58.30	0.50
Regulatory support	(% of firms)	38.00	0.49	21.40	0.41	61.10	0.49
Marketing and sales	(% of firms)	47.50	0.50	52.20	0.50	41.00	0.49

Source: Author's Survey

* p=0.003

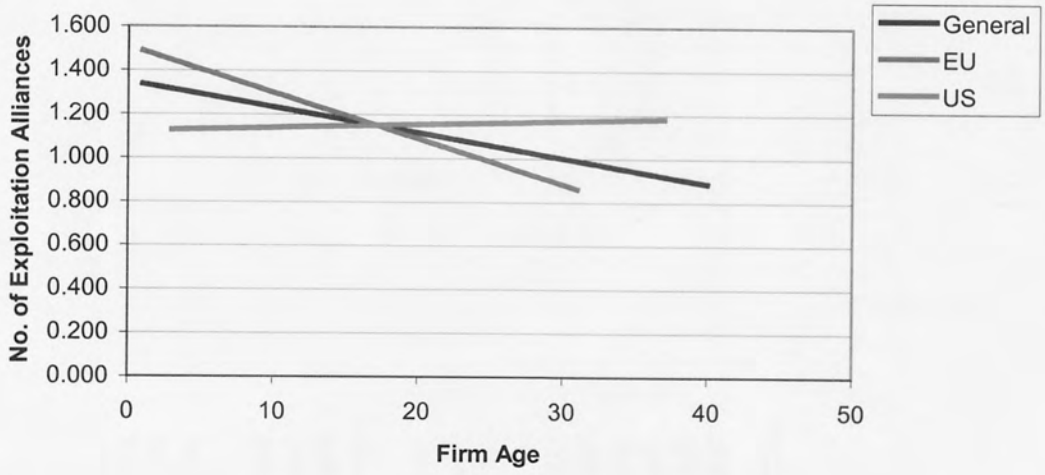
Notes: Mean values in bold format represent the existence of significant difference between the US and Europe regarding the same variable.

Figure 8. 1: Predicted Number of Exploitation Alliances: By Firm Size



Notes: Computed from marginal effect coefficients in Table 6.1 and 6.4. Variables at mean values.

Figure 8. 2: Predicted Number of Exploitation Alliances: By Firm Age



Notes: Computed from marginal effect coefficients in Table 6.1 and 6.4. Variables at mean values.

Table 8. 2: Zero-inflated Negative Binominal Regression Model of Exploratory Alliances: Whole Sample

Independent variables	Coef.	dy/dx
RACAP Indicators		
No. of patents	0.004*	0.013
Market monitoring capability	0.008	0.028
Knowledge management capability	-0.036	-0.125
Knowledge monitoring capability	0.907**	2.299
Internal communication capability	0.216	0.710
Firm Characteristics		
Firm age	-0.013	-0.046
No. of employees	0.020***	0.068
No. of employees Square	0.000***	0.000
Independent company	-0.111	-0.402
Market Characteristics		
Regional market	-0.007	-0.023
Foreign market	0.405	1.430
External market	0.342	1.263
Strategic Focus		
Basic R&D and preclinical dev.	-0.750**	-3.072
Clinical trials (Phase I, II, III)	-0.252	-0.852
Manufactory	-0.210	-0.736
Regulatory support	0.154	0.545
Marketing and sales	0.725***	2.585
Nationality (euus)	0.254	0.867
cons	-0.094	
Number of obs = 237	Wald chi2 (18) = 95.84***	

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 8. 3: Zero-inflated Negative Binominal Regression Model of Exploratory Alliances: Firm with Existing Exploitation Alliance(s)

Independent variables	Coef.	dy/dx
RACAP Indicators		
No. of patents	0.004*	0.013
Market monitoring capability	0.008	0.031
Knowledge management capability	-0.036	-0.134
Knowledge monitoring capability	0.907**	2.419
Internal communication capability	0.216	0.767
Firm Characteristics		
Firm age	-0.013	-0.049
No. of employees	0.020***	0.073
No. of employees Square	0.000***	0.000
Independent company	-0.111	-0.431
Market Characteristics		
Regional market	-0.007	-0.025
Foreign market	0.405	1.550
External market	0.342	1.347
Strategic Focus		
Basic R&D and preclinical dev.	-0.750**	-3.408
Clinical trials (Phase I, II, III)	-0.252	-0.958
Manufactory	-0.210	-0.792
Regulatory support	0.154	0.575
Marketing and sales	0.725***	2.685
Nationality (euus)	0.254	0.950
cons	-0.094	
Number of obs = 99	Wald chi2 (18) = 90.49***	

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 8. 4: Zero-inflated Negative Binominal Regression Model of Exploratory Alliances: Split EU/US Explanatory Variables

Independent variables	Coef	dy/dx
RACAP Indicators		
No. of patents for EU firms	0.008**	0.029
No. of patents for US firms	0.002	0.005
Market monitoring capability for EU firms	-0.379	-1.248
Market monitoring capability for US firms	0.261	0.954
Knowledge management capability for EU firms	0.107	0.375
Knowledge management capability for US firms	0.159	0.572
Knowledge monitoring capability for EU firms	0.916*	3.304
Knowledge monitoring capability for US firms	0.801~	3.105
Internal communication capability for EU firms	0.370	1.332
Internal communication capability for US firms	-0.089	-0.304
Firm Characteristics		
Firm age	-0.011	-0.039
No. of employees	0.020***	0.068
No. of employees square	0.000***	0.000
Independent company	-0.024	-0.082
Market Characteristics		
Regional market	0.046	0.158
Foreign market	0.393	1.384
External market	0.168	0.598
Strategic Focus		
Basic R&D and preclinical dev.	-0.715**	-2.897
Clinical trials (Phase I, II, III)	-0.280	-0.941
Manufactory	-0.090	-0.312
Regulatory support	0.073	0.255
Marketing and sales	0.707***	2.509
cons	-0.051	
Number of obs = 237	Wald chi2 (22) = 144.44***	

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 8.4. 1: Wald Tests for the Equality of Coefficients: US Versus Europe

	DF	χ^2
No. of patents	2	11.41**
Market monitoring capability	2	1.72
Knowledge management capability	2	0.34
Knowledge monitoring capability	2	10.05**
Internal communication capability	2	0.83

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 8. 5: Zero-inflated Negative Binominal Regression Model of Exploratory Alliances: Separate US and EU Equations

	EU		US	
	Coef.	dv/dx	Coef.	dv/dx
RACAP Indicators				
No. of patents	0.007~	0.025	-0.0005	-0.001
Market monitoring capability	-0.144	-0.547	0.5105~	1.527
Knowledge management capability	-0.167	-0.639	0.2692	0.853
Knowledge monitoring capability	0.810~	2.307	1.0186*	2.307
Internal communication capability	0.492	1.663	-0.0651	-0.217
Firm Characteristics				
Firm age	-0.021	-0.078	0.0016	0.005
No. of employees	0.024**	0.089	0.0167***	0.055
No. of employees Square	0.000**	0.000	0.0000***	0.000
Independent company	-0.142	-0.560	0.2583	0.761
Market Characteristics				
Regional market	0.032	0.119	-0.1764	-0.604
Foreign market	0.575	2.213	0.2194	0.723
External market	0.321	1.290	-0.0277	-0.090
Strategic Focus				
Basic R&D and preclinical dev.	-0.903*	-3.951	-0.4684~	-1.745
Clinical trials (Phase I, II, III)	-0.633	-2.059	-0.1292	-0.425
Manufactory	-0.194	-0.724	0.2159	0.689
Regulatory support	0.494	2.161	-0.2807	-0.942
Marketing and sales	0.452	1.657	0.7270***	2.598
Cons	0.382		-0.7641	
	Number of obs = 136		Number of obs = 101	
	Wald chi2 (17) = 80.95***		Wald chi2 (17) = 118.89***	

Source: Author's Survey

~ $\rho < 0.1$

* $\rho < 0.05$

** $\rho < 0.01$

*** $\rho < 0.001$

CHAPTER 9

RACAP, EXPLOITATION ALLIANCES AND COMPETITIVE ADVANTAGE

9.1 Introduction

This chapter empirically analyses the effect of RACAP and exploitation alliances on firms' competitive advantage. Using data from our large-scale survey of 2,173 biopharmaceutical firms across the US and Europe, we investigate how a firm's RACAP and exploitation alliances shape its competitive advantage. Further insights are gleaned by differentiating between the data relating to the US and European respondent firms.

External knowledge sourcing and internal capabilities development are identified as two important elements in the science-based industries like biopharmaceuticals, where knowledge and innovation are seen as the principal drivers of value-creation (Prahala and Hamel, 1990; Zuboff, 1996). The radical technology change and complexity of high technology products require the possession of advanced knowledge and skills in various technology fields. High technology firms may not have some knowledge or skills internally, and have to obtain these from external sources (Zahra, 1996). These firms access external sources of knowledge through alliances and harvest this knowledge by creating innovative products, goods and services (Arora and Gambardella, 1994; Deeds and Hill, 1996; Zahra and Bogner, 2000). As firms develop relationships to gain access to external knowledge, their ability to process and transfer the knowledge from one context to another becomes critical (Powell, 1998).

The relationship between RACAP and competitive advantage is more concerned with a dynamic capability view of competitive advantage (Eisenhardt and Martin, 2000), which emphasizes that the origins of competitive advantage may lie in the dynamic capabilities to identify and respond to environmental cues well in advance of observing performance-oriented pay-offs (Cockburn, 2000; Stichcombe, 2000, Amit and Zott, 2001). These dynamic capabilities are embedded in a firm's routines and processes, making it possible to analyse the stocks and flows of a firm's knowledge and relate these variables to the

creation and sustainability of competitive advantage (Zahra and George, 2002). Given the greater availability of external knowledge sources in the biopharmaceutical sector, a dynamic capability enables a firm to target, absorb and deploy the external knowledge necessary to feed the internal innovation process, and therefore, becomes a crucial source of competitive advantage (Fosfuri and Tribo, 2006).

Our study of the relationship between exploitation alliances and competitive advantage relates to the relational view of competitive advantage (Oliver, 1990) where strategic alliances are considered as central to the substance of competitive advantage. It shifts the important unit of analysis for understanding competitive advantage from firm level to inter-organisational level, by suggesting that a firm's critical resources may span firm boundaries and may be embedded in interfirm resources and routines (Dyer and Singh, 1998). Exploitation alliances are entered into with the goal to join existing competencies across organisational boundaries in order to generate synergies, which are then shared across the partners (Koza and Lewin, 1998). They can be characterised by the union of complementary assets (Teece, 1986), which is identified as one of the important sources of inter-organisational competitive advantage (Dyer and Singh, 1998).

We make two main contributions to the research in the area of absorptive capacity, alliances and competitive advantage. First and foremost, our findings provide empirical evidence for the theoretical studies focusing on RACAP (Zahra and George, 2002) and exploitation alliances (Koza and Lewin, 1998), in particular for how they influence firms' competitive advantage. Secondly, whilst previous research, relates exploitation alliances and PACAP to a firm's new product development (i.e. George et al, 2001; Rothaermel and Deeds, 2004), and innovation performance (Fosfuri and Tribo, 2006), we believe that our study brings new insights to this body of research by providing one of the few empirical analyses of the effects of RACAP and exploitation alliances on firms' competitive advantage.

The remainder of the chapter has the following structure: we begin with an overview of the key literature in areas of competitive advantage, exploitation alliances and RACAP, and build our hypotheses upon the theoretical underpinnings of these bodies of knowledge. We then briefly describe the data and the econometric approach that has been adopted. This is

followed by an empirical test of the hypotheses and a summary of the relevant results. Finally, we draw some conclusions based on a discussion of the empirical results, and the implications of these results are provided in chapter 12.

9.2 Literature and Hypotheses

9.2.1 Competitive Advantage

Studies about the origin of firms' competitive advantage tend to be surrounded by four main streams of arguments that are typified as the resource-based view (Barney, 1991), relational view (Dyer and Singh, 1998), institutional view (Zukin and DiMaggio, 1990), and industry structure view (Porter, 1980).

The resource-based view (RBV) argues that competitive advantage lies in the rare, specialised, inimitable resources and resource market imperfections that cause firm heterogeneity, and that successful firms are those that acquire and maintain valuable idiosyncratic resources for sustainable competitive advantage (Barney, 1991; Dierickx and Cool, 1989; Rumelt 1984).

In comparison to the RBV, the relational view (Dyer and Singh, 1998), offers a different, but complementary viewpoint about a firm's competitive advantage and suggests that a firm's critical resources may span firm boundaries and may be embedded in inter-firm resources and routines. It stresses that an increasingly important unit of analysis for understanding competitive advantage is the relationship between firms. In favour of this stream of arguments, institutional theory suggests firms' tendency toward conformity with predominant norms, traditions, and social influences in their internal and external environments lead to homogeneity among firms in their structures and activities, and that successful firms are those that gain support and legitimacy by conforming to social pressures (Oliver, 1992; Zukin and DiMaggio, 1990). At the inter-organisational level, these pressures mainly emerge from government, industry alliances and societal

expectations (DiMaggio and Powell, 1983). In other words, a firm's ability to manage inter-firm relations is one source of its sustainable advantage.

Quite differently, the industry structure view (Porter, 1980) argues that a firm's competitive advantage depends on its relative bargaining power. The mechanism to sustain this kind of advantage lies in the barriers to entry into an industry.

The resource-based view focuses on how individual firms generate supernormal returns based upon resources, assets, and capabilities that are housed within a firm, whereas the relational view considers the dyad/network as the unit of analysis and the rents that are generated to be associated with the dyad/network. Similarly, the industry structure view shifts the unit of analysis from the firm-level to the network-level, but it emphasises that the relationship between a firm and other network members is competition-orientated rather than alliance-orientated.

Although these arguments may be complementary to each other at a certain level, in effect, they are rather contradictory. For example, according to the resource-based view, an individual firm should attempt to protect, rather than share, valuable proprietary know-how to prevent knowledge spillover, which could erode or eliminate its competitive advantage. However, an effective strategy from a relational perspective should be for firms to systematically share valuable know-how with alliance partners (and willingly accept some spillover to competitors) in return for access to the stock of valuable knowledge residing within their alliance partners[30] ((Dyer and Singh, 1998). A similar example can be found in the competing views of a firm's relationship with its suppliers; the industry structure view suggests that firms should be eager to increase the number of their suppliers, and thereby maximise their bargaining powers and profits, whereas the relational view argues that, firms can increase profits by increasing their dependence on a smaller number of suppliers, thereby increasing the incentives of suppliers to share knowledge and make performance-enhancing investments in relation-specific assets.

Although these different arguments provide normative prescriptions to practising managers, and deepen our understanding of competitive advantage, the clear contradictions between

[30] Notably, this strategy only makes sense when the expected value of the combined inflows of knowledge from partners exceeds the expected loss/erosion of advantages due to knowledge spillover to competitors.

these views suggest that existing theories of advantage are not adequate to explain competitive advantage (Dyer and Singh, 1998).

9.2.2 Exploitation Alliances and Competitive Advantage

The relational view (Dyer and Singh, 1998) suggests that a firm's critical resources may span its boundary and may be embedded in inter-firm resources and routines. Dyer and Singh (1998) argue that an increasingly important unit of analysis for understanding competitive advantage is the relationship between firms. In fact, many studies have empirically corroborated that inter-firm collaboration contributes to the improvement of firms' performance and therefore provides a potential source of competitive advantage (Eisenhardt and Schoonhoven, 1996; Stuart, 2000; Hafsi and Xin, 2005; Gnyawali and Madhavan, 2001; Teng, 2007). For example, Sarkar et al (2001) found that alliance proactiveness led to superior market-based performance, and in particular in the biopharmaceutical industry, when the perceived technological uncertainty was higher, this effect was even stronger.

Earlier studies on strategic alliances formation that were grounded in transaction cost and game theories, over-emphasised the economic rents generated by alliances, and were confined to certain specific benefits associated with collaboration, such as learning, lower transaction costs, or pooling of resources (Dore, 1983; Dyer, 1996; Hamel, 1991; Larson, 1992; Powell et al, 1996; Teece, 1987). Recently, however, there has been increasing attention on the relational rents achieved by inter-organisational collaboration (Dyer and Singh, 1998).

Exploitation alliances are entered into with the goal to join existing competencies across organisational boundaries in order to generate synergies, which are then shared across the partners (Koza and Lewin, 1998). Exploitation alliances ensure that each potential partner has 'complementary resources' that can be accessed via inter-firm cooperation (Rothaermel, 2001; Teece, 1986). When combined, these resources result in a synergistic effect whereby the combined resource endowments are more valuable, rare, and difficult to imitate than they had been before they were combined (Dyer and Singh, 1998), and

therefore, they generate greater rents than the sum of those obtained from the individual endowments of each partner (Dyer and Singh, 1998). Similarly, Barney (1995) explains that specialised skills/capabilities that result from socially complex phenomena unique to a firm, are more likely to lead to advantages that are hard for competitors to duplicate. Thus, exploitation alliances provide a potential source of competitive advantage, and produce stronger competitive positions than those achievable by the firms operating individually.

In the studies of inter-firm collaboration in the biopharmaceutical industry, Teece (1992) and Rothaermel (2001) link exploitation alliances and competitive advantage together with biopharmaceutical firms' new product development. They found that exploitation alliances were positively associated with participant firms' new product development and in turn, improved their performance. Continued product introductions are particularly important in hyper-competitive environments (D'Aveni, 1994). New product introductions may allow the firm to establish first mover advantages and enjoy a temporary monopoly (Lieberman and Montgomery, 1988). This is particularly true in the biopharmaceutical industry where standards or effective patent protection create winner-take-all scenarios (Hill, 1997). Additionally, radical technological change in the biopharmaceutical industry that undermines incumbent firms' upstream value chain activities, will cause those firms to seek out a new source of competitive advantage within the redefined technological framework (Dosi, 1982). Therefore, participation in exploitation alliances with providers of the new technology creates a new source of competitive advantage when the incumbents have complementary assets within their firm boundaries that are critical to commercialise the new technology (Rothaermel, 2001). Sarkar et al (2001) offer an illustration, that being that in pharmaceuticals, the technological shift from organic chemistry to life science-based drug development implies that incumbent pharmaceutical companies that are capable of locking-in innovative new biotech firms through exploitation alliances are likely to be advantaged in product innovation. In an environment of technological change such as this, firms' participation in exploitation alliances should bring the advantage of being early movers.

Thus, we anticipate,

Hypothesis 4.1: There exists a positive relationship between exploitation alliances and participant firms' competitive advantage in the biopharmaceutical industry.

9.2.3 Realised Absorptive Capacity (RACAP) and Competitive Advantage

Realised absorptive capacity can improve a firm's performance by "exploiting existing internal and external firm-specific competencies to address changing environments" (Teece et al, 1997, p.510). In fact, Rothaermel and Thursby (2005) suggest that absorptive capacity itself is a set of firm-level capabilities that is expected to be heterogeneously distributed among firms and thus, should lead to variance in performance. Realised absorptive capacity is termed as a function of transformation and exploitation capabilities, which reflects the firm's capacity to leverage the knowledge that has been absorbed (Zahra and George, 2002). Cockburn (2000) and Stinchcombe (2000) found the origins of competitive advantage may, therefore, lie in the ability to identify and respond to environmental cues well in advance of observing performance-oriented pay-offs. A firm with well-developed realised absorptive capacity could predict the commercial potential of the technology more accurately, and it could, therefore, combine its existing knowledge and the new technology, and apply it to the commercial end more effectively. Consequently, realised absorptive capacity creates a source of competitive advantage, and in particular in the biopharmaceutical industry, where so called 'science-driven' drug discovery strategy has become very popular in response to the acceleration in the growth of publicly-available biological knowledge in the late 1970s.

Transformation capability denotes a firm's capability to develop and refine the routines that facilitate the combination of existing knowledge and newly-acquired and assimilated knowledge (Zahra and George, 2002). In fact, combining new knowledge with a firm's existing knowledge base is an important way to create new products (Zander and Kogut, 1995) and improve financial performance (Zahra et al, 2000). Exploitation capability, on the other hand, is built upon the routines that allow a firm to incorporate acquired and transformed knowledge into its operations (Zahra and George, 2002). These routines are socially complex and could be a valued organisational resource (Collis, 1994; Hall, 1992). Superior knowledge exploitation capability is identified by prior studies as one of the

important factors which will incur superior innovation and performance (i.e. Cockburn and Henderson, 1998; George et al, 2001; Leonard-Barton, 1995; Rothaermel and Thursby, 2005; Van den Bosch et al, 1999).

The transformation and exploitation dimensions of realised absorptive capacity facilitate firms' product and process innovation (Love and Roper, 1999), which is identified as one of the most important ways to achieve competitive advantage in dynamic markets (Barney, 1991). In particular, Kazanjian et al (2002) found that firms required knowledge leveraging and the recombination of skills to pursue product line extension and new product development. Transformation capability helps firms to develop new perceptual schema or changes to existing processes through the process of bisociation (Zahra and George, 2002). Exploitation capability takes this a step further and converts knowledge into new products (Kogut and Zander, 1996). Thus, realised absorptive capacity enhances firm performance (Liebaskind, 1996) and yields a competitive advantage. We predict, therefore:

> Hypothesis 4.2: The transformation dimension of RACAP is positively related to a biopharmaceutical firm's competitive advantage.

> Hypothesis 4.3: The exploitation dimension of RACAP is positively related to a biopharmaceutical firm's competitive advantage.

9.2.4 Market Characteristics

Barney (2001) suggests that for firms to obtain economic rents, they must acquire the resources and capabilities needed to conceive of and implement strategies in imperfectly competitive strategic factor markets. In dynamic industries like the bio-pharmaceutical industry, where firms extensively use alliances to gain access to complementary resources, continuing investment in in-house capabilities provides the firm with a greater realised absorptive capacity. This allow firms to transform the know-how embedded in the complementary resources, and combine them with their existing knowledge to create valuable and rare conditions that can exploit product market imperfections that create rent-producing potential (Maijoor and van Witteloostuijin, 1996).

According to the industry structure view (Porter, 1990), firms should strive to expand their main markets to increase their customer base, thereby maximising bargaining power and profits. Especially, when the product comes into the mature stage, and the patent protection period expires, existing technology know-how could be very easily imitated by their incumbent industry competitors. Also because of the fast-changing technology base of the biopharmaceutical industry, firms are competing to achieve product innovation, and this in turn accelerates the emergence of substitutes of existing products very soon after the new products have been commercialised. Thus, expanding their main markets allows firms to shift their new product life cycle to other markets i.e. external or foreign markets, and therefore lessen the threat from incumbent industry competitors (e.g. other incumbent pharmaceutical companies), new entrants (e.g. new biotechnology firms), and substitute products in the existing markets. On the other hand, introducing existing products to other markets may allow the firms to establish first mover advantages and enjoy a temporary monopoly in those markets (Lieberman and Montgomery, 1988). This is particularly true in the biopharmaceutical industry where standards for effective patent protection create winner-take-all scenarios (Hill, 1997).

Thus, we propose:

> Hypothesis 4.4: Market characteristics are positively related to a biopharmaceutical firm's competitive advantage.

9.3 Data and Methods

Data for the estimation are taken from our main survey, which offers comparable information on exploitation alliances, RACAP and competitive advantage, relating to 205 European biopharmaceutical firms and 144 US firms. This corresponds to a response rate of 17.5 percent in Europe and 14.4 percent in the US with a general response rate of 16.0 percent. Firms responding to our main survey provided background information on the company, details of their latest sales growth, and information on their absorptive capacities

and alliance activities. Typical respondent firms are 13.6 years old, and have an average size of 47 full-time employees.

Table 9.1 provides a description of the responses from these firms. In terms of our measures for transformation dimension, the majority (more than 63.3 percent) of the respondent firms have well-developed capabilities in market monitoring, knowledge management, knowledge monitoring and internal communication. And the proportion of the firms with well-developed knowledge transformation capabilities in the US and Europe is very similar (Table 9.1). For firms' exploitation alliance activities, the indicator - number of exploitation alliances, is a count variable taking on discrete non-negative integer values but including zero, and our respondent firms show an average of 2.1 exploitation alliances. We find a signficant difference between the US and Europe in firms' exploitation capabilities measured by the average number of patents held by our repondent firms, which is generally greater in the US, and more than twice amount held by the European firms.

The impact of RACAP and exploitation alliances on firms' competitive advantage predicted in our hypotheses can be modeled by a simple linear formulation as follows:

$$A_l = \alpha + \beta_1 TransformC_l + \beta_2 ExploiC_l + \gamma Exploi_l + \delta_1 FC_l + \delta_2 MC_l + \delta_3 SP_l + \varepsilon_l$$

where A_l is the competitive advantage (proxied by sales growth). β_m coefficients capture the potential for a relationship between RACAP and sales growth, γ indicates the effect of exploitation alliances on sales growth and the δ_m the impact of three groups of control variables relating to firm characteristics (FC), market characteristics (MC) and firms' strategic profile (SP). Our dependent variable, sales growth has a mean value of 59.5 percent, and on average, the European respondent firms grow faster than those in the US. However, as we only consider the value of sales growth as from –0.8 to 3, and drop all the observations in which the value of sales growth is less than –0.8 or more than 3, it would be inappropriate to use a Tobit estimator, which requires censored data with all the observation included. Meanwhile, this also amounts to a restriction of range on both of our dependent and independent variables. As a consequence, it will incur the change of the coefficient of our independent variables in comparison to the results without restriction.

Thus, OLS estimates would be biased. A better approach to analyse this type of data (i.e. the truncation of sales growth) is to use truncated regression (Greene, 2003).

We also control those variables relating to a firm's background characteristics (e.g. age, size, ownership status), the geographic market orientation of the firm and its strategic focus (Table 9.1) in the econometric analysis. On average the US respondent firms are marginally older, larger and more likely to be independent firms than the European respondents. They are also more likely to be engaged in the early stage of the discovery process but less likely than the EU firms to be engaged in sales and marketing activities (Table 9.1). In addition, sample weights[31] are derived according to the different response rates within Europe, and those between the US and Europe for adjusting for the non-response bias and some of the estimates and standard errors.

9.4 Empirical Results

Truncated estimates of equation are given for all of our US and European respondent firms (Table 9.2). We also differentiate between those values of each independent variable relating to the US and Europe in Table 9.3 to allow coefficients to be compared. Table 9.3.1 reports the Wald tests for the equality of the US and EU coefficients. The results further confirm the explanatory power of relational review in predicting firms' potential sources of sustained competitive advantage in the biopharmaceutical industry[32].

Hypothesis 4.1 predicts that there exists a positive relationship between exploitation alliances and participant firms' competitive advantage. However, in the results, we find a significant V-shape relationship between exploitation alliances and competitive advantage. A similar relationship is also found across the US and Europe, but is only significant in the European case. Holding all the other variables at their mean values, we illustrate this

[31] The absolute weights among different countries have been calculated as US 6.938, UKI3.636, France 7.057, and Germany 7.169.

[32] On average, each of the firms included in the study of this chapter has 2.5 exploratory alliances and 1.4 exploitation alliances with a size of 51 employees. The characteristics of these firms are close to the common features of the whole sample with respondent firms having an average of 2.8 exploratory alliances and 2.1 exploitation alliances with 47 employees in general. Therefore, they represent the typical respondent firms in our overall sample.

effect in Figure 9.1 which suggests that the turning point of increasing return of sales growth starts between one and two exploitation alliances in both the US and Europe. The suggestion is that although engagement in market-based alliances (exploitation alliances) may initially have a negative effect on a firm's competitive advantage in both the US and Europe, this relationship exhibits increasing returns once the firm has certain specific experiences in exploitation alliances. Thus, Hypothesis 4.1 is partially supported.

More significant results are achieved for the dimensions of RACAP – the knowledge-transformation capability and the knowledge-exploitation capability. In terms of the aspects of transformation capability, we find a significant and positive relationship between firms' market monitoring capability and competitive advantage, suggesting market-monitoring capability as an important source of competitive advantage for a firm. Therefore, regularly considering the impact of market changes for new products proves beneficial to the respondent firms. However, after we differentiate between those values of each independent variable relating to the US and Europe in Table 9.3, we find that the effect of transformation capability on firms' competitive advantage is mixed in Europe. In particular, sales growth has a significantly and positive relationship with a firm's market monitoring capability on one hand; on the other hand, it is negatively affected by the firm's knowledge monitoring capability, whereas in the US, a firm's sales growth is significant but negatively related to the knowledge management capability, providing little support for Hypothesis 4.2. The suggestion is that in Europe, the influence of the transformation dimension on firms' competitive advantage varies according to the different aspects of the transformation capability, while in the US, firms' knowledge transformation capability does not contribute to their competitiveness.

For the aspect of exploitation capability, we find a significant and inverted U-shape relationship between number of patents and sales growth, a result which is consistent across the US and Europe. We illustrate this effect in Figure 9.2 with all the other variables estimated at their mean value. Meaningful increases of sales growth appear to be within 1.1 standard deviations above the mean value of number of patents, which is around 80 in both the US and Europe (Figure 9.2). However, bearing in mind that the majority (around 82.5 percent) of our respondent firms have less than 30 patents, the effect of number of patents on firms' sales growth is considered to be significantly positive within the scope of

this study. Thus, Hypothesis 4.3 is supported. The suggestion is that exploitation-based RACAP plays an important role in shaping firms' competitive advantage in both the US and Europe.

In terms of firms' market characteristics, only external market proves a significant determinant of sales growth (Table 9.2), suggesting the development of external markets as a way for firms to seek a potential source of competitive advantage. However, other market characteristics such as regional market, and foreign market have insignificant and negative coefficients, providing little support for Hypothesis 4.4. This suggests that the industry structure view is only confined to the explanation of the relationship between a firm's external market activities and its competitive advantage.

These results are tested by separate TRUNCREG models estimated for the US and European respondent firms (Table 9.4). However, as there are not enough observation for the estimation in each case, the results in Table 9.4 might not be able to provide reliable evidence to confirm our previous findings of the influences of RACAP and exploitation alliances on firms' competitive advantage in Tables 9.2 and 9.3.

Additionally, we have some interesting findings from the set of control variables, in particular those relating to the firm characteristics. We find a significant but negative effect of firm age on sales growth in both the US and Europe (Figure 9.3). A similar effect is found in the relationship between size and firms' sales growth[33] (Figure 9.4). The results suggest that small start-up firms grow faster than large incumbent firms in both the US and Europe.

Taken as a whole, our results prove that RBV has its authority in explaining firm's competitive advantage in the biopharmaceutical industry. Specifically RBV extends our understanding of the relationship between a biopharmaceutical firm's internal capabilities and its potential source of sustained competitive advantage. This is reflected in the results that knowledge exploitation capability is a significant determinant of a firm's competitive advantage. Although both age and size prove significant and negative determinants of

[33] Although the relationship between firm size and sales growth actually takes on a significant U-shape, we only consider the significant negative relationship between them in this study, given that for 96.3 percent of our respondent firms, size has a negative effect on their sales growth.

firms' sales growth, the fact that large established firms grow more slowly than small start-up firms has been empirically demonstrated by many empirical studies (Almeida et al, 2003; Evans, 1987; Pisano, 1990).

9.5 Empirical Conclusions

The aim of our study in this chapter has been to investigate the impact of exploitation alliances, transformation and exploitation dimensions of RACAP on firms' competitive advantage in the context of the biopharmaceutical industry. Our empirical findings not only shed new light on the development of absorptive capacity, strategic alliances and innovation literature, but also provide important insight into the three sets of competing views: namely the relational view, resource-based view and industry structure view, in explaining firms' competitive advantage in the biopharmaceutical industry. Our study empirically corroborates the argument that accessing to complementary resources through exploitation alliances, and development of internal capabilities i.e. RACAP, is increasingly important to a biopharmaceutical firm's innovation performance, and shapes its competitive advantage (Caloghirou, 2004; Fosfuri, 2006; George et al, 2001; Nooteboom et al, 2006; Stuart, 2000; Rothaermel and Deeds, 2004). In particular, the international comparison in this study highlights the differences between the US and European biopharmaceutical firms' in their exploitation alliance activities and the management of RACAP. The findings, therefore, provide important empirical evidence to the comparative studies of the US and European biopharmaceutical industries (Cooke, 2001; Giesecke, 2000; Lavoie, 2000; Owen-Smith, 2002), particularly in respect of those that focus on firms' competitive advantage (Attridge, 2007; Narula, 1999; Thumm, 2001; Yeoh and Roth, 1999; Rothaermel, 2001).

Our results reveal a V-shape relationship between exploitation alliances and firms' competitive advantage, in particular in Europe, suggesting that engagement in market-based alliances (exploitation alliances) may initially have a negative effect on a firm's competitive advantage. This relationship exhibits increasing returns once the firm has certain specific experiences in exploitation alliances. On the one hand, the results highlight

the importance of partner-specific experience (Zollo et al, 2002) for those firms who have never been involved in exploitation alliances before. From a knowledge spillover perspective, engaging in alliances over time gives the opportunity to gain a more refined understanding of each other's culture, management system, capabilities, weaknesses and so forth. Thus, both partners might tacitly develop a set of routines that underpin the way they interact among themselves. These inter-organisational routines are reinforced and adapted in their subsequent alliance activities, and progressively smoothen their interaction patterns (Zollo et al, 2002). Alliance partners who develop this kind of routine find this strategy tends to help mitigate co-ordination, conflict resolution, or information-gathering problems, and consequently facilitates iterative learning and adjustment cycles (Doz, 1996). On the other hand, the results suggest that for firms that develop regular partnerships with other firms, participation in exploitation alliances contributes to the improvement of their competitive position. This reflects the results of previous research which suggests that exploitation alliances contribute to an improvement of participant firms' industry performance (i.e. Rothaermel, 2001; Shan et al, 1994). In specific terms, the results empirically support a relational view of exploitation alliances as a firm's potential source of competitive advantage in the context of the biopharmaceutical industry. Participation in exploitation alliances creates a new source of competitive advantage when the established firm has 'complementary assets' within its firm boundaries that are critical to commercialising the new technology (Rothaermel, 2001), and the start-up possesses state-of-the-art technology necessary for successful new products, and that are transferable for use in the established firm's development efforts (Shan et al, 1994).

Our results also suggest that exploitation-based RACAP (measured by number of patents) plays an important role in shaping a biopharmaceutical firm's competitive advantage in both the US and Europe. This empirically corroborates the argument of superior knowledge exploitation capability as one of the important factors which will incur superior innovation and performance (i.e. Cockburn and Henderson, 1998; George et al, 2001; Leonard-Barton, 1995; Rothaermel and Thursby, 2005; Van den Bosch et al, 1999); and reflects the results of previous studies which suggest patenting activities as a important factor affecting firms' innovation performance (McMillan et al, 2003; DeCarolis and Deeds, 1999; Atun et al, 2006; Niosi, 2003). Our results presented here place emphasis on the importance of firms' internal capabilities as a potential source of competitive advantage

(Caloghirou, 2004; Yeoh and Roth, 1999), and are therefore in favourite of a RBV of firms' competitive advantage. Unlike certain types of capabilities that are easily imitated by replication, internal capabilities are based upon highly complex organisational routines, which tend to defy successful replication (Yeoh and Roth, 1999). In dynamic industries like the bio-pharmaceutical industry, where firms extensively use alliances to access complementary resources, continuing investment in in-house capabilities provides a firm with a greater RACAP, allowing it to combine the know-how embedded in the complementary resources, with its existing knowledge to create valuable and rare conditions that can exploit product market imperfections that create rent-producing potential (Maijoor and van Witteloostuijin, 1996).

The most interesting aspect of the chapter is the differences it highlights in the determinants of firms' competitive advantage in the US and Europe. We find that exploitation alliances prove significant determinant of firms' competitive advantage in Europe but not in the US. The result is broadly consistent with the preceding research in the European biotechnology industry which finds that alliances and internal capabilities are important for upgrading innovative performance (Caloghirou, 2004). A possible explanation for this could be that the European firms under-exploit their existing science base (e.g. de Looze et al, 2001; Lemarie et al, 2000; Sharp, 1995; Orsenigo, 1989), and the exploitation mechanisms in Europe are not as effective as those in the US which are always stronger and swifter (Cooke, 2001), because of a lower level of public support and less amount of venture capital investment received (Bains, 2006; Fazeli, 2004); most of the incumbent firms could not be properly aware of the commercial advantage of their new technologies, and this makes exploitation alliances crucial for a firm's competitiveness in Europe, which is also the main way to promote the commercialisation of public research in Europe (European Biotechnology Innovation System Report, 2001). We also find that in Europe, a firm's competitive advantage depends strongly on its market monitoring capability while at the same time it is negatively affected by the knowledge monitoring capability. In the US, however, a firm's competitive advantage is negatively affected by its knowledge management capability. These results suggest that for those US biopharmaceutical firms with relatively high sales growth, recording and storing newly-acquired knowledge for future reference could not pose any competitive advantage; whereas for the same type of firms in Europe, recognition of the usefulness of new external

knowledge does not contribute to the improvement of their competitive position. And regular consideration of the impact of market changes for new products proves beneficial only to the European firms.

However, we could only find partial support for our hypothesis regarding firm's market characteristics (Hypothesis 4.4). Since only the external market proves a significant and positive determinant of firms' competitive advantage, other market characteristics such as regional market and foreign market, have negative and insignificant impacts on firms' competitive advantage. This suggests that the industry structure view could not completely explain firms' competitive advantage in the context of the biopharmaceutical industry. Expanding their main markets increases firms' customer base, thereby maximising their bargaining power and profits, and allowing them to establish first mover advantages and enjoy a temporary monopoly in those markets (Lieberman and Montgomery, 1988), especially in the biopharmaceutical industry where standards for effective patent protection create winner-take-all scenarios (Hill, 1997). However, when market uncertainty is high, the level of ambiguity about competitive behaviour, composition of customers and their preferences, and substitutes that may appear in that market, increase (Boyd et al, 1993). This makes customer definition and translation into product specification more complex and challenging (Tatikonda and Montoya-Weiss, 2001), thereby diminishing firms' first mover advantages. Meanwhile, shifting the new product development cycle to other markets incurs more transaction cost, management co-ordination cost, etc. And even if co-operating with local competitors for product distribution, there are still risks associated with knowledge spillovers, such as the steal of new product know-how by alliance partners.

In addition, our results show that some of our control variables, in particular those relating to firm characteristics, such as firm age and size, have significant and negative effects on firms' sales growth, suggesting that small start-up firms grow faster than large established ones (Evans, 1987). Increased size may enhance a firm's potential and abilities to exploit opportunities but at same time this may be offset by decreasing some of their abilities in respect of learning, in particular the ability to learn from more informal sources (Almeida et al, 2003). Equally, the fast-changing technology base in the biopharmaceutical industry makes established firms whose technology tradition is built around organic chemistry, foreign to biotechnology innovation (Pisano, 1990).

Table 9. 1: Variable Descriptives

Variables		All Firms (n=349)		EU (n=205)		US (n=144)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
No. of exploitation alliances	(per firm)	2.10	6.467	2.03	7.049	2.18	5.643
RACAP Measures							
Market monitoring capability	(% of firms)	65.03	0.48	62.37	0.49	68.57	0.47
Knowledge management capability	(% of firms)	63.30	0.48	63.30	0.48	63.31	0.48
Knowledge monitoring capability	(% of firms)	87.23	0.33	86.77	0.34	87.86	0.33
Internal communication capability	(% of firms)	75.38	0.43	73.12	0.44	78.42	0.41
No. of patents currently*	(per firm)	33.79	86.15	**20.21**	54.78	**53.10**	114.63
Competitive Advantage							
Sales growth	(% per firm)	59.50	1.342	64.40	1.472	51.30	1.097
Firm Characteristics							
Firm age	(year)	13.60	12.41	12.10	11.53	15.90	13.30
No. of employees	(per firm)	47.00	84.04	35.00	68.01	65.00	101.25
Independent company	(% of firms)	83.50	0.37	80.30	0.40	88.10	0.33
Market Characteristics							
Regional market	(% of firms)	76.10	0.43	74.50	0.44	78.30	0.41
Foreign market	(% of firms)	47.30	0.50	47.10	0.50	47.60	0.50
External market	(% of firms)	32.10	0.47	26.80	0.44	39.60	0.49
Strategic Focus							
Basic R&D and preclinical Dev.	(% of firms)	67.30	0.47	60.00	0.49	77.80	0.42
Clinical trials (Phase I, II, III)	(% of firms)	38.10	0.49	26.30	0.44	54.90	0.50
Manufactory	(% of firms)	51.60	0.50	46.80	0.50	58.30	0.50
Regulatory support	(% of firms)	38.00	0.49	21.40	0.41	61.10	0.49
Marketing and sales	(% of firms)	47.50	0.50	52.20	0.50	41.00	0.49

Source: Author's Survey

* p=0.003

Notes: Mean values in bold format represent the existence of significant differences between the US and Europe regarding the same variable.

Table 9. 2: Truncated Regression Model of Competitive Advantage: Baseline Model

Dependent variable	Sales Growth (%)	
Independent variables	Coef.	dy/dx
Exploitation Alliances		
Log(No. of Exploitation Alliance(s)+1)	-0.210*	-0.210
Log(No. of Exploitation Alliance(s)+1) Sq.	0.105*	0.105
RACAP Indicators		
Market Monitoring Capability	0.179**	0.179
Knowledge Management Capability	-0.044	-0.044
Knowledge Monitoring Capability	-0.186	-0.186
Internal Communication Capability	0.035	0.035
No. of Patents	0.006*	0.006
No. of Patents Square	0.000*~	0.000
Firm Characteristics		
Firm age	-0.007*	-0.007
No. of Employees	-0.002*	-0.002
No. of Employees Square	0.000*	0.000
Independent company	0.063	0.063
Market Characteristics		
Regional Market	-0.119	-0.119
Foreign Market	-0.081	-0.081
External Market	0.170*	0.170
Strategic Focus		
Basic R&D and Pre-clinical Dev.	-0.103	-0.103
Clinical Trials (Phase I, II, III)	0.024	0.024
Manufactory	-0.042	-0.042
Regulatory support	-0.055	-0.055
Marketing&sales	0.137*	0.137
Nationality (euus)	0.050	0.050
cons	0.495	
Number of obs = 162	Wald chi2(21) = 40.00**	

Source: Author's Survey

* ρ <0.1
*~ ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 9. 3: Truncated Regression Model of Competitive Advantage: Split US Vs. EU Explanatory Variables

Dependent variable	Sales Growth (%)	
Independent variables	Coef.	dy/dx
Exploitation Alliances		
Log(No. of Exploitation Alliance(s)+1) for EU	-0.247*	-0.247
Log(No. of Exploitation Alliance(s)+1) for US	-0.314	-0.314
Log(No. of Exploitation Alliance(s)+1) Sq. for EU	0.120*	0.120
Log(No. of Exploitation Alliance(s)+1) Sq. for US	0.142	0.142
RACAP Indicators		
Market Monitoring Capability for EU Firms	0.232**	0.232
Market Monitoring Capability for US Firms	0.093	0.093
Knowledge Management Capability for EU Firms	0.065	0.065
Knowledge Management Capability for US Firms	-0.273**	-0.273
Knowledge Monitoring Capability for EU Firms	-0.341*	-0.341
Knowledge Monitoring Capability for US Firms	0.000	0.000
Internal Communication Capability for EU Firms	0.101	0.101
Internal Communication Capability for US Firms	-0.027	-0.027
No. of Patents for EU Firms	0.007*	0.007
No. of Patents for US Firms	0.008*	0.008
No. of Patents Sq. for EU Firms	0.000*	0.000
No. of Patents Sq. for US Firms	0.000*	0.000
Firm Characteristics		
Firm Age	-0.009**	-0.009
No. of Employees	-0.002	-0.002
No. of Employees Square	0.000*	0.000
Independent Company	0.022	0.022
Market Characteristics		
Regional Market	-0.132	-0.132
Foreign Market	-0.072	-0.072
External Market	0.132	0.132
Strategic Focus		
Basic R&D and Pre-clinical Dev.	-0.083	-0.083
Clinical Trials (Phase I, II, III)	0.060	0.060
Manufactory	-0.061	-0.061
Regulatory Support	-0.025	-0.025
Marketing&Sales	0.152*	0.152
_cons	0.603	
Number of obs = 162	Wald chi2(28) = 56.60**	

Source: Author's Survey

* ρ <0.1
*~ ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 9.3. 1: Wald Tests for the Equality of Coefficients: US Versus Europe

Independent Variables	DF	χ^2
Exploitation Alliances		
Log(No. of Exploitation Alliance(s)+1)	2	4.94*
Log(No. of Exploitation Alliance(s)+1) Sq.	2	4.50
RACAP Indicators		
Market Monitoring Capability	2	11.06**
Knowledge Management Capability	2	7.75*
Knowledge Monitoring Capability	2	5.90*
Internal Communication Capability	2	2.05
No. of Patents	2	6.03*
No. of Patents Sq.	2	7.99*

Source: Author's Survey

* ρ <0.1
*~ ρ <0.05
** ρ <0.01
*** ρ <0.001

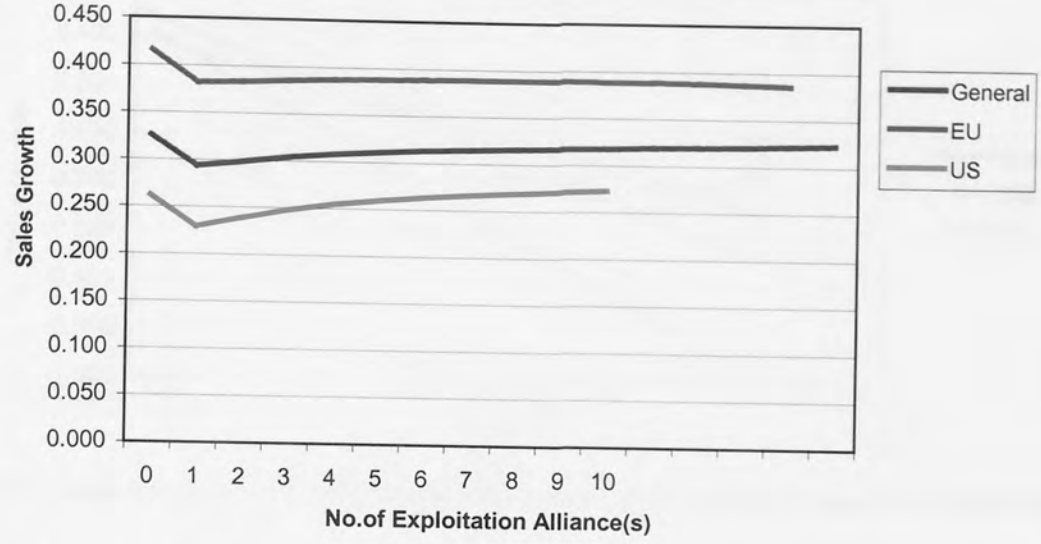
Table 9. 4: Truncated Regression Model of Competitive Advantage: Separate US&EU Equations

Dependent variable	EU	US
	Sales Growth	Sales Growth
Exploitation Alliances		
Log(No. of Exploitation Alliance(s)+1)	-0.203	-0.237
Log(No. of Exploitation Alliance(s)+1) Sq.	0.092	0.129
RACAP Indicators		
Market Monitoring Capability	0.247**	0.090
Knowledge Management Capability	0.043	-0.294*
Knowledge Monitoring Capability	-0.264*	-0.224
Internal Communication Capability	0.112	-0.001
No. of Patents	0.009*	0.006
No. of Patents Square	0.000*	0.000
Firm Characteristics		
Firm age	-0.010**	-0.014*
No. of Employees	-0.003	-0.001
No. of Employees Square	0.000	0.000
Independent company	-0.105	0.292
Market Characteristics		
Regional Market	-0.139	-0.252*
Foreign Market	0.072	-0.290*
External Market	-0.056	0.277*
Strategic Focus		
Basic R&D and Pre-clinical Dev.	-0.137	-0.010
Clinical Trials (Phase I, II, III)	0.023	0.109
Manufactory	-0.053	0.097
Regulatory support	0.239*	-0.219
Marketing&sales	0.087	0.197*
cons	0.701	0.647
	Number of obs = 97	Number of obs = 65
	Wald chi2(20) = 40.10**	Wald chi2(20) = 25.27

Source: Author's Survey

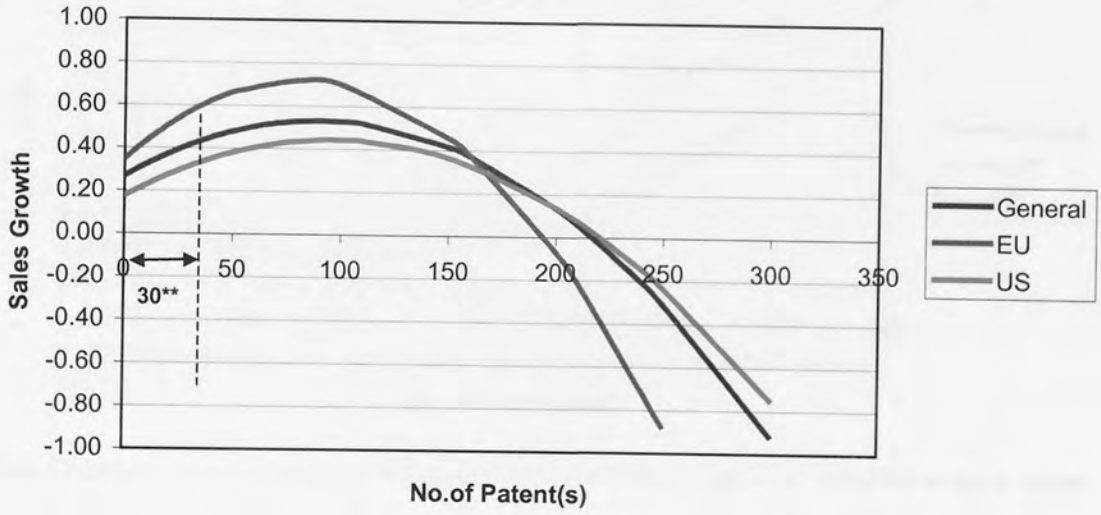
* ρ <0.1
*~ ρ <0.05
** ρ <0.01
*** ρ <0.001

Figure 9. 1: Predicted Competitive Advantage: By Exploitation Alliances



Notes: Computed from the marginal effect coefficients in Table 8.2and 8.4. Variables at mean values.

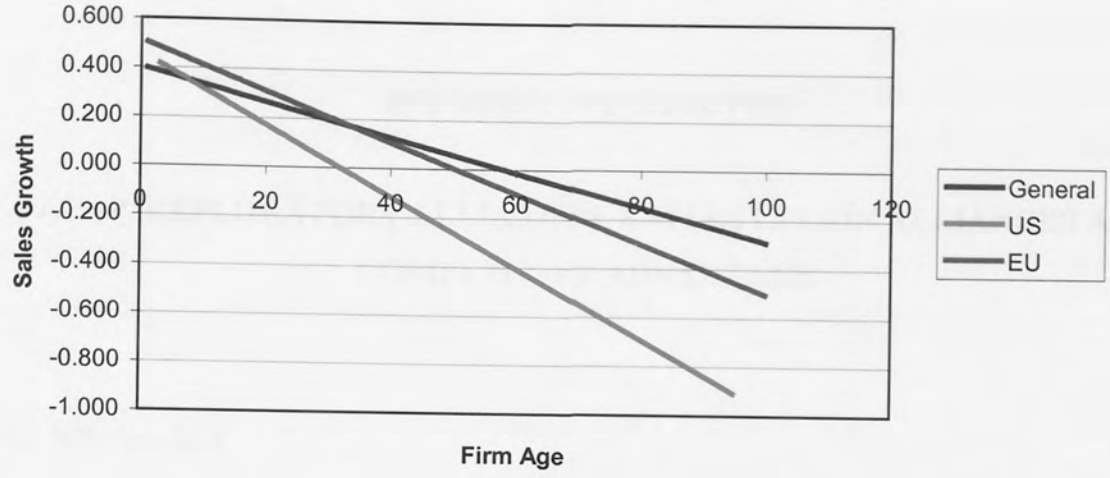
Figure 9. 2: Predicted Competitive Advantage: By Exploitation Dimension of RACAP[34]



Notes: Computed from the marginal effect coefficients in Table 8.2and 8.4. Variables at mean values.

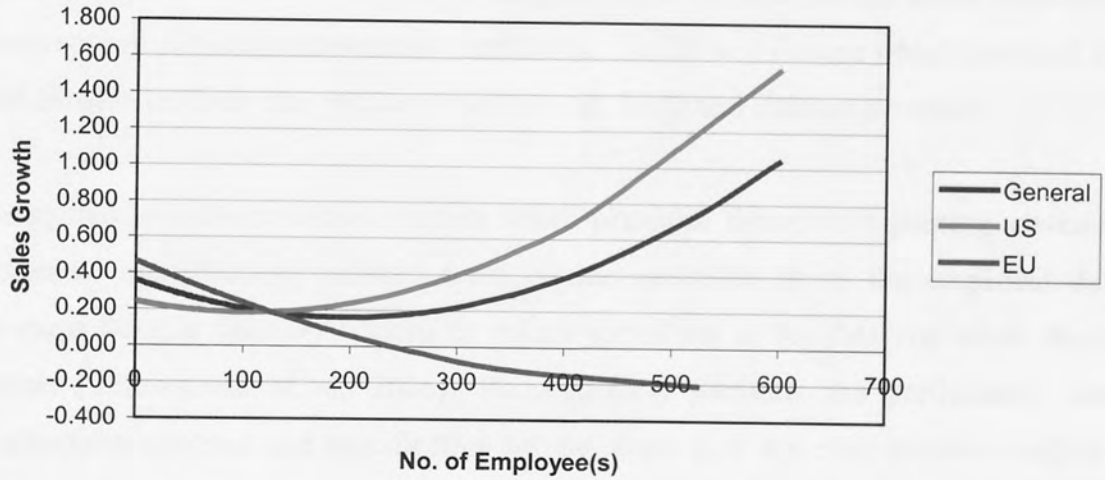
[34] 82.35 percent of our respondent firms have less than 30 patents, and 90.4 percent have less than 80 patents (including 80).

Figure 9. 3: Predicted Competitive Advantage: By Firm Age



Notes: Computed from the marginal effect coefficients in Table 8.2and 8.4. Variables at mean values.

Figure 9. 4: Predicted Competitive Advantage: By Firm Size



Notes: Computed from the marginal effect coefficients in Table 8.2and 8.4. Variables at mean values.

CHAPTER 10

INTEGRATIVE ANALYSIS

PACAP, EXPLORATORY ALLIANCES, EXPLOITATION ALLIANCES AND COMPETITIVE ADVANTAGE

10.1 Introduction

In this chapter, we are aiming to integrate the analysis of absorptive capacity, alliances and competitive advantage in the previous chapters through a reduced form model, which will provide more insights into the issue concerning how PACAP, exploratory, and exploitation alliances shape a firm's competitive advantage. The theoretical contexts concerning PACAP, exploratory alliances, exploitation alliances, and competitive advantage, have already been discussed in the earlier chapters. Data for analysis are taken from our large-scale survey of biopharmaceutical firms across the US and Europe which provided detailed information on their new product development, R&D and alliance activities.

Compared with the structural models which prioritise theory as a guiding source for the empirical specification, reduced form models prioritise fit to the empirical data and propose flexible functional forms to reflect variations in the data and allow the data to speak (Chintagunta et al, 2006). Reduced-form methods are particularly useful in exploratory analyses and specification testing, since they are often simpler, require fewer and much weaker assumptions, and allow for more flexible semi-parametric and non-parametric estimation methods (Chintagunta et al, 2006). This is in contrast with structural models which are only parametrically identified (Rust 1994) and could not be estimated by completely non-parametric methods. However, structural models allow a better reflection of the interaction between the dependent and independent variables. Reduced form models are criticised for running the risk of producing misleading forecasts of the effects of strategy changes that alter the stochastic context in which decisions are made (Chintagunta et al, 2006). For example in our case, a future change of existing strategies within a firm might impact on those factors which affect the firm's competitive advantage, while this

might not be reflected in the effects of PACAP, exploratory and exploitation alliances on firms' competitive advantage. Suppose, however, that the strategy change is known to occur, if structural estimates are available, they may be modified appropriately and revised reduced form estimates derived from them (Goldberger, 1964). Alternatively, a structural model could better address these issues by looking into the underlying decision-making mechanism and explicitly modeling the decision primitives (Guo, 2006), therefore providing a prediction that does not vary with the effects of strategy change.

We used structural equations to examine the interaction of PACAP, exploration alliances, RACAP and exploitation alliances in the earlier chapters. In this chapter, we adopt a reduced form approach to investigate the implicit assumptions that have been suggested by our previous structural models. We attempt to bring out the explicit dependence of competitive advantage on PACAP, exploratory and exploitation alliances. In addition, using a reduced form method in estimating the effect of PACAP, exploratory and exploitation alliances on competitive advantage, eliminates the interference of RACAP parameters, which is considered in our previous structural models, and therefore avoids the problem of developing additional measures for RACAP.

Our study in this chapter contributes to the literature in several ways. Firstly, our results provide important empirical evidence for the theoretical studies focusing on the notion of PACAP (Zahra and George, 2002) and the conceptual distinction between exploratory and exploitation alliances (Koza and Lewin, 1998), in particular for those investigating their influences on firms' competitive advantage (i.e. Zahra and George, 2002; Koza and Lewin, 1998). Secondly, we developed a set of measures capturing PACAP. Given that a better theoretical understanding of multiple faces of absorptive capacity is necessary, it would be important to empirically operationalise these distinctive characters. Finally, while previous studies relate PACAP, exploratory and exploitation alliances to firms' new product development (i.e. George et al, 2001; Rothaermel and Deeds, 2004), and innovation performance (Fosfuri and Tribo, 2006); our study adds new insights by providing one of the few empirical analyses of the effects of PACAP, exploratory and exploitation alliances on firms' competitive advantage.

In line with the previous chapters, the rest of this chapter is organised as follows: Section 10.2 explains the deduction method of our reduced form model and the hypotheses that have been formulated based on a review of the relevant literature on PACAP, exploration and exploitation alliances, and competitive advantage. Section 10.3 describes the data and the empirical methods that have been used to test our hypotheses. The following section presents the results of our empirical analysis. And a discussion of these empirical results is given in the final conclusion section of the chapter. The relevant implications are addressed in Chapter 12.

10.2 Literature and Hypotheses

10.2.1 Derivation of Reduced Form Model

In Chapter 7, we have already examined the influences of PACAP and exploratory alliances on firms' RACAP using the following formulations:

$$A_{ij} = \alpha_1 + \beta_{11} RDINT_{ij} + \beta_{12} RDCONT_{ij} + \beta_{13} EMSKILLS_{ij} + \gamma_1 EXPLOR_{ij} + \delta_{11} FC_{ij} + \delta_{12} MC_{ij} + \delta_{13} SP_{ji} + \varepsilon_{ij}$$

(10.1)

Where A_{ij} stands for the transformation capability of firm j, i denotes the subdimensions of firms' transformation capabilities. The β_{1j} coefficients capture the potential for a relationship between PACAP and the transformation capability, the γ_j indicates the effect of exploratory alliances on the transformation capability and the δ_{1j} the impact of three groups of control variables relating to firm characteristics (FC), market characteristics (MC) and firms' strategic profile (SP).

$$A_j = \alpha_2 + \beta_{21} RDINT_j + \beta_{22} RDCONT_j + \beta_{23} EMSKILLS_j + \gamma_2 EXPLOR_j + \delta_{21} FC_j + \delta_{22} MC_j + \delta_{23} SP_j + \varepsilon_j$$

(10.2)

In equation 10.2, A_j represents a firm's exploitation capability. β_{2j} coefficients capture the potential for a relationship between PACAP and the transformation capability, the γ_j indicates the effect of exploratory alliances on the transformation capability and the δ_{2j} the impact of three groups of control variables relating to firm characteristics (FC), market characteristics (MC) and firms' strategic profiles (SP).

In fact, the relationships between PACAP, exploratory alliances and RACAP tested by these two separate equations can be specified in a formulation as follows:

(10.1) + (10.2):

$$RACAP_K = \alpha_3 + \beta_3 PACAP_K + \gamma_3 EXPLOR_K + \delta_3 Control_K + \varepsilon_K \qquad \textbf{(10.3)}$$

$RACAP_K$ denotes a firm's realised absorptive capacity. The β_3 coefficient catches the potential for a relationship between PACAP and RACAP, the γ_3 indicates the effect of exploratory alliances on RACAP and the δ_3 the impact of three groups of control variables relating to firm characteristics (FC), market characteristics (MC) and firms' strategic profile (SP).

In chapter 9, we use the following equation to investigate how aspects of RACAP, exploitation alliances shape a firm's competitive advantage,

$$A_I = \alpha + \beta_1 TransformC_I + \beta_2 ExploiC_I + \gamma Exploi_I + \delta_1 FC_I + \delta_2 MC_I + \delta_3 SP_I + \varepsilon_I \qquad \textbf{(10.4)}$$

Where A_I is the competitive advantage, i.e. sales growth. β_m coefficients capture the potential for a relationship between aspects of RACAP and sales growth, γ indicates the effect of exploitation alliances on sales growth and the δ_m the impact of three groups of control variables relating to firm characteristics (FC), market characteristics (MC) and firms' strategic profile (SP).

The influences of RACAP and exploitation alliances on firms' competitive advantage examined by the formulation above can also be summarised as follows,

$$CA_m = \alpha_0 + \beta_4 RACAP_m + \gamma_4 Exploi_m + \delta_4 Control_m + \varepsilon_m \quad \textbf{(10.5)}$$

Here CA_m represents the competitive advantage, i.e. sales growth. β_4 coefficient captures the potential for a relationship between RACAP and sales growth, γ_4 indicates the effect of exploitation alliances on sales growth and the δ_4 the impact of three groups of control variables relating to firm characteristics (FC), market characteristics (MC) and firms' strategic profile (SP).

The structural form model 10.3 and 10.5 reflect the process of how exploration alliances and potential absorptive capacity affect sales growth through RACAP. To obtain a clear picture of the direct relationship between exploration alliances, potential absorptive capacity and sales growth, we aggregate these two models together and introduce an aggregate form model as follows:

$$CA_m = \alpha_0 + \alpha_3\beta_4 + \beta_3\beta_4 PACAP_k + \beta_4\gamma_3 EXPLOR_k + \beta_4\delta_3 Control_k + \beta_4\varepsilon_k + \gamma_4 Exploi_m + \delta_4 Control_m + \varepsilon_m \quad \textbf{(10.6)}$$

The corresponding reduced form model:

$$CA_n = \alpha_5 + \beta_5 PACAP_n + \gamma_{51} EXPLOR_n + \gamma_{52} Exploi_n + \delta_5 Control_n + \varepsilon_n \quad \textbf{(10.7)}$$

Here CA_n stands for the competitive advantage, measured by a firm's sales growth. β_5 captures the potential for a relationship between PACAP and sales growth, γ_{51}, γ_{52} indicate the effects of exploratory and exploitation alliances on sales growth respectively and the δ_5 the impact of three groups of control variables relating to firm characteristics (FC), market characteristics (MC) and firms' strategic profile (SP).

We could also estimate the coefficients of PACAP and exploration alliances in the reduced form model (10.7) according to their one-to-one relationship with the structural form coefficients. The coefficient of exploration alliances γ_{51} in the reduced form model, equals the value of $\beta_4\gamma_3$ (γ_3 represents the coefficient of exploration alliances in our structural

form model 10.3, β_4 denotes the coefficient of RACAP in our structural form model 10.5. γ_3 is positive, β_4 exhibits a mix of positive and negative signs, thus γ_{51} is ambiguous. This suggests a sign of ambiguity in the relationship between exploration alliances and competitive advantages. On the other hand, the coefficient of PACAP, β_5 in our reduced form model, equals the value of $\beta_3\beta_4$. β_3 is the coefficient of PACAP in our structural form model 10.3, β_4 is the coefficient of RACAP in our structural form model 10.5. We measure each of these two variables by a set of different indicators. And the coefficients of these indicators reflect different signs in our empirical results. This gives rise to the signs of ambiguity of both β_3 and β_4. Therefore, the sign of β_5 is ambiguous, indicating that the relationship between PACAP and competitive advantage is uncertain. In this chapter, we focus on untangling the 'ambiguous' relationship between exploration alliances, PACAP and competitive advantage.

10.2.2 Potential Absorptive Capacity and Competitive Advantage

Zahra and George (2002) argue that firms with well-developed capabilities in knowledge acquisition and assimilation are more likely to sustain a competitive advantage. Well developed PACAP helps firms track changes in industries more effectively, and facilitates the deployment of necessary capabilities at the right timing, which in turn reduces sunk investments in changing the firm's resource positions and operational routines (Zahra and George, 2002). It gives firms greater flexibility in reconfiguring the resource bases to capitalise upon emerging strategic opportunities (Raff, 2000). These opportunities may help the firms sustain superior performance because of first mover advantages (Ferrier et al, 1999), responsiveness to customers (Matusik and Hill, 1998), or other advantages. For example, after studying the innovation activities of 2,464 Spanish firms, Fosfuri and Tribo (2006) find that PACAP is a source of competitive advantage in innovation, especially in the presence of efficient internal knowledge flows that help reduce the distance between potential and realised absorptive capacity,

In the studies of organisational learning (Boynton et al, 1994; Szulanski, 1996; Veugelers, 1997), potential absorptive capacity is identified as the essential part of a firm's learning

system (Kim, 1998). This kind of capacity grounded in learning form the basis of sustained competitive advantage (Lei et al, 1996). Actually, heterogeneity in the level of ability to recognise, acquire and assimilate external knowledge itself could be translated into difference in benefits from otherwise similar stocks of external knowledge.

In the empirical analysis of the previous chapters, we operationalised PACAP as R&D intensity (acquisition dimension), employee skills and continuity of R&D activities (assimilation dimension). In fact, these indicators themselves are important determinants of firms' performance or sales growth. In particular, R&D intensity has been examined by plenty of earlier studies as an important factor in contributing to firms' innovation performance (Hall and Bagchi-Sen, 2007; Rocha, 1999; Cantner and Pyka, 1998), new product development performance (Stock et al, 2001), and other performance. Meanwhile, a higher level of employee skills increases firms' productivities, and serves as an enabling factor in profitable innovation (Leiponen, 2005). Similarly, continuous R&D activities prove significantly and positively related to firms' sale growth in the previous research (Becker and Peter, 2000), and firms with a continuous approach to R&D usually achieve a higher innovation output than firms which do not follow this approach (Oltra and Flor, 2003).

Although the variation in the capabilities to transform and exploit external knowledge is well documented as a major source of performance differences by previous researchers (Zahra and George, 2002; Fosfuri and Tribo, 2006), the path dependence and cumulativeness nature of absorptive capacity (Cohen and Levinthal, 1990; Eisenhardt and Martin, 2000) determine that RACAP is only a fraction of PACAP, and specifically that firms cannot possibly exploit knowledge without first acquiring it. Thus we propose,

> Hypothesis 5.1: A biopharmaceutical firm's competitive advantage will be positively associated with its PACAP.

10.2.3 Exploratory Alliances and Competitive Advantage

From a relational view, exploratory alliances can be viewed as a way by which firms gain access to complementary technological know-how from alliance partners. This kind of

complementary know-how is extremely important because when combined with firms' own know-how, a synergistic effect results, whereby the combined technological know-how is more valuable, rare, and difficult to imitate than before the combination (Dyer and Singh, 1998). RACAP allows the firms to combine these two different types of know-how together and convert it into new products so that the firms could apply it to the commercial end. Consequently, exploratory alliances produced stronger competitive positions than those achievable by the firms operating individually. In actual fact, new product development of biopharmaceutical firms is increasingly an interdisciplinary task that requires the integration of know-how from different areas (Dosi, 1982; Mowery and Rosenberg, 1989; Rosenberg, 1982). Thus, to develop a new product, the firm's technology know-how may have to be combined with the complementary technology know-how possessed by other firms. Previous research finds that exploratory alliances have a positive effect on biopharmaceutical firms' innovation output, i.e. number of patents (Shan et al, 1994), and number of new products in development (Rothaermel and Deeds, 2004). The higher a firm's rate of new product development, the more likely the firm is to achieve and maintain first mover advantages in access to early cash flows, external visibility, legitimacy and early market share (Deeds and Hills, 1996). This is particular true in an industry like biopharmaceuticals, where the effectiveness of patent protection creates a "winner take all" scenario (Hill, 1997).

On the other hand, Doz and Hamel (1998) consider the exploratory alliances as a kind of learning alliance. It is formulated with the intention to facilitate learning or with prospecting expectations from their parents (Koza and Lewin, 1998). The outcome of the exploration process is the embodiment of new knowledge learned through exploration into a prototype product that can be extended into testing and development process, or the codification of new knowledge through patenting. And the value of this new knowledge is viewed as a key source of competitive advantage in organisational theory (Grant, 1996).

Moreover, according to the transaction cost theory, exploratory alliances require specific investments, and activities of different partners in this process (exploratory alliances) are non-transferable to other contexts, increasing the asset specificity of the transaction (Lambe and Spekman, 1997). In fact, investment in specialised assets in conjunction with the assets of the partners is proved as a potential source of relational rents (Amit and

Schoemaker, 1993; Carney, 1998). Researchers have also found that investments in such non-recoverable relational assets can lead to improved performance (i.e., financial performance) of both alliance partners (Carney, 1998; Holm et al, 1999). Thus we postulate,

> Hypothesis 5.2: A biopharmaceutical firm's competitive advantage will be positively associated with its engagement with exploratory alliances.

However, it is worth noting that although the creation of knowledge is important, the conversion of this new knowledge into new products is the foundation of superior performance (Leonard-Barton, 1995; Moon, 1999; Nonaka and Takeuchi, 1995). This is the envisioned outcome, but paybacks are still distant in time and generally exhibit high variance (Deeds and Hill, 1996), given that a new technological opportunity or idea only materialises when it turns into a new product. Furthermore, the radical technology change of the biopharmaceutical industry accelerates the depreciation of the value of firms' existing technological value chain activities (Tushman and Anderson, 1986; Rothaermel, 2001). In addition, exploratory alliances are associated with a high risk of opportunism behaviour and coordination cost (Faems et al, 2006), and particularly in the biopharmaceutical industry where technology uncertainty is high. Thus, exploratory alliances might not sustain a biopharmaceutical firm's competitive advantage in the long run.

10.2.4 Exploitation Alliances and Competitive Advantage

The relational view (Dyer and Singh, 1998) suggests that a firm's critical resources may span its boundary and may be embedded in inter-firm resources and routines. Dyer and Singh (1998) argue that an increasingly important unit of analysis for understanding competitive advantage is the relationship between firms. In fact, many studies have empirically corroborated the fact that inter-firm collaboration contributes to the improvement of firms' performance and, therefore, provides a potential source of competitive advantage (Eisenhardt and Schoonhoven, 1996; Stuart, 2000; Hafsi and Xin, 2005; Gnyawali and Madhavan, 2001; Teng, 2007). For example, Sarkar et al (2001) found

that alliance proactiveness led to superior market-based performance, particularly in the biopharmaceutical industry, and when the perceived technological uncertainty was higher, this effect was even stronger.

Earlier studies on strategic alliance formation are grounded in transaction cost and game theories, over-emphasised the economic rents generated by alliances, and are confined to certain specific benefits associated with collaboration, such as learning, lower transaction costs, or pooling of resources (Dore, 1983; Dyer, 1996; Hamel, 1991; Larson, 1992; Powell et al, 1996; Teece, 1987). Recently, however, there has been increasing attention on the relational rents achieved by inter-organisational collaboration (Dyer and Singh, 1998).

Exploitation alliances are entered into with the goal of joining existing competencies across organisational boundaries in order to generate synergies, which are then shared among the partners (Koza and Lewin, 1998). Exploitation alliances ensure that each potential partner has 'complementary resources' that can be accessed via inter-firm co-operation (Rothaermel, 2001; Teece, 1986). When these resources are combined, it results in a synergistic effect whereby the combined resource endowments are more valuable, rare, and difficult to imitate than they had been before they were combined (Dyer and Singh, 1998), and therefore, greater rents are generated than the sum of those obtained from the individual endowments of each partner (Dyer and Singh, 1998). Similarly, Barney (1995) explains that specialised skills/capabilities that result from socially complex phenomena unique to a firm, are more likely to lead to advantages that are hard for competitors to duplicate. Thus, exploitation alliances provide a potential source of competitive advantage, and produce stronger competitive positions than those achievable by the firms operating individually.

In the studies of inter-firm collaboration in the biopharmaceutical industry, Teece (1992) and Rothaermel (2001) link exploitation alliances and competitive advantage together with biopharmaceutical firms' new product development. They found that exploitation alliances were positively associated with participant firms' new product development, and in turn these alliances improved their performance. Continued product introductions are particularly important in hyper-competitive environments (D'Aveni, 1994). New product introductions may allow the firm to establish first mover advantages and enjoy a temporary

monopoly (Lieberman and Montgomery, 1988). This is particularly true in the biopharmaceutical industry where standards or effective patent protection create winner-take-all scenarios (Hill, 1997). Additionally, radical technological change in the biopharmaceutical industry that undermines incumbent firms' upstream value chain activities will cause those firms to seek out a new source of competitive advantage within the redefined technological framework (Dosi, 1982). Therefore, participation in exploitation alliances with providers of the new technology, creates a new source of competitive advantage when the incumbents have complementary assets within their firm boundaries that are critical in commercialising the new technology (Rothaermel, 2001). Sarkar et al (2001) offer an illustration in pharmaceuticals, where the technological shift from organic chemistry to life science-based drug development implies that incumbent pharmaceutical companies that are capable of locking-in innovative new biotech firms through exploitation alliances are likely to be advantaged in product innovation. In an environment of technological change such as this, firms' participation in exploitation alliances should have an advantage as a result of being early movers.

Thus, we propose,

Hypothesis 5.3: A biopharmaceutical firm's competitive advantage will be positively associated with its engagement with exploitation alliances.

10.3 Data and Methods

Data that have been used to test our hypotheses are drawn from our main survey. This required information on PACAP, exploratory and exploitation alliances, and competitive advantage comes from 2,173 US and European biopharmaceutical firms. A final response rate of 16.0 percent was achieved, with 17.5 percent in Europe and 14.4 percent in the US. Firms that responded to our survey provided information on their alliance and R&D activities, details of sales growth, and company background. Table 10.2 presents descriptive statistics for these data. In general, our respondent firms have a mean company tenure of 13.6 years, with an average size of 47 full-time employees. Typically, US respondent firms are older and larger than their European counterparts.

In terms of our measures of PACAP, we see relatively similar mean values across our US and European respondent firms. Average R&D density in each case (i.e. the proportion of the workforce engaged in R&D) was close to 42-43 per cent with around 86-88 per cent of firms engaging in R&D on a continuous basis. In a typical US or European respondent firm, approximately 70 per cent of the employees had a degree or its equivalent. The number of exploratory or exploitation alliances are count variables taking on discrete non-negative integer values but including zero with our respondent firms having an average of 2.8 exploratory alliances, and 2.1 exploitation alliances.

Our main variable of interest is sales growth (A_m), which we modeled using the following formulation:

$$A_m = \alpha + \beta_1 RDINT_m + \beta_2 RDCONT_m + \beta_3 EMSKILLS_m + \gamma EXPLOR_m + \eta EXPLOI_m + \delta_1 FC_m + \delta_2 MC_m + \delta_3 SP_m + \varepsilon_m$$

where β_n coefficients capture the potential for a relationship between RACAP and sales growth, γ reflects the importance of exploratory alliances on sales growth. η indicates any effect of exploitation alliances and the δ_n the impact of three groups of control variables relating to firm characteristics (FC), market characteristics (MC) and firms' strategic profile (SP). Our dependent variable, sales growth has a mean value of 59.5 percent, on average, the European respondent firms grow faster than those in the US. However, here we only consider the value of sales growth as from –0.8 to 3, and drop all the observations in which the value of sales growth is less than –0.8 or more than 3. This amounts to restriction of the range on both of our dependent and independent variables. As a consequence, it will incur the change of the coefficients of our independent variables when compared to the results without restriction. In other words, the truncation of sales growth in the data will lead to biased estimates. A better approach to analysing this type of data is to use truncated regression (Greene, 2003).

In addition to the main variables of interest, we use three groups of control variables relating to firms' background characteristics (e.g. age, size, ownership status), the geographic market orientation of the firm and its strategic focus (Table 10.1) in the econometric analysis. On average the US respondent firms are marginally older, larger

and more likely to be independent firms than the European respondents. They are also more likely to be engaged in the early stages of the discovery process but less likely than the EU firms to be engaged in sales or marketing activities (Table 10.1). We also weight our response rates of the US and Europe[35] in order to adjust the non-response bias and some of the estimates and standard errors.

10.4 Empirical Results

Tables 10.2 and 10.3 present the results from our truncated estimates of the impact of PACAP, exploration and exploitation alliances on firms' competitive advantage. In the model shown in Table 10.3, we differentiate between those values of each independent variable relating to the US and Europe to allow coefficients to be compared. Table 10.3.1 reports Wald tests for the equality of the EU and US coefficients. In terms of firms' alliance activities, we find a significant but negative relationship between the number of exploratory alliances in which firms are engaged and sales growth, in particular in the European case. The suggestion is that engagement in exploratory alliances does not pose any competitive advantage for a firm, and specifically in Europe, it provides little support for Hypothesis 5.2. We also find that number of exploitation alliances have a positive but insignificant relationship with sales growth in both the US and Europe. The suggestion is that participation in exploitation alliances does not contribute to firms' competitive advantage no matter whether in the US or Europe, and this provides little support for Hypothesis 5.

More significant effects are identified for some of the aspects of PACAP – firms' engagement in continuous R&D and employee skills – providing some support for hypothesis 5.1, which reflects firms' acquisition and assimilation capabilities. In particular, both continuous R&D and employee skills prove significant determinants of sales growth in Europe, while in the US, only the skills level is significant. The suggestion is that in Europe, firms' competitive advantage depends strongly on their assimilation capabilities. In the US, on the other hand, firms' competitive advantage is not conditional on either

[35] The absolute weights among different countries have been calculated as US 6.938, UKI3.636, France 7.057, and Germany 7.169.

R&D intensity or continuity, i.e. any aspect of internal knowledge creation. Instead, the improvement of firms' competitive position depends more strongly on skill-based absorptive capacity. However, we find a positive but insignificant relationship between R&D intensity and sales growth, a result which is consistent across the US and Europe. The suggestion is that firms' acquisition capability does not contribute to its competitiveness in either the US or in Europe.

Our Wald test results suggest that the US and the European firms are significantly different in their skills level and engagement with continuous R&D activities, or assimilation capabilities (Table 10.3.1). We confirm this by differentiating between those values of continuous R&D and employee skills relating to the US and Europe in the model given in Table 10.4. In the results presented in Table 10.4, both continuous R&D and employee skills – representing the assimilation dimension of ACAP - proves significant and positive again in Europe, suggesting some support for Hypothesis 5.1, while only employee skills prove important in the US. Marginal value in the model in Table 10.4 suggests that a move from undertaking occasional to continuous R&D activities raises sales by 2.5 percent for a firm in Europe, whereas only 0.9 percent sales increased is seen by a firm by the same movement in the US. On the other hand, a one percent increase in employee skills will raise firms' sales growth by 4.1 percent in the US, but only 3.0 percent in Europe.

In addition to the independent variables, we also find that some of our control variables, i.e. those relating to firms' strategic focus, appear to be significant in the estimation of sales growth (see Tables 10.2, 10.3 and 10.4). In particular, we find that in both the US and Europe, marketing and sales proves a significant determinant of firms' sales growth, whereas basic R&D and pre-clinical development proves significant but negative. These results suggest that firms with superior performance tend to structure their strategic portfolio to focus more on leveraging their market-oriented value chain activities, i.e. marketing and sales, than on rebuilding their technology-oriented value chain activities, i.e. basic R&D and pre-clinical development. Most importantly, it highlights an opportunity to seek potential sources of competitive advantage within a firm's redefined technological framework (Dosi, 1982).

10.5 Empirical Conclusions

In this chapter, we are aiming to gain some understanding of the effects of different alliance types and absorptive capacity on firms' competitive advantage by integrating the analysis of absorptive capacity, alliances, and competitive advantage in the previous chapters. Our results suggest that employee skills and continuous R&D activities are significantly and positively related to firms' sales growth, suggesting that the assimilation dimension of PACAP (proxied by employee skills and continuous R&D activities) plays an important role in shaping a biopharmaceutical firm's competitive position. This provides empirical evidence for the earlier conclusion which points to the necessity of the development of human skill and internal R&D capabilities in order to produce high added value and innovation (Caloghirou et al, 2004; Leiponen, 2000; Camuffo and Comacchio, 2005). It also offers broad support to the previous findings of PACAP as an important source of competitive advantage in innovation (Fosfuri and Tribo, 2006). On one hand, a higher level of employee skills increases firms' productivities, and serves as an enabling factor in profitable innovation (Leiponen, 2005). On the other hand, firms with a continuous approach to R&D usually achieve a higher innovation output than firms which do not follow this approach (Oltra and Flor, 2003; Becker and Peter, 2000). The origin of competitive advantage, thereby, lies in the heterogeneity in the level of employee skills and continuity of R&D engagement which translates into the differences in the benefits from otherwise similar stock of external knowledge (Fosfuri and Tribo, 2006). For the other dimension of PACAP, however, we find a positive but insignificant relationship between acquisition capabilities (captured by R&D intensity) and competitive advantage. This suggests that R&D investment itself is not enough to determine a firm's competitive position. The performance differences between firms' new products development lie in the levels of their employee skills and the continuity of the firms' R&D activities, rather than the relevant amount of investment in R&D. In strategic terms, this suggests the need for continuity in R&D within a firm, and also the need for relevant investments in skills to facilitate the successful commercialisation of new products.

In terms of firms' exploration and exploitation alliance activities, our results reveal that firms do not gain any advantage from the engagement with either type of alliances in both the US and Europe. This suggests that engagement with alliances is not the sufficient

condition to achieve superior performance, and that firms still need skills, internal capabilities and R&D to internalise and effectively utilise the knowledge created or accessed through alliances. Without these, there will be no performance differences because the knowledge can also be obtained by competitors from the same source. In particular, our results suggest that participation in exploration alliances has a negative effect on firms' competitive advantage. The results reflect the earlier research which has suggested that more external sourcing during the early (i.e. idea generation) stage was related with lower competitive success (Kessler et al, 2000). Alliances that are formed too early i.e. exploratory alliances can lead to contracts where biopharmaceutical firms lose most of the benefits of their innovations because of the low valuation of under-developed intellectual property assets (Niosi, 2003).

Several important insights are identified from our analysis of firms' exploration and exploitation alliance behaviours in this chapter. Firstly, alliances are not enough to explain growth (Niosi, 2003). Previous studies suggest that there are many other factors apart from alliances that have an impact on rapid growth, in particular internal activities and strategies, such as product area (Niosi, 2003), protection of intellectual property through patents (Atun et al, 2006), and exports (Niosi, 2000), as well as venture capital financing (Cooke, 2001; Fazeli, 2004). In fact, the human health sector (Vivo therapeutics) that we focused on in this research, seems to be the sector where rapid growth occurred, because firms operating in this area do not have the problems of consumer acceptance that plague environment, food and agricultural biotechnology (Niosi, 2003). Secondly, collaboration slows down the new product development process (Kessler et al, 2000). Externally-generated knowledge usually takes longer to integrate with firms' existing knowledge bases in that it is harder to richly understand and interpret (Brierly and Chakrabarti, 1996), because of the different frames of reference, standards, language and codes the firm may use (Kaz and Kahn, 1966). Meanwhile, knowledge from external sources faces more organisational barriers than internally-developed knowledge. For example, employees may feel threatened by the new idea and may be resistant mostly because it was not initiated in-house (Katz and Allen, 1982). Finally, the collaborative project incurs more costs than projects that mainly rely on internally-generated ideas (Kessler et al, 2000), in particular the co-ordination costs of integrating external knowledge with a firm's existing knowledge base, and the cost of valuable, internal knowledge leaking out of the organisation.

Additionally, as we discussed before, collaboration slows down the new product development process, and the longer a new product development process lasts, the more extra cost it requires.

The most interesting aspect of the study in this chapter is the differences it highlights in the key determinants of firms' competitive advantage in the US and Europe. Previous US and European comparative studies in the biotechnology industry focus on the role of government (Giesecke, 2000), innovation system (Cooke, 2001), source of comparative advantage (Lavioe and Sheldon, 2000), industry-university relations (Owen-Smith et al, 2002), but our study brings new insights to this body of research by specifying the different impact of engagement with exploration and exploitation alliances and absorptive capacity in determining the competitiveness of the US and European biopharmaceutical firms. We find that assimilation capability (employee skills and continuous R&D) is extremely important in shaping firms' competitive advantage in Europe, whereas in the US, the improvement of firms' competitive position is more conditional on the skill-based absorptive capacity. The results reflect the findings of the earlier research which suggested human capital as an important determinant of the growth of the US biotechnology industry (Zucker et al, 1998). It also empirically corroborates the previous findings of the assimilation dimension of PACAP as a source of firms' competitive advantage in innovation in Europe (Fosfuri and Tribo, 2006). This is probably because in Europe, lower levels of public support (e.g. Bains, 2006) and investment in publicly-funded R&D (Fazeli, 2004; Wolter, 2003; Cooke, 2001) increase the relative importance of firms' internal capability and resources, in particular employee skill levels and the continuity of internal R&D activities. In the US, on the other hand, greater public investments and support in biotechnology R&D (Lemarie et al, 2000; Sharp, 1995; Orsenigo, 1989) may be substituting for firms'own investments in R&D, with sales growth more dependent on skills-related aspects of ACAP rather than on firms'on-going R&D activities.

In addition, our results reveal some significant relationships between some of the control variables (i.e. those relating to firm strategic focus) and competitive advantage. Specifically, our results suggest that firms tend to structure their strategic portforlio to focus more on leveraging their market-oriented value chain activities, i.e. marketing and sales rather than on rebuilding their technology-oriented value chain activities, i.e. basic

R&D and pre-clinical development. One possible explanation is that radical technological change of the biopharmaceutical industry undermines firms' upstream value chain activities, and will cause those firms to seek out a new source of competitive advantage within their redefined technological framework (Dosi, 1982), i.e. marketing and sales.

However, it is noteworthy that in this chapter, our results suggest a positive but insignificant relationship between exploitation alliances and firms' competitive advantage, a result which is slightly different from those of Chapter 9, in which we find exploitation alliances have a V-shape relationship with firms' competitive advantage. Two main reasons are identified for this difference. Firstly, the results revealed in this chapter reflect an average effect of engagment with exploitation alliances on firms' competitive advantage, because in this chapter, we are aiming to obtain an integrative view of the influences of absorptive capacity and alliances on firms' competitive advantage through a reduced-form analysis of PACAP, exploration and exploitation alliances as determinants of firms' competitive advantage. However, the V-shape relationship suggested by our structural model analysis in Chapter 9 only reflects the effect of exploitation alliances on firms' competitive advantage in certain specific conditions, in which we estimate the effect of exploitation alliances and RACAP on firms' competitive advantage separately without considering the influences of PACAP and exploratory alliances. Secondly, apart from exploitation alliances, we are examining the effect of two different sets of determinants on firms' competitive advantage in the structural and reduced-form models. In the structural model (Chapter 9), we examine the effect of RACAP and exploitation alliances on firms' competitive advantage, while in the reduced-form analysis in this chapter, we test PACAP and exploitation alliances as determinants of firms' competitive advantage. Therefore, the coefficients of exploitation alliances in these two kinds of models are supposed to be different. In other words, the effect of exploitation alliances on firms' competitive advantage estimated by these two kinds of models with different sets of independent variables, is very likely to be different.

Table 10. 1: Variable Descriptives

Variables		All Firms (n=349)		EU (n=205)		US (n=144)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.
Alliances							
No. of exploratory alliances	(per firm)	2.78	4.01	2.58	3.87	3.04	4.18
No. of exploitation alliances	(per firm)	2.10	6.467	2.03	7.049	2.18	5.643
PACAP Measures							
R&D intensity	(% per firm)	43.20	0.34	41.70	0.34	45.10	0.34
Employee skills	(% per firm)	68.80	0.28	66.90	0.29	71.40	0.26
Continuous R&D	(% of firms)	86.90	0.34	86.00	0.35	88.10	0.33
Competitive Advantage							
Sales growth	(% per firm)	59.50	1.342	64.40	1.472	51.30	1.097
Firm Characteristics							
Firm age	(year)	13.60	12.41	12.10	11.53	15.90	13.30
No. of employees	(per firm)	47.00	84.04	35.00	68.01	65.00	101.25
Independent company	(% of firms)	83.50	0.37	80.30	0.40	88.10	0.33
Market Characteristics							
Regional market	(% of firms)	76.10	0.43	74.50	0.44	78.30	0.41
Foreign market	(% of firms)	47.30	0.50	47.10	0.50	47.60	0.50
External market	(% of firms)	32.10	0.47	26.80	0.44	39.60	0.49
Strategic Focus							
Basic R&D and preclinical Dev.	(% of firms)	67.30	0.47	60.00	0.49	77.80	0.42
Clinical trials (Phase I, II, III)	(% of firms)	38.10	0.49	26.30	0.44	54.90	0.50
Manufactory	(% of firms)	51.60	0.50	46.80	0.50	58.30	0.50
Regulatory support	(% of firms)	38.00	0.49	21.40	0.41	61.10	0.49
Marketing and sales	(% of firms)	47.50	0.50	52.20	0.50	41.00	0.49

Source: Author's Survey

* p=0.003

Notes: Mean values in bold format represent the existence of significant difference between the US and Europe regarding the same variable.

Table 10. 2: Truncated Regression Model of Competitive Advantage: Whole Sample

Independent Variables	Coef.	dy/dx
Alliances		
No. of exploitation alliance(s)	0.02422~	0.024
No. of exploration alliance(s)	-0.01657~	-0.017
PACAP Indicators		
Log (R&D intensity +1)	0.01609	0.016
Employee skills	0.34508**	0.345
Continuous R&D activities	0.19525*	0.195
Firm Characteristics		
Firm age	-0.00372	-0.004
Firm size	0.00019	0.000
Firm size sq.	0.00000	0.000
Ownership status (independent firm)	0.00325	0.003
Market Characteristics		
Regional market	-0.09385	-0.094
Foreign market	0.02125	0.021
External market	0.08135	0.081
Strategic Focus		
Basic R&D and pre-clinical dev.	-0.16771~	-0.168
Clinical trials (Phase I, II, III)	-0.01183	-0.012
Manufactory	0.01337	0.013
Regulatory support	-0.11016	-0.110
Marketing&sales	0.18043*	0.180
Nationality (euus)	-0.00310	-0.003
cons	0.11449	
Number of obs = 153	Wald chi2(18) = 37.81**	

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 10. 3: Truncated Regression Model of Competitive Advantage: Split EU/US Explanatory Variables

Independent Variables	Coef.	dy/dx
Alliances		
No. of exploitation alliance(s) for European firms	0.02578	0.025
No. of exploitation alliance(s) for US firms	0.01687	0.017
No. of exploration alliance(s) for European firms	-0.02753~	-0.027
No. of exploration alliance(s) for US firms	-0.00836	-0.008
PACAP Indicators		
Log (R&D intensity +1) for European firms	0.02831	0.028
Log (R&D intensity +1) for US firms	0.14031	0.150
Employee skills of European firms	0.32381~	0.345
Employee skills of US firms	0.41085*	0.396
Continuous R&D activities of European Firms	0.28035**	0.272
Continuous R&D activities of US Firms	0.08383	0.093
Firm Characteristics		
Firm age	-0.00379	-0.004
Firm size	0.00020	0.000
Firm size sq.	0.00000	0.000
Ownership status (independent firm)	-0.01063	-0.001
Market Characteristics		
Regional market	-0.09286	-0.100
Foreign market	0.01547	0.016
External market	0.07576	0.069
Strategic Focus		
Basic R&D and pre-clinical dev.	-0.16507~	-0.164
Clinical trials (Phase I, II, III)	-0.00904	-0.004
Manufactory	0.02324	0.026
Regulatory support	-0.11663	-0.106
Marketing&sales	0.18747*	0.175
Nationality (euus)	-0.04391	-0.042
cons	0.09526	
Number of obs = 153	Wald chi2(23) = 40.14*	

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 10.3. 1: Wald Tests for the Equality of Coefficients: US Versus Europe

	DF	$\chi 2$
Alliances		
No. of exploitation alliance(s)	2	2.78
No. of exploration alliance(s)	2	3.27
PACAP Indicators		
Log (R&D intensity +1)	2	0.38
Employee skills	2	8.03*
Continuous R&D activities	2	9.30*

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 10. 4: Truncated Regression Model of Competitive Advantage: Preferred Model

Independent Variables	Coef.	dy/dx
Alliances		
No. of exploitation alliance(s)	0.02342	0.02342
No. of exploration alliance(s)	-0.01672~	-0.01672
PACAP Indicators		
Log (R&D intensity +1)	0.01959	0.01959
Employee skills of European firms	0.30376~	0.30376
Employee skills of US firms	0.40571*	0.40571
Continuous R&D activities of European firms	0.25374**	0.25374
Continuous R&D activities of US firms	0.09841	0.09841
Firm Characteristics		
Firm age	-0.00382	-0.00382
Firm size	0.00022	0.00022
Firm size sq.	0.00000	0.00000
Ownership status (independent firm)	-0.01454	-0.01454
Market Characteristics		
Regional market	-0.08854	-0.08854
Foreign market	0.02148	0.02148
External market	0.07484	0.07484
Strategic Focus		
Basic R&D and pre-clinical dev.	-0.17117~	-0.17117
Clinical trials (Phase I, II, III)	-0.01398	-0.01398
Manufactory	0.01572	0.01572
Regulatory support	-0.10807	-0.10807
Marketing&sales	0.19188*	0.19188
Nationality (euus)	-0.06982	-0.06982
cons	0.17234	
Number of obs = 153	Wald chi2(20) = 38.47**	

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

CHAPTER 11

SUMMARY OF RESULTS

11.1 Introduction

This chapter aims to provide a brief summary of the empirical results arising from our analysis. Section 11.2 deals with those results regarding firms' activities in the early stage of new product development, section 11.3 summarises the results relating to the commercialisation stage, and section 11.4 presents the results from the integrative analysis. All these three sections follow the same structure, in which each of the hypotheses and its relevant empirical results will be presented first, and be followed by a further discussion of the differences between the US and the European biopharmaceutical firms. An integrative comparison of our conceptual framework and the empirical results will be detailed in section 11.5.

11.2 New Product Development Stage (Research Question 1 and 2)

11.2.1 PACAP and Exploratory Alliances

Our first group of hypotheses (i.e.H1.1, H1.2, H1.3) relate to the relationship between PACAP and exploratory alliances. A summary of the hypotheses and the related empirical results are presented in Table 11.1. We assume that PACAP, as an important determinant of a firm's choice for exploratory alliances, will positively affect the firm's exploratory alliance activities. Our results only provide partial support for this argument. We find that assimilation dimension of PACAP plays an important role in determining firms' engagement with exploratory alliances, while acquisition dimension has no influence on firms' number of exploratory alliances either in the US or Europe. Furthermore, our results suggest that the US firms' engagement with exploratory alliances depends more strongly

on the skill-based ACAP, whereas in Europe, participation in exploratory alliances is more conditional on continuous R&D (internal knowledge creation and ACAP).

Table 11.1: Summary of Hypotheses and Empirical Results Relating to the Determinants of Exploratory Alliances

Hypotheses	Common Results	EU/US Differences
1. Determinants of Exploratory Alliances		
H1.1: R&D intensity will be positively related to exploratory alliances. H1.2: Continuous R&D will be positively related to exploratory alliances. H1.3: Employee skill levels will be positively related to exploratory alliances.	R&D intensity has an insignificant impact on exploratory alliances in both the US and Europe (Figures 10.2.1 and 10.2.2).	Continuous R&D is a significant determinant of exploratory alliances only in the EU (Figure 10.2.1). Skill levels are a significant determinant of exploratory alliances only in the US (Figure 10.2.2).

Our empirical results fail to provide any support for H1.1. The relationship between number of exploratory alliances and R&D intensity proves insignificant both in the US and Europe, albeit that increasing one percent of the R&D intensity increases firms' number of exploratory alliances by 1.2 in Europe, and 2.3 in the US. The suggestion is that acquisition capability does not contribute to firms' engagement with exploratory alliances in either case. Investment in R&D itself is not enough to make alliances work, and firms might need other commitments in particular continuity in R&D within the firms, or at least a certain level of investment in skills to facilitate external knowledge gathering.

Our results show that employee skills and continuous R&D (assimilation dimension of PACAP) prove significant determinants of a firm's number of exploratory alliances. In particular, we find that skill level is significant in the US but not Europe, whereas continuous R&D is significant in Europe only. And a one percent increase in employee skills in the US will increase firms' number of exploratory alliances by 0.16, while a move from undertaking discontinuous to continuous R&D in Europe increases firms' number of exploratory alliances by 1.7. These results support the arguments advanced in H1.2 and 1.3, suggesting assimilation capability as an important determinant of firms' exploratory

alliance activities. It also highlights the most interesting differences between the US and Europe in terms of the factors affecting firms' engagement with exploratory alliances - it is the skill aspect of assimilation dimension of PACAP which seems to matter in the US, while it is the R&D aspect which matters most in Europe.

11.2.2 Exploratory Alliances, PACAP and RACAP

In our second group of hypotheses (i.e. H2.1, 2.2 and 2.3), we test the role of exploratory alliances and PACAP as determinants of RACAP. A summary of the relevant hypotheses and empirical results is provided in Table 11.2. Our empirical results demonstrate the existence of a significant and positive relationship between number of exploratory alliances and each of the dimensions of RACAP, in particular in the US. We find that acquisition dimension of PACAP proves significant in determining firms' RACAP in Europe but not the US, whereas the R&D aspect of assimilation dimension of PACAP proves an important factor affecting the exploitation dimension of RACAP in the US only. However, for both the European and US firms, we could not find sufficient evidence that the assimilation dimension has a positive effect on the transformation and the exploitation of new external knowledge. Rather, the results highlight that improving acquisition capability and employee skills may be more effective in contributing to the development of exploitation capability for the European firms. However, to achieve this, the US firms may benefit more by engagement with continuous R&D activities.

Table 11.2: Summary of Hypotheses and Empirical Results Relating to the Determinants of RACAP

Hypotheses	Common Results	EU/US Differences
2 Determinants of RACAP		
H2.1: Exploratory alliances will (a) positively affect the transformation dimension of RACAP; (b) positively affect the exploitation dimension of RACAP. H2.2: The acquisition dimension of PACAP is a pre-requisite (necessary but insufficient condition) of (a) the transformation dimension of RACAP; (b) the exploitation dimension of RACAP. H2.3: The assimilation dimension of PACAP will (a) positively affect the transformation dimension of RACAP; (b) positively affect the exploitation dimension of RACAP.		Acquisition dimension of PACAP has a significant and positive impact on each of the dimensions of RACAP only in the Europe (Figure 10.2.1). In the US, (a) exploratory alliances are the only significant factor affecting the transformation dimension of RACAP; (b) continuous R&D is the only significant factor affecting the exploitation dimension of RACAP (Figure 10.2.2). Skill levels are significant and negative in the estimation of exploitation dimension of RACAP only in Europe (Figure 10.2.1).

Hypothesis 2.1 predicts that exploratory alliances positively affect the transformation and the exploitation dimensions of RACAP. In the results, we find that exploratory alliances prove a significant determinant of firms' transformation capability only in the US. The suggestion is that engagement with exploratory alliances contributes to the transformation, rather than the exploitation of firms' newly-acquired and assimilated knowledge in the US, adding support to H2.1a.

More significant results are identified for the aspects of PACAP – R&D intensity and firms' engagement with continuous R&D – providing support for H2.2a and 2.3b which reflect firms' acquisition and the assimilation capabilities respectively. Our results suggest that acquisition dimension of PACAP (R&D intensity) contributes to the development of firms' RACAP, in particular in Europe. For the assimilation dimension of PACAP-employee skills and firms' engagement with continuous R&D activities - we find that employee skills has a significant but negative effect on firms' number of patents in Europe but not in the US, while continuous R&D proves an important factor in determining firms' number of patents in the US only. The suggestion is that possession of skill-based PACAP

does not facilitate the development of firms' knowledge exploitation capability in Europe, whereas in the US, the development of firms' knowledge exploitation capability depends on the firms' engagement with continuous R&D or the R&D aspect of assimilation dimension of PACAP, thereby giving partial support to Hypothesis 2.3b.

11.3 Commercialisation Stage (Research Question 3 and 4)

11.3.1 RACAP and Exploitation Alliances

In the third group of hypotheses (H3.1 and 3.2), we explore the role of the transformation and the exploitation dimensions of RACAP as important determinants of firms' exploitation alliance activities. Table 11.3 presents a summary of the relevant hypotheses and empirical results relating to the determinants of exploitation alliances. On one hand, our results suggest that the development of firms' capabilities in knowledge monitoring and knowledge exploitation, fosters the growth of the firms' exploitation alliances. On the other hand, our results highlight that in Europe, transformation and exploitation capabilities (RACAP) play important roles in determining firms' engagement with exploitation alliances, whereas in the US, participation in exploitation alliances is more dependent on the transformation dimension of RACAP.

Table 11.3: Summary of Hypotheses and Empirical Results Relating to the Determinants of Exploitation Alliances

Hypotheses	Common Results	EU/US Differences
3. Determinants of Exploitation Alliances		
H3: exploitation alliance(s) will be 1. positively related to the transformation dimension of RACAP. 2. positively related to the exploitation dimension of RACAP.	Transformation capabilities, in particular knowledge monitoring capability, have a significant and positive effect on exploitation alliances across the US and Europe (Figures 10.2.1 and 10.2.2).	Exploitation dimension of RACAP is a significant determinant of exploitation alliances only in the European case (Figure 10.2.1).

We find that knowledge-monitoring capability is significant and positively related to exploitation alliances, a result which is consistent across the US and Europe. The results highlight knowledge-monitoring capability as an important factor affecting the growth of firms' exploitation alliances in both the US and Europe, suggesting some support for H3.1. Moreover, in each case, firms with well-developed knowledge monitoring capability will have at least two more units of exploitation alliances than those whose knowledge monitoring capability is under-developed.

We also find that exploitation dimension of RACAP (number of patents) proves a significant determinant of firms' exploitation alliance activities. Marginal values in the models in Table 7.1 suggest that firms with strong exploitation capabilities will have 1.3 percent more chance of entering an exploitation alliance than those with relatively weak exploitation capabilities. Adding support to H3.2, exploitation dimension of RACAP proves important in Europe but not in the US, suggesting that firms' engagement with exploitation alliances depends more strongly on their knowledge exploitation capabilities, in particular in Europe.

11.3.2 Exploitation Alliances, RACAP and Competitive Advantage

Our fourth group of hypotheses (H4.1, 4.2, 4.3 and 4.4) concerns the determinants of competitive advantage (Table 11.4). We test the role of exploitation alliances, the RACAP, as well as market characteristics, as important factors in determining a firm's competitive position. Our results show a significant V-shape relationship between exploitation alliances and firms' competitive advantage; and the influence of exploitation dimension of RACAP on competitive advantage is significant and takes on an inverted U-shape. Our results also show the external market as an important determinant of firms' competitive advantage, and that other market characteristics have negative but insignificant effects on the firms' competitiveness.

We also find some interesting results after we differentiate those values of each independent variable relating to the US and Europe. In particular, exploitation alliances and market-monitoring capability prove more important in shaping firms' competitive

advantage in Europe but not in the US. More significant results are identified from the aspects of transformation dimension of RACAP: i.e. knowledge monitoring capability negatively affects firms' competitive advantage in Europe only; knowledge management capability has a significant but negative effect on competitive advantage only in the US. Table 11.4 summarises the hypotheses and empirical results relating to the determinants of competitive advantage.

Table 11.4: Summary of Hypotheses and Empirical Results Relating to the Determinants of Competitive Advantage

Hypotheses	Common results	EU/US differences
4. Determinants of Competitive Advantage		
H4.1: Exploitation alliances have a significant and positive effect on competitive advantage. H4.2: Transformation dimension of RACAP has a significant and positive effect on competitive advantage. H4.3: Exploitation dimension of RACAP has a significant and positive effect on competitive advantage. H4.4: Market characteristics will positively affect competitive advantage.	The impact of exploitation dimension of RACAP on competitive advantage is significant and takes on an inverted U-shape[36] in each case (Figures 10.2.1 and 10.2.2).	The impact of exploitation alliances on competitive advantage takes on a significant V-shape only in Europe (Figure 10.2.1)[37]. As for the transformation dimension of RACAP, (a) market monitoring capability is significant and positively affects competitive advantage only in the European case. (b) knowledge monitoring capability has a significant and negative effect on competitive advantage in Europe only. (c) knowledge management capability has a significant and negative effect on competitive advantage only in the US.

Hypothesis 4.1 predicts that a positive relationship exists between exploitation alliances and participant firms' competitive advantage. However, in the results, we find a significant V-shape relationship between exploitation alliances and competitive advantage. A similar relationship is also found across the US and Europe, but is only significant in the European case. Specifically, the marginal value in the model in Table 9.2 suggests that each exploitation alliance denotes 10.5 percent of the sales growth within a firm. The suggestion is that although engagement in market-based alliances (exploitation alliances) may initially have a negative effect on a firm's competitive advantage in both the US and Europe, this

[36] However, in this research, we only consider the significant and positive effect of exploitation capability on firms' competitiveness, considering the fact that 82.5 percent of our respondent firms have less than 30 patents.
[37] The turning point of increasing return starts between one and two units of alliances.

relationship exhibits increasing returns once the firm has certain specific experiences in exploitation alliances. Thus, Hypothesis 4.1 is partially supported.

More significant results are achieved for the dimensions of RACAP – the knowledge-transformation capability and the knowledge-exploitation capability. In terms of the aspects of transformation capability, we find a significant and positive relationship between firms' market monitoring capability and competitive advantage, suggesting market-monitoring capability as an important source of competitive advantage for a firm. Therefore, regularly considering the impact of market changes for new products proves beneficial to the respondent firms. However, after we differentiate between those values of each independent variable relating to the US and Europe in Table 9.3, we find that the effect of transformation capability on firms' competitive advantage is mixed in Europe. In particular, sales growth has a significant and positive relationship with a firm's market monitoring capability on the one hand; however, on the other hand it is negatively affected by the firm's knowledge monitoring capability, whereas in the US, a firm's sales growth is significant but negatively related to the knowledge management capability, providing little support for H4.2. The suggestion is that in Europe, the influence of transformation dimension on firms' competitive advantage varies according to the different aspects of the transformation capability, while in the US, firms' knowledge transformation capability does not contribute to their competitiveness.

H4.3 proposes that exploitation dimension of RACAP has a significant and positive effect on competitive advantage. In the results, we observe that the relationship between exploitation capability (number of patents) and competitive advantage is significant and takes on an inverted U shape, a result which is consistent across the US and Europe. However, bearing in mind that 82.5 percent of our respondent firms have less than 30 patents, the effect of exploitation capability on firms' competitive advantage is considered to be significantly positive within the scope of this study. Therefore, the importance of exploitation capability as a potential source of competitive advantage is empirically confirmed. The marginal values in the models in Table 9.2 suggest that well-developed exploitation capability will raise 0.6 percent of the sales growth within a firm.

However, we could only find partial support for H4.4. In terms of firms' market characteristics, only external market proves a significant determinant of sales growth (Table 9.2), suggesting external markets as an important source where firms could seek potential competitive advantage. Other market characteristics such as regional market, and foreign market prove insignificant and negative, providing little support for H 4.4. This suggests that the industry structure view is only confined to the explanation of the relationship between a firm's external market activities and its competitive advantage.

11.4 Integrative Analysis (Reduced Form Model)

11.4.1 Exploratory Alliances, PACAP and Competitive Advantage

In the last group of hypotheses (H5.1, 5.2 and 5.3), we examine the effect of PACAP, and exploration and exploitation alliances on firms' competitive advantage. However, our empirical results only prove assimilation dimension of PACAP as an important determinant of a firm's competitive advantage, since the acquisition dimension of PACAP has no influence on firms' performance in either the US or the European cases. Our results also suggest that engagement with either type of alliance does not contribute to a firm's competitive position no matter whether in the US or Europe. Alternatively, we find that in the US it is the skill-aspect of assimilation dimension of PACAP which matters most in determining a firm's competitiveness, whereas in Europe, any aspect of the assimilation capability could matter. A summary of the relevant hypotheses and empirical results is provided in Table 11.5.

Table 11.5: Summary of Hypotheses and Empirical Results Relating to the Determinants of Competitive Advantage (Integrative Analysis)

Hypotheses	Common results	EU/US differences
5. Determinants of Competitive advantage (Integrative Analysis)		
H5.1: PACAP will positively affect competitive advantage. H5.2: Exploratory alliances will positively affect competitive advantage. H5.3: Exploitation alliances will positively affect competitive advantage.	Skills levels are a significant and positive determinant of competitive advantage in both the US and Europe (Figures 10.3.1 and 10.3.2).	Exploratory alliances have a significant but negative impact on competitive advantage only in the EU. Continuous R&D is a significant determinant of competitive advantage only in the Europe (Figure 10.3.1).

In hypothesis 5.1, we postulate that potential absorptive capacity is positively related to a biopharmaceutical firms' competitive advantage. Our results only prove assimilation dimension (skills levels and continuous R&D) of PACAP as a significant determinant of firms' competitive advantage; while the impact of R&D intensity on competitive advantage proves insignificant, a result which is consistent in both the US and Europe. The suggestion is that firms' acquisition capability does not contribute to its competitiveness in either the US or Europe. Alternatively, we find skill levels are consistantly significant and positive across the US and Europe, whereas continuous R&D is highly significant in the European case but not in the US. A one percent increase in employee skill levels will raise firms' sales growth by 4.1 percent in the US, while only by 3.0 percent in Europe; on the other hand, a move from undertaking discontinous to continous R&D in Europe increases firms' sales growth by 2.5 percent. The suggestion is that the competitiveness of the US firms depends more strongly on skill-based absorptive capacity rather than on any aspect of internal knowledge creation, i.e. internal R&D intensity or continuity; in Europe, the achievement of superior performance is more conditional on continuous R&D and employee skills, indicating assimilation dimension of PACAP as an important factor in shaping firms'competitive advantage in Europe.

However, the empirical results reflect a significant but negative relationship between engagement with exploratory alliances and firms' competitive advantage, a result completely opposite to H5.2. In particular, the negative effect of exploratory alliances on

competitive advantage is only significant in the European case. This suggests that engagement in exploratory alliances does not pose any competitive advantage for the European firms.

Similarly, we find a positive but insignificant relationship between firms' engagment with exploitation alliances and sales growth, a result which is consistent in both the US and Europe. The suggestion is that engagement with exploitation alliances does not enhance a firm's competitive position in either the US or Europe – giving little support to H5.3.

11. 5 Conceptual Framework and Empirical Results

We hypothesise that during the new product development stage, potential absorptive capacity affects a firm's choice for exploratory alliances, and is associated with its alliances' intention (see research question 1). However, our results only suggest assimilation dimension of PACAP as an important determinant of firms' exploratory alliance activities; while acquisition dimension shows no influence on firms' choice for exploratory alliances either in the US or Europe. It seems that the US firms' engagement with exploratory alliances depends more strongly on the skill-based ACAP, whereas in Europe, participation in exploratory alliances is more conditional on continuous R&D (internal knowledge creation and ACAP).

It is also hypothesised that PACAP and exploratory alliances collectively influence RACAP (see research question 2). On the one hand, RACAP is subject to PACAP at firm level. On the other hand, the outcome of engagement with exploratory alliances is positively related to a firm's RACAP. In the general results presented in Table 7.4A, we find that the transformation dimension RACAP depends on the assimilation dimension of PACAP and firms' engagement with exploitation alliances rather than the acquisition dimension of PACAP, while the exploitation dimension of RACAP is conditional upon the acquisition dimension of PACAP only. In particular, the results also highlight some differences between the determinants of firms' RACAP in the US and Europe, i.e. acquisition capability proves more important in determining the firms' RACAP in Europe

but not in the US, whereas exploratory alliances prove a significant determinant of the transformation dimension of RACAP in the US only. However, for both the US and the European firms, there is not enough evidence suggesting that assimilation dimension has any significant effect on the dimensions of RACAP. The results rather suggest that improving acquisition capability and employee skills may be more effective in contributing to the development of exploitation capability of the European firms; whilst to achieve the same level, the US firms may benefit more by engagement with continuous R&D activities.

When new products come into the commercialisation stage (see research question 4), we predict that RACAP and exploitation alliances shape firms' competitive advantage. Specifically, we postulate PACAP as a significant determinant of exploitation alliances (see research question 3). The results empirically confirm that RACAP (i.e. the knowledge monitoring capability and the knowledge exploitation capability) plays an important role in determining firms' engagement with exploitation alliances, in particular in Europe. Similarly, exploitation alliances prove more important in shaping firms' competitiveness only in the European case. We also find that different aspects of RACAP affect firms' competitive advantage in various ways. i.e. market monitoring capability has a significant and positive effect on firms' competitive advantage, whereas the influence of exploitation dimension of RACAP on firms' competitive advantage is significant but takes on an inverted U-shape.

Figure 11. 1: Conceptual Framework

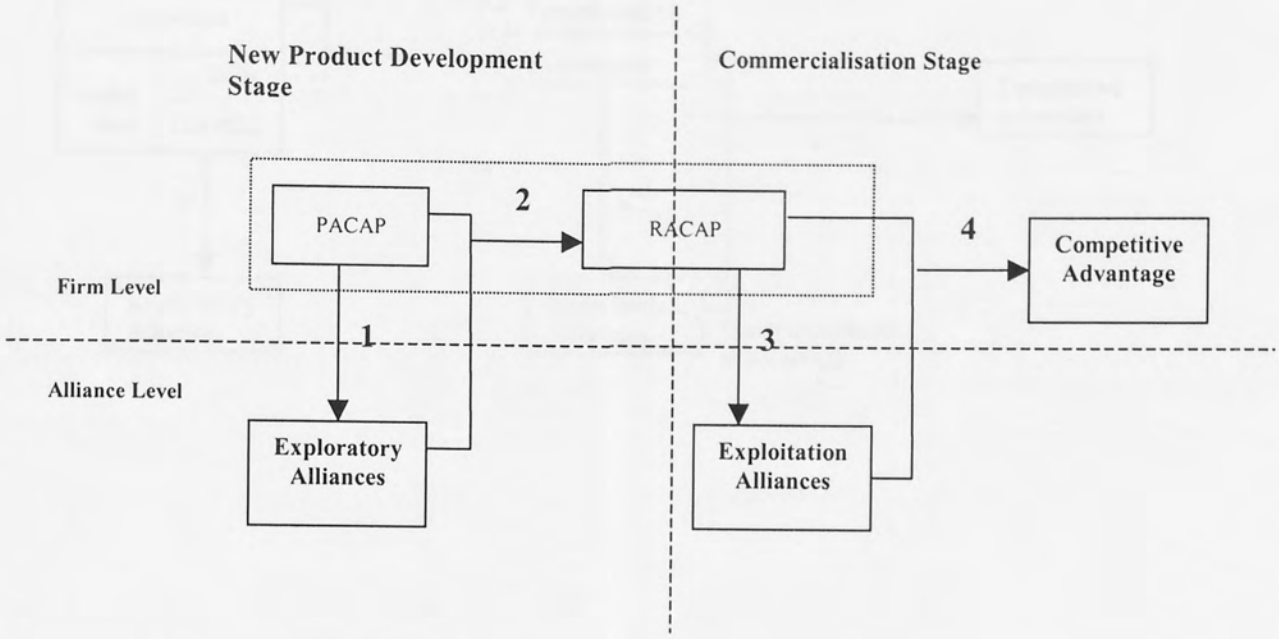


Figure 11. 2: General Model (based on the results from our general models)

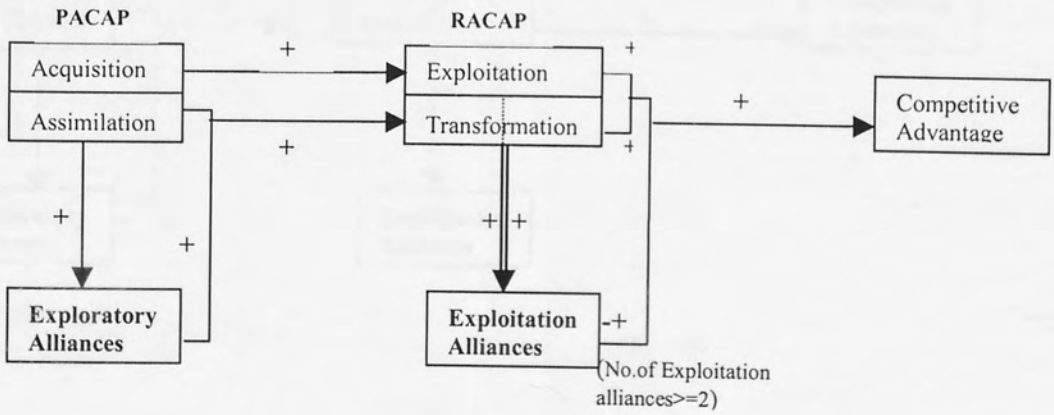


Figure 11.2. 1: European Model (based on our European respondents)

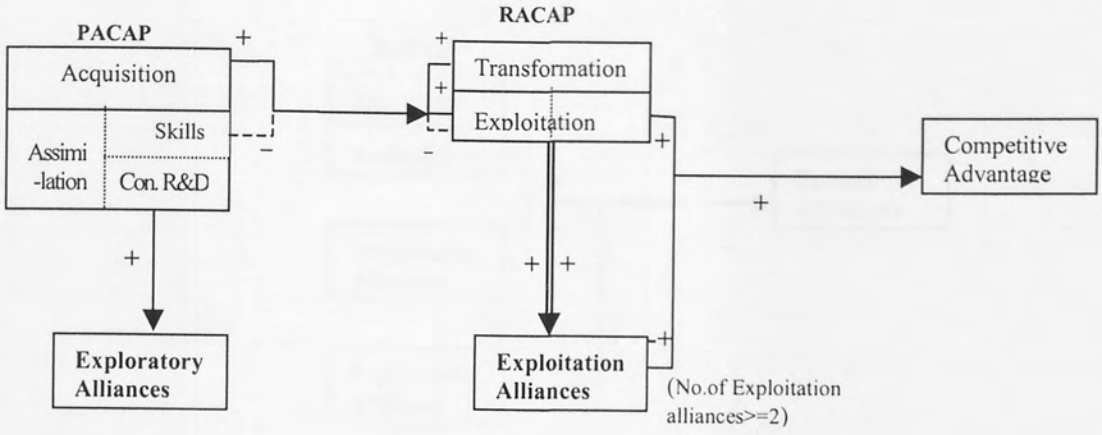
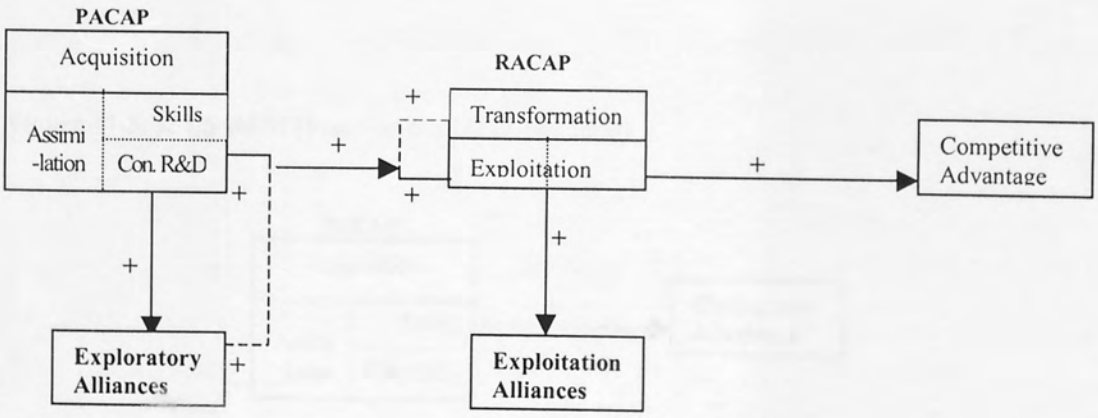


Figure 11.2. 2: US Model (based on our US respondents)



Reduced form model (Integrative analysis)

Figure 11. 3: General RFM (based on the results from our general model)

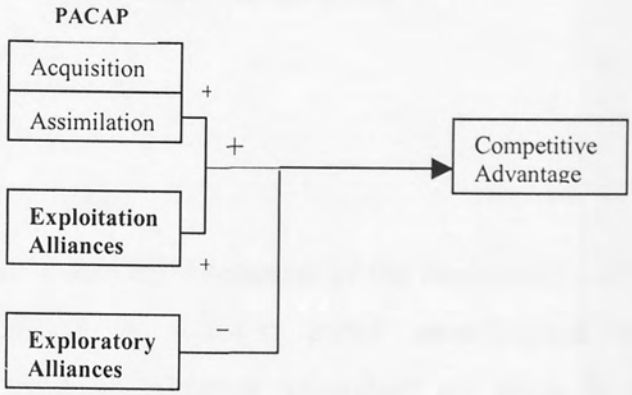


Figure 11.3. 1: European RFM (based on our European respondents)

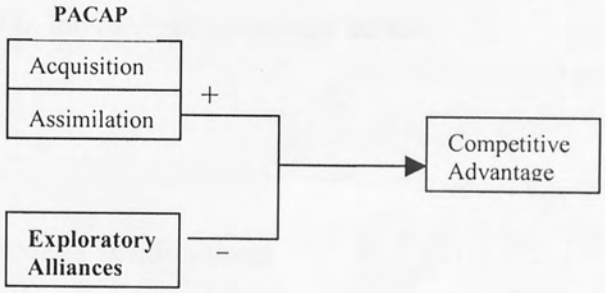
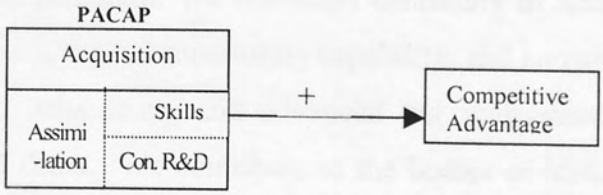


Figure 11.3. 2: US RFM (based on our US respondents)



CHAPTER 12

IMPLICATIONS

12.1 Introduction

In this chapter, we present a detailed discussion of the implications of our research. The chapter has been organised as follows: initial contributions and the relevant recommendations of our research to future researchers are given in section 12.2; then several important implications arising from the research for the managers of biopharmaceutical firms are discussed in the following section. In the last section, we use the US policy as a benchmark, to tease out the implications of our research to the future European policy in the biopharmaceutical sector.

12.2 Future Research Implications

Our research contributes to the development of bodies of literature on absorptive capacity and alliances, and advances a better understanding of the relationships between absorptive capacity and alliances, and their influence on firms' competitive advantage in the context of open innovation paradigm. We identified continuity in R&D, skills levels, knowledge monitoring capability, market monitoring capability, and knowledge exploitation capability as firms' alliance behaviours, and advanced our understanding of alliance growth in biopharmaceutical firms. We contribute to the bodies of research on absorptive capacity and alliances by extending and empirically corroborating the conceptual distinction between potential and realised absorptive capacities (Zahra and George, 2002), and exploration and exploitation alliances. Our study advances research concerning the linkage between absorptive capacity, alliances and competitive advantage. Our conceptual framework incorporates dimensions of absorptive capacity, exploration and exploitation alliances and competitive advantage, into a biopharmaceutical firm's new product development process, and theoretically identifies how the distinctive characteristics of

different dimensions of PACAP and RACAP affect firms' choices for exploration and exploitation alliances, and consequently shape firms' competitive advantage. The model has been empirically tested and enhanced, and a distinction has been made between the US and European models.

Our results reveal that firms' choices for exploration or exploitation alliances are determined by different aspects of the dimensions of PACAP and RACAP. Most importantly, our research contributes to the understanding of why certain aspects of the dimensions of PACAP/RACAP affect exploration or exploitation alliances and competitive advantage more than others. The distinctive characteristics between the US and European biopharmaceutical firms that have been highlighted in our research contribute to the comparative studies between the US and European biopharmaceutical industries in the related areas. For example, we find that firms' engagement with exploratory alliances and their competitive advantage depend strongly on assimilation dimension of PACAP in Europe, while in the US, participation in exploratory alliances, and competitive advantage, are more conditional on the skill aspect of the assimilation dimension of PACAP. Meanwhile, interaction between dimensions of PACAP and RACAP are also specified, and this extends our existing knowledge concerning the cumulativeness and path-dependent nature of absorptive capacity (Cohen and Levinthal, 1990).

One potential issue concerning these conclusions is that our analysis is based only on biopharmaceutical firms – albeit both in Europe and the US – an industry which is often regarded as having distinctive characteristics and being heavily regulated. However, recent studies demonstrate that research results from the biotechnology industry are generalisable to other high technology industries such as telecommunications and semi-conductors at least (Almeida, 1996). Before being confident about any generalisation, however, other studies could usefully be undertaken in an attempt to generalise our results to other high technology industries, e.g. data processing and telecommunication industries.

We find that R&D intensity does not contribute to firms' engagement with exploratory alliances either in the US or Europe; whereas continuous R&D proves to be an important determinant of exploratory alliances in Europe. The results seem to suggest that continuity in R&D is more important than investment in R&D on its own, in determining firms'

exploratory alliance activities. However, firms do need certain levels of R&D investment to sustain their on-going R&D activities. An interesting avenue for future research would be to examine whether the frequency or intensity, or other aspects of R&D, are more important in determining firms' exploratory alliance activities. On the other hand, empirical literature has laid special stress on the ambiguity of the impact of R&D intensity on exploratory alliances. In fact, the relationship between R&D intensity and exploratory alliances is always surrounded by the empirical controversy of complementary (Veugelers and Cassiman, 2002 and 2005; Cassiman and Veugeler, 2006; Pisano, 1990; Vedovello, 1998), positive (Arora and Germbardella, 1994; Colombo, 1995), mixed (Berg et al, 1982; Colombo and Garrone, 1996), and no influence (Kleinknecht and Reijnen, 1992). Our finding here only reflects certain aspects of the reality under the specified conditions, in other words, the findings are confined to a particular industry within specific countries. Thus, the relationship between R&D intensity and number of exploratory alliances may be worthy of further examination, using data from different countries and industries.

Our findings reveal that a firm's choice of exploratory alliances is affected by the different aspects of assimilation dimension of PACAP in the US and Europe. Possible explanation could be that our profile of companies reflects greater investment and support for bio-technology companies in the US than in Europe and European firms are under-exploiting their existing science base (e.g. de Looze et al, 2001; Lemarie et al, 2000; Sharp, 1995; Orsenigo, 1989). Thus, it may be worth exploring the underlying factors which cause these differences between the US and European biopharmaceutical industries. In addition to the differences between the US and the European biopharmaceutical industries that have been highlighted, the findings underpin several important implications. Firstly, they suggest that the notion of ACAP is very dynamic under different circumstances, and might not apply in a uniform but a contextual way. Future research should attempt to refine this concept by bringing in more contextual-based measures of ACAP, and linking the theoretical notion with firms' different organisational, industrial and national backgrounds. Secondly, we find that skill levels and firms' continuity in R&D are not only important factors in benefiting from R&D collaboration (Leiponen, 2005), but also foster the growth of firms' exploratory alliances. Therefore, further investigation to both confirm this result and explore its behavioural foundations and implications, is clearly needed. In particular, it may be worth under-taking more in-depth company case studies of the process of alliance

formulation and development in order to highlight potential links to skill development and R&D. However, it is noteworthy that our findings suggest that skill levels have a significant but negative effect on firms' exploitation capability. On the one hand, skills and knowledge embedded in individuals are important in shaping firms' competitiveness because of their heterogeneity. On the other hand, it is possible that skills and knowledge embedded in individuals can turn into core rigidities because they are less amenable to change (Grant, 1991; Leonard-Barton, 1992). And consequently these kinds of rigidity may impede firms in their efforts to harvest and incorporate existing and newly-acquired and transformed knowledge into their operations. Moreover, the negative impact of skills on firms' exploitation capability might reflect the nature of the measures that have been used, specifically those related to skills levels, because we only focus on the particular aspect of skills (i.e. the academic skills) in this research; and other aspects of skills, i.e. management skills, technical skills, commercialisation skills, etc. may also affect the exploitation of firms' knowledge bases. Future research might benefit from exploring the impact of other aspects of skills on firms' exploitation capability. Moreover, it will also be interesting to deepen this analysis by incorporating other factors such as the utilisation of the skills, and the relevant levels of strategic flexibilities.

Our findings suggest that acquistion dimension of PACAP (R&D intensity) contributes to the development of each of the dimensions of RACAP in Europe but not in the US. This supports the argument regarding to the path-dependent nature of absorptive capacity (Cohen and Levinthal, 1990; Eisenhardt and Martin, 2000; Schmidt, 2005; Zahra and George 2002), and confirms that higher levels of R&D efforts improve a firm's ability to exploit sources of technical knowledge outside its boundaries (Gambardella, 1992; Mowery et al, 1996). More specifically, the findings highlight the dynamic role of R&D intensity in facilitating the development of internal capabilities and external knowledge acquisition and exploitation under different circumstances. This suggests that R&D intensity might contribute to certain types of absorptive capacity more than the others, depending on the kind of knowledge firms, individuals, regions or nations that have been examined (Schmidt, 2005). Future research may benefit from collecting more precise measures for PACAP and RACAP in combination with the firms' environmental and organisational differences, in particular, intra-industry, inter-industry and inter-nation differences.

Our findings also reveal the differences within the sub-dimensions of the transformation dimension of RACAP in affecting firms' exploratory alliance activities. We find that knowledge monitoring capability is an important factor in determining firms' exploitation alliances across the US and Europe, whereas market-monitoring capability is a significant determinant of exploitation alliances only in the US. This is probably related to the distinctive characteristics within different sub-dimensions of transformation capability. Consequently it may point to the fact that we use subjective indicators (Likert-scales) to measure the transformation dimension of RACAP, due to the inherent difficulty in measuring this construct (Jansen el al., 2005). In future research, more objective indicators for the dimensions of PACAP and RACAP need to be developed. In fact, the use of other measures would help to establish the robustness and reliability of the current findings. Alternatively, it would be worthwhile to further refine the existing constructs for absorptive capacity. Another possible explanation for these results could be that exploitation alliances may depend on one aspect of the transformation capability more than the other, due to the differences embedded in individual alliances, typified as the duration of exploitation alliances, and the motivation of alliance partners. However, this research's cross-sectional design makes it difficult to capture the time in some of the variables, and we could only measure exploration and exploitation alliances according to their absolute numbers. In fact, it is important to note that alliances in the biopharmaceutical industry are characterised by its longevity since the product development process can take 15 years or more (Rothaermel, 2004). Future research requires better measures of the activities of individual exploration and exploitation alliances. A feasible avenue for future research could be to conduct longitudinal studies of the evolution and development of exploration and exploitation alliances and dimensions of PACAP and RACAP over time. This would deepen our understanding of the dynamic relationship between PACAP/RACAP and exploration/exploitation alliances, and their potential influences on firms' competitive advantage.

The inverted-U shape relationship between exploitation dimension of RACAP and competitive advantage, suggests that firms either under-exploit or over-exploit their knowledge base. Considering that more than 80 percent of our respondent firms are under-exploiting their existing knowledge base, we only focus on the significant and positive effect of exploitation capability on firms' competitiveness in this research. However, there

is still a need in future research to explore this kind of relationship as a whole, in particular the investigation of the organisational or managerial factors that would explain the inverted-U shape relationship between exploitation capability and competitive advantage as we found here. Another interesting question is whether the level of exploitation capability at which sales growth reaches its maximum could be improved by other factors apart from patent quantity. Because it might not be enough for firms to maximise the benefit from the exploitation of their knowledge base simply by limiting the patents within certain numbers.

In this research, we only examine the one way relationship between ACAP and alliances, and it would be interesting to investigate the existence of a two-way relationship between these variables, especially the chance of exploration and exploitation alliances being a solution (complement, positive/negative determinants or no influence) for the development of firms' PACAP or RACAP. It would also be interesting to examine what mixtures of exploratory and exploitation alliances in a firm's alliance portfolio could maximise the positive effect of alliances on firms' PACAP, RACAP and competitive advantage. However, the most challenging question for future research is whether there is any interaction between these two types of alliances. Additionally, our findings suggest that biopharmaceutical firms shift their attention towards exploration alliances (857) rather than exploitation alliances (652). This is completely the opposite of the previous findings, which reported that exploitation alliances crowd out exploration alliances (Rothaermel, 2001; Levinthal and March, 1993). The time gap between these two different kinds of findings is only six years. Therefore, the conjecture that the dominance of exploitation alliances might reverse over time as incumbents shift their attention towards exploration alliances or in-house development (Zucker and Darby, 1997) needs to be further tested in future research.

It is worth noting that in this research, we define exploration and exploitation alliances according to the special development process of biopharmaceutical products. However the distinctive characteristics of the biopharmaceutical industry have been stressed in the recent literature as an important factor affecting firms' alliance activities (Rothaermel, 2001). There is a growing body of research attempting to restructure or employ this notion in a general term, in particular that by Rothaermel and Deeds (2004) and Faems et al

(2006). This helps future researchers to develop a better understanding of the notion of exploration and exploitation alliances, in order to apply it to different contexts, as well as to test our model across different industries and sectors.

Alternative explanations for the EU-US differences that have been highlighted in our research need to be developed in future studies. For example, the importance of continuity in R&D in Europe might not be the result of its relatively lower level of public or private investment than encountered by the US pioneers at the same stage eight years ago. In fact, Fazeli (2005) stresses that there is enough cash in Europe to allow firms to bring products to the markets. The biggest problem is that Europe has a geographically-fragmented equity capital market, which limits the pool of capital accessible to individual companies (Fazeli, 2004). For instance, a UK generalist small/mid-cap investor is often prohibited from investing in Switzerland or France, even hundreds miles away. In addition, many other factors, i.e. different legal systems, variant employment laws (Bains, 2006), and linguistic and cultural differences within Europe may also hinder the free flow of investment within Europe. In the US, however, this is never the case, because a uniform capital market allows a US generalist investor to invest in biopharmaceutical firms thousands miles away in New York, without any problem.

Our integrative analysis shows that exploratory alliances have a negative effect on firms' competitive advantage. On one hand, exploratory alliances may not have a direct effect on firms' performance, but on the other hand, it is empirically corroborated that exploratory alliances contribute to the number of new products in development at a firm (Rothaermel and Deeds, 2004). In fact, the new product development process in the biopharmaceutical industry is relative long, and protracted. It can take from six to nine years to successfully bring a new drug to the market (Powell and Brantley, 1992). Moreover, it is worth noting that the performance distribution of commercialised products, particularly in the biotechnology industry is heavily skewed, and even a successful blockbuster drug might accrue several billion dollars of revenues for decades (Rothaermel, 2001). Thus, further investigation of the negative effect of exploratory alliances on firms' competitive advantage is clearly needed, i.e. by using different measures or data from different industries or nations.

However, in this research, we only focus on those firms with existing alliance(s). Although the biopharmaceutical industry has been identified as a high technology industry with intensive alliance activities, accounting for 20% of all strategic alliances (Hagedoorn, 1993), it is possible that some firms may prefer in-house development rather than a collaboration strategy, given that the potential benefit may overweigh the high opportunity cost of adopting an exploration-exploitation alliance strategy in the new product development process, i.e. the high degree of uncertainty associated with the new product development process and the costs of alliance management (Rothaermel and Deeds, 2004). Future research should attempt to study those firms without any alliance. Specifically, comparative studies of these two types of firms would be of great value to future research and management practice.

12.3 Strategy Implications

Our findings have several implications for the R&D managers of biopharmaceutical firms. The most important point arising from our empirical analysis is the significant and positive roles of skill-based PACAP, and exploitation dimension of RACAP in determining firms' competitive advantage. We find that firms with relatively higher rates of accumulation of skill-based PACAP and/or knowledge exploitation capabilities, tend to generate larger shares of sales from their newly-commercialised products. This may be associated with the fast-changing technology base of the biopharmaceutical industry, which makes knowledge and skills in this industry become out-dated more quickly. Meanwhile, the heterogeneity in the levels of skill is imperfectly imitable and persistent over time, and therefore, skill-based PACAP is an important source of sustainable competitive advantage (Barney, 1991). Equally, well-developed knowledge exploitation capabilities allow firms to capitalise upon emerging strategic opportunities (Raff, 2000), which may help the firms sustain superior performance more effectively than those with less accumulation of this kind of capability because of first mover advantages (Ferrier et al, 1999). Actions improving employee skills levels, and the management of knowledge exploitation capabilities, therefore become crucial in enhancing firms' competitive positions in a very dynamic industrial environment like biopharmaceuticals. In particular, it might be of great importance for R&D directors to hire highly-educated people who are aware of the latest technologies; while continuously retraining them at the same time. Managers should also be active in establishing mechanisms and routines to encourage refining, extending, and leveraging existing competencies or creating new ones by incorporating acquired and transformed knowledge into their operations. Furthermore, additional strategies are suggested to the EU managers, in particular, the support of continuity in R&D with firms, which could be achieved by continuously involvement in R&D-related projects or programmes, etc.; and the use of relevant mechanisms or routines to guarantee a regular consideration of the impact of market changes for new products, such as regular meetings and communications between R&D departments and marketing departments.

In particular, our results reveal a great distinction between the US and Europe in the impact of the dimensions of absorptive capacity and alliance type on firms' competitive advantage. These distinctions yield different implications for the management practices across

different national/geographic contexts. Managers should realise the fact that aspects of the dimensions of PACAP and RACAP and exploration and exploitation alliances may affect firms' competitive advantage in completely different ways across the US and Europe. For the US managers, a potential way to improve a firm's competitive position is through the development of the firm's market domain, i.e. regional, foreign and external markets, whereas for those managers from the European firms, continuity in R&D, and regular consideration of the impact of market changes for new products, may be more effective in enhancing firms' competitive positions. Additionally, our results suggest that the use of market-based alliances i.e. exploitation alliances, are also very helpful for the EU managers to improve firms' performances. However this strategy has to be adopted with great caution, because the positive effect of exploitation alliances on firms' performance may not come out immediately after the alliance formation. Considering alliances as a process, it is clear that they will not generate returns straight away. This means that firms have to participate in at least more than one exploitation alliance, in order to increase their sales growth.

Interestingly, previous studies emphasise a complementary rather than a positive relationship between internal capability development and external collaboration (Pisano, 1990; Veugelers and Cassiman, 2005; Cassiman and Veugelers, 2006; Vedovello, 1998); while our model and empirical results seem to suggest that managers need to understand the particular importance of the development of internal capabilities in promoting the growth of external linkages. Specifically, it is very crucial for these managers to realise the importance of the abilities to recognise the usefulness of new external knowledge in facilitating the growth of firms' exploitation alliances. However, the development of this ability must be built upon good exploitation of this existing knowledge base, as well as a good understanding of the impact of market changes for new products. This therefore, points to the necessity of the development of relevant knowledge exploitation capability, and the market monitoring capability to support firms' internal capability development and the growth of their external linkages. In particular, for managers of the European firms, the development of some routines or mechanisms to encourage good exploitation of their existing and new knowledge base may be more effective in fostering the growth of their exploitation alliances. However, to achieve this, managers of the US firms may benefit more by employing mechanisms such as regular meetings to discuss the impact of market

change on new products, and increasing the frequency and intensity of the communication between the R&D department and the marketing department.

Another important implication for managerial practice is the fact that investment in R&D itself is not enough to make exploratory alliances work. Rather, managers should be aware that firms need a certain level of employee skills to internalise the external knowledge that has been acquired, or at least to facilitate the external learning process. In strategic terms, this suggests the need for continuity in R&D within a firm and also relevant investments in skills to facilitate external knowledge gathering. Specifically, different strategic options are also suggested for the managers of US and European biopharmaceutical firms. It is more sensible for the EU managers to capitalise on the continuity in R&D within firms in facilitating their exploration alliance activities, whereas investment in skills is probably the most appropriate strategy for the US managers in promoting firms' engagement with exploratory alliances.

Several important insights emerge from our results concerning the development of firms' absorptive capacity across different national contexts. Firstly, the R&D aspect of PACAP plays a very important role in contributing to the accumulation of firms' RACAP. This supports the path-dependent nature of absorptive capacity (Cohen and Levinthal, 1990). R&D related investment and continuity in R&D within a firm warranty the external knowledge gathering, and advance a better understanding of newly-acquired knowledge. Specifically, our results further suggest that to a great extent the accumulation of RACAP is contingent on firms' related R&D investment in Europe, while in the US, it is the continuity in R&D within a firm which contributes most to the exploitation of new external knowledge. Secondly, our results reveal the importance of R&D-based collaboration (i.e. exploratory alliances) in facilitating the development of knowledge transformation capabilities. We find that firms engaged in exploratory alliances develop stronger knowledge transformation capabilities, in particular in the US. For most of the biopharmaceutical firms, engagement with exploratory alliances not only offers access to external new knowledge, but also provides opportunities for these firms to discover new insights which fit their existing practice. This process, therefore improves firms' ability to combine existing knowledge and newly-acquired and assimilated knowledge. On the other hand, these results suggest that managers could also view alliances as a capability-

enhancing process. However, it is worth noting that most of these capabilities, especially knowledge transformation capabilities, are unobservable although existing for a nominal term, and thus, managers might not realise other non-financial returns of alliances apart from access to complementary sets of resources and assets. The scales developed by our research could be used as a valuable tool for these managers to evaluate firms' levels of knowledge transformation capabilities.

12.4 Policy Implications

The empirical analysis presented in this research complements and reinforces the Lisbon Agenda (2000) and Sapir Report (2003) by advancing our understanding of the importance of R&D, skills and other factors, i.e. alliances to firms' competitiveness in the context of the biopharmaceutical industry. The Lisbon Strategy (2000) and Sapir Report (2003) emphasise the achievement of increasing investment in R&D, and improving the quality and effectiveness of EU education and training systems, as well as other objectives to stimulate economic growth in catching up with the US. Comparing the US and European experience in developing the biopharmaceutical sector, the US market-driven approach may prove to be superior to the policy-orchestrated one in the EU. One of the reasons why the market-driven approach is superior over the policy one is the fact that private leadership in industry development suggests that there is a suitable entrepreneurial culture in the region, which is a key factor in the commercialisation of science. In the US, government plays an 'enabling' role in shaping the industry environment and encouraging entrepreneurship. Policy has limited its involvement to creating a suitable framework. Government programmes funding research and development as well as small firms have helped the development of biotechnology without being targeted at biotech in particular or a specific region (Wolter, 2003). On the other hand, policy in Europe is more strategic and directive. Government acts as 'co-ordinator' in the sector. Policy has been very actively involved in building the industry through specialised programmes, the most well known being the European framework programmes. Another reason is associated with the concern that private leadership in industry development has also meant that more finance for new business ventures has come from private rather than public sources. And this in turn, could help to minimise the gap between the US and EU investment in the private sector. We use the policy mechanism of the US biopharmaceutical sector as a benchmark, and spell out precise recommendations for the EU policy initiatives or directions. The findings further refined the strategy and policy recommendations addressed by the Lisbon Agenda (2000) and Sapir Report (2003). Several areas, i.e. skills, continuity in R&D and RACAP as well as exploitation alliances, are identified as the key issues that have important implications for the EU policy on the biopharmaceutical sector.

One of the important implications for policy that have been addressed by our research is concerned with R&D investment. The current level of investment in research in the EU amounts to 1.9 percent of GDP, compared to 2.7 percent in the US (Eurostat, 2005; 2006). The gap between the EU and US research investment is already in excess of 120 billion Euros per year, and widening fast, with consequences for long-term potential for innovation, growth and employment creation in Europe. Especially, expenditure in the private sector accounts for 100 billion Euros of the difference (Eurostat, 2006). The EU is perceived to provide less attractive conditions for private investment, due both to lower and possibly less effective public support, and to various obstacles in the wider framework conditions of European research and innovation. To catch up with the US, close the gap between EU and the US research investment means that the EU R&D effort needs to increase by more than 50 percent (Sapir Report, 2003). However, we find that R&D investment itself is not enough to make some of the innovation activities (i.e. exploratory alliances) work either in the US or Europe. Rather, at the European level, our results points to the need for continuity in R&D within a firm to facilitate external knowledge gathering. Most importantly, our results highlight that continuity in R&D is a significant determinant of firms' competitive advantage only in Europe. Actions towards sustaining continuity in R&D not only foster the growth of firms' exploratory alliances, but also give rise to an overall improvement of the firms' competitive positions. In line with the Lisbon Agenda (2000) in promoting the necessary investment in R&D within Europe, which is three percent of GDP, our research further suggests that extra attention should be paid by policy-makers to ensure the continuity in R&D within firms. Additionally, in fostering the growth of exploratory alliances, the European Commission's framework programmes have already served as good evidence of the policy initiatives to encourage R&D collaboration (i.e. exploratory alliances), with the aim of creating an area of free movement of knowledge, researchers and technologies, in achieving a better allocation of resources in Europe.

Another important implication for policy-making arising from our analysis is that skills levels are a significant and positive determinant of competitive advantage in both the US and Europe. Policy measures aiming at improving skill levels may result in an overall performance improvement of both the US and European firms. This reinforces the necessity of investment in higher education to achieve better skills as suggested by the Sapir Report (2003) and the Lisbon Agenda (2000). The US already spends a higher share

of GDP on higher education from public sources than the EU average, but the addition of very substantial private sources means that the US spends more than double the EU average on higher education and more than any Member State (Sapir Report, 2003). Specifically, it is proved that higher education plays an important role in determining the competitiveness of the EU, i.e. the economic growth (Aghion et al, 2003), and R&D productivity, since economies endowed with a skilled labour force are better able to create and make effective use of new technologies. On the other hand, our results reveal that skill levels have a negative effect on knowledge exploitation capabilities in Europe. It is very important for the policy-makers to realise that skills and knowledge embedded in individuals can also turn into core rigidities because they are less amenable to change. This suggests the need for upgrading skill levels within Europe. Thus, policy initiatives such as promoting substantial modernisation of Europe's education and training systems become necessary, particular in the light of Lisbon goals, to make Europe a world leader in the quality of the education and training it provides by 2010.

In addition to encouraging investment in R&D and skills (PACAP), it may be worth building policy initiatives about enhancing firms' RACAP. Although investment in R&D and skills (PACAP) are necessary conditions for achieving growth, firms also need to develop the capacity to transform knowledge into new products, processes and services, which in turn generate benefits to society through skilled jobs and prosperity (RACAP). Our results suggest that policy measures aiming at improving firms' knowledge exploitation capability, and the ability to identify the impact of market changes for new products, as well as the ability to recognise the usefulness of new external knowledge, will enhance the competitiveness of the EU companies. One of Europe's main strengths is its world-class science base. However, so far the main way to promote application-oriented research within Europe is through public-private research collaboration and use of public sector research results. This can be seen by the fact that in the past, the majority of the government funding in this area has been allocated to encourage university-industry research links (exploratory alliances), assuming it could stimulate firms' growth. However, our results suggest that more attention should be paid to promoting the formation of exploitation alliances (market-oriented alliances) between companies, which act as a performance enhancer of firms. Policy initiatives should be devoted to raising the awareness of 'market-match' between companies from different environments. For

example, a new product developed by one company could be manufactured and/or go to the markets of the other companies. Actions could target the promotion of inter-firm linkage focusing on the downstream activities. In addition, Europe suffers from fragmentation of public research support, while in the US, firms have considerable opportunities to exploit the National Institute of Health (NIH) research results though some funding provision programmes i.e. SBIR[38] and various support from Federal agencies, some support industrial research, university-industry links, whilst others are more concerned with promoting technology transfer (Wolter, 2003). Thus, it may be worth having action plans in the EU to enhance research co-operation and technology transfer among regions and Member States. In particular, there is a need to promote and facilitate different forms of networking and linking-up to overcome fragmentation (European Commission COM (2002) 27). Moreover, it might be effective to have programmes to encourage firms to adopt new technologies and raise industrial awareness about the biopharmaceutical industry at the same time.

More policy insights can be gained through our research, in particular, those results relating to firms' engagement with exploitation alliances. It is suggested that policy measures encouraging the formation of exploitation alliances (market-oriented alliances) may prove beneficial in enhancing the competitive position of Europe. Exploitation alliances provide access to complementary assets to commercialise new technologies, and contribute to the improvement of participant firms' industry performance (Rothaermel, 2001; Shan et al, 1994). Instead of distributing funds to encourage university-industry research links, exploitation alliances are more flexible and straightforward than those policy schemes in promoting the commercial exploitation of biotechnology. Although current EU policy has been very actively involved in setting incentives for commercial activities in the biopharmaceutical sectors, and enhancing networking between companies, measures assigning resources to the identification and the development of exploitation alliances (market-oriented alliances) may create values and better performance. Actions such as the "BIRD[39]" scheme might prove more effective in promoting the growth of exploitation alliances (market-oriented alliances) within Europe.

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[38] There are no special programmes to support biotech SMEs, but they are eligible to apply for financial support under the Small Business Innovation Research Program, to which the National Institute of Health (NIH) contributes significant funds (Wolter, 2003).

[39] "BIRD" is an acronym for Israel-US Binational Industrial Research and Development. The "BIRD" Foundation's mission is to stimulate, promote and support industrial R&D of mutual benefit to the US and Israel.

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Appendices

Appendix 1: Questionnaires for the Main Survey

Appendix 2: Control Variables

Appendix 3: Data Summary

Appendix 4: Results of Chapter

NEW PRODUCT DEVELOPMENT IN EUROPEAN BIOTECHNOLOGY INDUSTRIES

U.S.A.-2006 ABS

These are the contact details that we have for your company. Please amend if necessary.

Label Here

1. Background

When was your company established? Year

How many employees currently work at this site?

How many full-time employees work in your company worldwide?

Is your company's primary market: (Please tick relevant boxes)

National ☐ Europe ☐ N. America ☐ Asia ☐ Others ☐

Please indicate whether your company is: (Please tick relevant box)

An independent company	
A parent or group HQ	
A subsidiary company in a group	
Other	

Please indicate the main activities which you focus on at this site? (Please tick relevant boxes)

	Yes	No
Basic research and drug discovery		
Pre-clinical development		
Clinical development Phase I		
Clinical development Phase II		
Clinical development Phase III		
Manufacturing		
Regulatory support		
Marketing and sales		

Who are your main customers? (Please tick relevant boxes)

	Yes	No
Hospitals		
Doctors (GPs)		
Other healthcare professionals		
Other companies		
Individual patients		
Others		

Please indicate the percentage growth of your business here over the last 3 years:

	Percentage over the last 3 years
Sales growth	%

What proportion of your employees have a degree or higher qualification? %

Please indicate whether you are a spin-off company from: (Please tick relevant box)

	Yes	No
Universities or research institute		
Hospital or healthcare centre		
Commercial company		
Others		

Do you outsource any of the following activities? (Please tick relevant boxes)

	Yes	No
Pre-clinical testing		
Clinical trial Phase I		
Clinical trial Phase II		
Clinical trial Phase III		
Manufactory		
Regulatory process		
Marketing & sales		
Public Relations activity		

Over the last three years has your business here received financial support from? (Please tick relevant boxes)

Venture capital companies ☐ Government ☐ Overseas funding ☐ Others ☐

2. *Research and Development*

Do you carry out any R&D within your business here?	Yes	No

IF NO SKIP TO SECTION 3

	Yes	No
Do you *licence in* any intellectual property?		
Do you *licence out* any of your intellectual properties?		

Approximately what percent of your turnover was spent on R&D in the last financial year? %

How would you describe your investment in R&D since 2003? *(Please tick one)*

Continuous ☐ Occasional ☐ Infrequent ☐

How important were the following constraints on your R&D activities?

	Completely insignificant				Extremely significant
	1	2	3	4	5
Lack of capital					
Lack of suitable managerial staff					
Lack of suitably *qualified* research and technical staff					
Lack of suitably *experienced* research and technical staff					
Lack of research data and / or information					
Difficulty in accessing appropriate technology					
Lack of information about markets					
Problems caused by market or research regulation					
Lack of development partners					

3. *New Product Development*

Thinking now about your patenting activity, please indicate:

The number of patent applications made from this site over the last year	
The number of patents your business currently holds	

On average, please estimate the length of your new product development cycle:

Years

Thinking now about your product range, please indicate how many products you have at each of the following stages of the development process

	Number of products
Basic R&D	
Pre-clinical	
Phase I	
Phase II	
Phase III	
Awaiting for regulatory approval	
Products on the market	

How strongly do you agree or disagree with the following statements? *(Please tick relevant boxes)*

	Strongly disagree				Strongly agree
	1	2	3	4	5
We regularly consider the impact of market changes for new products					
Employees record and store newly acquired knowledge for future reference					
We recognize the usefulness of new external knowledge					
Employees in our firm often share practical experiences					
We try hard to identify new external knowledge					
We meet regularly to discuss market trends and new products					

How important are the following to your success in developing new product ideas? (Please tick as appropriate)

	Completely insignificant				Extremely significant
	1	2	3	4	5
Internal R&D					
Good Internal Communication					
Good Project Management					
Awareness of Leading Edge Research					
Effective Partnerships					
Employees' Skills					

4. Early Stage of New Product Development

This section focuses on your basic research, drug discovery and development activities; please indicate whether you have any partnerships or alliances as part of these activities: *(Tick as appropriate)*

Yes	No

IF NO SKIP TO SECTION 5

Please indicate the total number of alliances or partnerships focusing on basic research, drug discovery and development you have currently?

Who are your partners in these relationships? (Please tick relevant boxes)

	No. of Partner(s)
Other small companies within your industry (200 or less employees)	
Other large companies within your industry (200 or more employees)	
Universities or other academic institutes	
Government research organisations	
Private research institutes	
Commercial laboratories/R&D enterprises	

How important were the following motivations in your decision to cooperate in basic research, drug discovery and development? *(Please tick relevant boxes)*?

	Not important 1	2	3	4	Very important 5
Access to partners' intellectual capital					
Expand the range of products offered to customers					
Increased speed of new product development					
Access to infrastructure					
Achieve operational flexibility					
Finance, e.g. project-funding					
Access to larger projects					
Spread R&D risks/costs of new equipment					
Response to customers					
Improve financial and market credibility					

In general, do your alliance(s) involve: *(Please tick as appropriate)*

	Yes	No
Monthly or more frequently formal meetings or communication		
Quarterly or less frequently formal meetings or communication		
Inclusion of a partner inside your management team		
Staff working with your partners as a "joint development team"?		

In general terms, how successful are your alliances in the early stage new product development? *(Please tick as appropriate)*

Made little progress towards objectives ☐ Partially achieved objectives ☐ Achieved objectives ☐ Surpassed objectives ☐

5. Commercialisation of New Products

Now we would like to ask about your commercialisation activities, e.g. clinical trials, FDA regulatory process, marketing and sales, etc. Please specify if you have any alliances or partnerships to help with these activities: *(Tick as appropriate)*

Yes	No

IF NO SKIP TO SECTION 6

Please indicate the number of alliances focusing on commercialisation activities, e.g. clinical trials, FDA regulatory process, marketing and sales etc. ?

Who are your partners in these relationships? (Please tick relevant boxes)

	No. of Partner(s)
Other small companies within your industry (200 or less employees)	
Other large companies within your industry (200 or more employees)	
Manufacturers outside your industry	
Contract research organisations (CRO)	
Regulatory/patents/intellectual property consultancies	
Marketing/distribution companies	
PR companies	

How important were the following motivations in your decision to cooperate in your commercialisation activities? *(Please tick relevant boxes)*?

	Not important 1	2	3	4	Very important 5
Complementary knowledge					
Increased speed of new product development					
Operational flexibility					
Finance					
Access to larger projects					
Access to new **US** markets					
Access to overseas markets					
Improve financial and market credibility					
Response to customers					

In general, do your alliance(s) involve: *(Please tick as appropriate)*

	Yes	No
Monthly or more frequently formal meetings or communication		
Quarterly or less frequently formal meetings or communication		
Inclusion of a partner inside your management team		
Staff working with your partners as a "joint development team"?		

In general terms, how successful were your alliances in the commercialisation stage new product development? *(Please tick as appropriate)*

Made little progress towards objectives ☐ Partially achieved objectives ☐ Achieved objectives ☐ Surpassed objectives ☐

Now, please thinking about your **partnership/alliances in the area of basic research, drug discovery and development**; and your **partnership/alliances in the area of clinical trials, FDA regulatory process, marketing and sales**.

Is there any overlap between your alliance partners in these two areas? *(Please tick as appropriate)*

Yes	No

IF NO SKIP TO SECTION 6

If yes, please indicate the type of partners where any overlap occurs: *(please tick as appropriate)*

	Yes	No
Other small companies within your industry (200 or less employees)		
Other large companies within your industry (200 or more employees)		
Universities or other academic institutes		
Government research organisations		
Private research institutes		
Commercial laboratories/R&D enterprises		
Manufacturers		
Contract research organisations (CRO)		

6. Future Alliances

Do you anticipate developing any new partnerships over the next 2-3 business years? *(Please tick as appropriate)*

Yes	No

IF NO SKIP TO SECTION 7

Please indicate the type of your potential partners for early stage development and commercialisation: *(Please tick relevant boxes)*

	Early stage	Commercialisation
Other small companies within your industry (200 or less employees)		
Other large companies within your industry (200 or more employees)		
Universities or other academic institutes		
Government research organisations		
Private research institutes		
Commercial laboratories/R&D enterprises		
Manufacturers		
Contract research organisations (CRO)		

7. Competitive Advantages

How important are the following in contributing to the commercial success of your new product development: (*Please tick relevant boxes*)

	Not important				Very important
	1	2	3	4	5
Ability to develop products to meet market requirements					
Alliances or partnership focusing on the commercialisation of new products					
Specialized expertise					
Range of products					
Patent quality					
Platform technologies					
Operational flexibility					
Legal, regulatory and policy environment					
In-house R&D					
Outsourcing					
Effective management operations					
Product Safety profile					
Cost advantages					

Thank You for your help

Please send your completed form in the post free return envelope provided to

Helen Xia, Economy & Strategy Group, ABS, Aston University, Aston Triangle, Birmingham B4 7ET, UK

Tel: +44 (0)121 242 3158; Fax: +44 (0)121 242 3326

NEW PRODUCT DEVELOPMENT IN EUROPEAN BIOTECHNOLOGY INDUSTRIES

UK-2006 ABS

These are the contact details that we have for your company. Please amend if necessary.

Label Here

1. Background

When was your company established? Year

How many employees currently work at this site?

How many full-time employees work in your company worldwide?

Is your company's primary market: (Please tick relevant boxes)

National ☐ Europe ☐ N. America ☐ Asia ☐ Others ☐

Please indicate whether your company is: (Please tick relevant box)

An independent company	
A parent or group HQ	
A subsidiary company in a group	
Other	

Please indicate the main activities which you focus on at this site? (Please tick relevant boxes)

	Yes	No
Basic research and drug discovery		
Pre-clinical development		
Clinical development Phase I		
Clinical development Phase II		
Clinical development Phase III		
Manufacturing		
Regulatory support		
Marketing and sales		

Who are your main customers? (Please tick relevant boxes)

	Yes	No
Hospitals		
Doctors (GPs)		
Other healthcare professionals		
Other companies		
Individual patients		
Others		

Please indicate the percentage growth of your business here over the last 3 years:

	Percentage over the last 3 years
Sales growth	%

What proportion of your employees have a degree or higher qualification? %

Please indicate whether you are a spin-off company from: (Please tick relevant box)

	Yes	No
Universities or research institute		
Hospital or healthcare centre		
Commercial company		
Others		

Do you outsource any of the following activities? (Please tick relevant boxes)

	Yes	No
Pre-clinical testing		
Clinical trial Phase I		
Clinical trial Phase II		
Clinical trial Phase III		
Manufactory		
Regulatory process		
Marketing & sales		
Public Relations activity		

Over the last three years has your business here received financial support from?

(Please tick relevant boxes)

Venture capital companies ☐ Government ☐ Overseas funding ☐ Others ☐

2. *Research and Development*

Do you carry out any R&D within your business here?	Yes	No

IF NO SKIP TO SECTION 3

	Yes	No
Do you *licence in* any intellectual property?		
Do you *licence out* any of your intellectual properties?		

Approximately what percent of your turnover was spent on R&D in the last financial year? %

How would you describe your investment in R&D since 2003? *(Please tick one)*

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Problems caused by market or research regulation					
Lack of development partners					

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The number of patents your business currently holds	

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Years

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Basic R&D	
Pre-clinical	
Phase I	
Phase II	
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Awaiting for regulatory approval	
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	Strongly disagree				Strongly agree
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We try hard to identify new external knowledge					
We meet regularly to discuss market trends and new products					

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	Completely insignificant				Extremely significant
	1	2	3	4	5
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Good Internal Communication					
Good Project Management					
Awareness of Leading Edge Research					
Effective Partnerships					
Employees' Skills					

4.

Early Stage of New Product Development

This section focuses on your basic research, drug discovery and development activities; please indicate whether you have any partnerships or alliances as part of these activities: *(Tick as appropriate)*

Yes	No

IF NO SKIP TO SECTION 5

Please indicate the total number of alliances or partnerships focusing on basic research, drug discovery and development you have currently?

Who are your partners in these relationships? (Please tick relevant boxes)

	No. of Partner(s)
Other small companies within your industry (200 or less employees)	
Other large companies within your industry (200 or more employees)	
Universities or other academic institutes	
Government research organisations	
Private research institutes	
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Access to infrastructure					
Achieve operational flexibility					
Finance, e.g. project-funding					
Access to larger projects					
Spread R&D risks/costs of new equipment					
Response to customers					
Improve financial and market credibility					

In general, do your alliance(s) involve: *(Please tick as appropriate)*

	Yes	No
Monthly or more frequently formal meetings or communication		
Quarterly or less frequently formal meetings or communication		
Inclusion of a partner inside your management team		
Staff working with your partners as a ''joint development team''?		

In general terms, how successful are your alliances in the early stage new product development? *(Please tick as appropriate)*

Made little progress towards objectives ☐ Partially achieved objectives ☐ Achieved objectives ☐ Surpassed objectives ☐

5. Commercialisation of New Products

Now we would like to ask about your commercialisation activities, e.g. clinical trials, FDA regulatory process, marketing and sales, etc. Please specify if you have any alliances or partnerships to help with these activities: *(Tick as appropriate)*

Yes	No

IF NO SKIP TO SECTION 6

Please indicate the number of alliances focusing on commercialisation activities, e.g. clinical trials, FDA regulatory process, marketing and sales etc. ?

Who are your partners in these relationships? (Please tick relevant boxes)

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Other small companies within your industry (200 or less employees)	
Other large companies within your industry (200 or more employees)	
Manufacturers outside your industry	
Contract research organisations (CRO)	
Regulatory/patents/intellectual property consultancies	
Marketing/distribution companies	
PR companies	

How important were the following motivations in your decision to cooperate in your commercialisation activities? *(Please tick relevant boxes)*?

	Not important 1	2	3	4	Very important 5
Complementary knowledge					
Increased speed of new product development					
Operational flexibility					
Finance					
Access to larger projects					
Access to new **UK** markets					
Access to overseas markets					
Improve financial and market credibility					
Response to customers					

In general, do your alliance(s) involve: *(Please tick as appropriate)*

	Yes	No
Monthly or more frequently formal meetings or communication		
Quarterly or less frequently formal meetings or communication		
Inclusion of a partner inside your management team		
Staff working with your partners as a ''joint development team''?		

In general terms, how successful were your alliances in the commercialisation stage new product development? *(Please tick as appropriate)*

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Is there any overlap between your alliance partners in these two areas? *(Please tick as appropriate)*

Yes	No

IF NO SKIP TO SECTION 6

If yes, please indicate the type of partners where any overlap occurs: *(please tick as appropriate)*

	Yes	No
Other small companies within your industry (200 or less employees)		
Other large companies within your industry (200 or more employees)		
Universities or other academic institutes		
Government research organisations		
Private research institutes		
Commercial laboratories/R&D enterprises		
Manufacturers		
Contract research organisations (CRO)		

6. Future Alliances

Do you anticipate developing any new partnerships over the next 2-3 business years? *(Please tick as appropriate)*

Yes	No

IF NO SKIP TO SECTION 7

Please indicate the type of your potential partners for early stage development and commercialisation: *(Please tick relevant boxes)*

	Early stage	Commerciali -sation
Other small companies within your industry (200 or less employees)		
Other large companies within your industry (200 or more employees)		
Universities or other academic institutes		
Government research organisations		
Private research institutes		
Commercial laboratories/R&D enterprises		
Manufacturers		
Contract research organisations (CRO)		

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Alliances or partnership focusing on the commercialisation of new products					
Specialized expertise					
Range of products					
Patent quality					
Platform technologies					
Operational flexibility					
Legal, regulatory and policy environment					
In-house R&D					
Outsourcing					
Effective management operations					
Product Safety profile					
Cost advantages					

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NEW PRODUCT DEVELOPMENT IN EUROPEAN BIOTECHNOLOGY INDUSTRIES

France-2006 ABS

Les coordonnées dont nous disposons pour votre société sont les suivantes. Merci de corriger si nécessaire.

Label Here

1. Contexte

Quand a été créée votre société ? Année

Combien compte-t-elle d'employés sur votre site ?

Combien compte-t-elle d'employés à plein temps à travers le monde ?

Le marché primaire de votre société est : (cocher les cases pertinentes)

National ☐ Européen ☐ Nord-américain ☐ Asiatique ☐ Autre ☐

Votre société est : (cocher les cases pertinentes)

Une société indépendante	
Une société dominante d'un groupe	
Une filiale dans un groupe	
Autre	

Quelles sont les principales activités sur le site mentionné ? (cocher les cases pertinentes)

	Oui	Non
Recherche fondamentale et découverte de médicaments		
Développement pré-clinique		
Développement clinique – Phase I		
Développement clinique – Phase II		
Développement clinique – Phase III		
Fabrication		
Soutien à la réglementation		
Ventes et marketing		

Qui sont vos principaux clients ? (cocher les cases pertinentes)

	Oui	Non
Hôpitaux		
Médecins généralistes		
Autres professionnels de la santé		
Autres sociétés		
Patients		
Autre		

Veuillez indiquer le taux de croissance de votre société pour le site considéré dans les 3 dernières années :

	Pourcentage depuis les 3 dernières années
Croissance des ventes	%

Quelle proportion de vos employés a un diplôme universitaire ? %

Veuillez indiquer si votre société a été créée à la suite des activités émanant d'une des sources suivantes. (cocher les cases pertinentes)

	Oui	Non
Universités ou instituts de recherche		
Hôpitaux or centres de santé		
Entreprises		
Autre		

Faites-vous appel à de la sous-traitance pour les activités suivantes ? (cocher les cases pertinentes)

	Oui	Non
Essai pré-clinique		
Essai clinique – Phase I		
Essai clinique – Phase II		
Essai clinique – Phase III		
Fabrication		
Processus de réglementation		
Ventes et marketing		
Relations publiques		

Votre société a-t-elle sur le site concerné bénéficié au cours des trois dernières années d'un apport financier de la part d'une des sources suivantes ? (cocher les cases pertinentes)

Sociétés à capital risque ☐ Gouvernement ☐ Fonds étrangers ☐ Autre ☐

2. *Recherche et développement*

Votre société se livre-t-elle à de la recherche et développement sur le site considéré ?	Oui	Non

Si non, veuillez vous reporter à la section 3

	Oui	Non
Ces activités vous amènent-elles à acquérir des droits de propriété intellectuelle ?		
Ces activités vous amènent-elles à vendre des droits de propriété intellectuelle ?		

Veuillez estimer le pourcentage de votre chiffre d'affaires dévolu à la recherche et développement au cours de la dernière année financière. %

Quelle est la fréquence de vos investissements en recherche et développement depuis 2003 ?

Élevée et continue ☐ Occasionnelle ☐ Faible ☐

Quelle importance ont eu les contraintes suivantes sur vos activités de recherche et développement ?

	Peu significative				Significative
	1	2	3	4	5
Manque de capital					
Manque de cadres compétents					
Manque de chercheurs et techniciens ayant la formation nécessaire					
Manque de chercheurs et techniciens ayant l'expérience nécessaire					
Manque de données de recherche et / ou d'information					
Accès difficile à la technologie nécessaire					
Manque d'information sur les marchés					
Contraintes posées par le marché ou la réglementation de la recherche					
Manque de sociétés associées pour la création de produits					

3. *Création de produits*

Concernant le brevetage, veuillez indiquer :

le nombre de demandes de brevets faites par le site considéré dans la dernière année	
le nombre de brevets détenus par votre société	

Pouvez-vous estimer la durée moyenne du processus de création de produits ?

Années

Concernant la gamme de vos produits, veuillez en indiquer le nombre qui en sont aux stades suivants du processus de création.

	Nombre de produits
Recherche fondamentale	
Pré-clinique	
Phase I	
Phase II	
Phase III	
En attente de l'approbation réglementaire	
Produit disponible sur le marché	

Jusqu'à quel point êtes-vous en (dés)accord avec les propositions suivantes ? (cocher les cases pertinentes)

	désaccord				accord
	1	2	3	4	5
Nous évaluons régulièrement l'impact des changements dans le marché pour la création de nouveaux produits					
Les employés notent et archivent les connaissances nouvellement acquises pour considération ultérieure					
Nous reconnaissons l'utilité des connaissances existantes (provenant de l'extérieur de l'entreprise)					
Nos employés partagent souvent leur expérience professionnelle					
Nous nous efforçons d'identifier de nouvelles connaissances (provenant de l'extérieur de l'entreprise)					
Nous nous rencontrons régulièrement pour discuter des tendances du marché et de nouveaux produits					

Quelle importance revêtent les éléments suivants dans la création d'idées de produits ? (cocher les cases pertinentes)

	Peu significatif				Significatif
	1	2	3	4	5
Recherche et développement interne					
Bonnes communications internes					
Bonne gestion de projet					
Connaissance de la recherche de pointe					
Partenariats efficaces					
Aptitudes des employés					

4. Création de produits : les premiers stades

Entretenez-vous des alliances ou des partenariats concernant les stades initiaux de la création de produits, comprenant la recherche fondamentale, la découverte de médicaments et leur développement ?

Oui	Non

Si non, reportez-vous à la section 5

Veuillez indiquer le nombre total d'alliances ou de partenariats en cours ciblant la recherche fondamentale, la découverte et le développement de médicaments.

Qui sont vos associés dans ces alliances et partenariats ?

	Nombre d'associés
Autres petites et moyennes entreprises dans votre secteur industriel (de 200 employés et moins)	
Autres grandes entreprises dans votre secteur industriel (de 200 employés et plus)	
Universités et instituts de recherche	
Organisations gouvernementales de recherche	
Instituts privés de recherche	
Laboratoires commerciaux ou de recherche et développement	

Quelle importance ont eu les motifs suivants dans votre décision d'établir des collaborations dans le domaine de la recherche fondamentale, la découverte et le développement de médicaments ? (cocher les cases pertinentes)

	Peu important				Important
	1	2	3	4	5
Accès au capital intellectuel des associés					
Extension de la gamme des produits offerts aux consommateurs					
Accélération du processus de création de produits					
Accès à des infrastructures					
Amélioration de la flexibilité opérationnelle					
Accès à du financement					
Accès à des projets plus importants					
Partage des risques de la recherche et développement, des coûts de nouveaux équipements					
Réponse à la demande des consommateurs					
Amélioration de la réputation financière face au marché					

Selon quelles modalités ces collaborations sont-elles assurées ? (cocher les cases pertinentes)

	Oui	Non
Rencontre ou communication formelles à chaque mois au moins		
Rencontre ou communication formelles à chaque trimestre au plus		
Intégration d'un associé à votre équipe de gestion		
Intégration de vos employés à l'environnement de travail de vos associés en vue de la formation d'équipes conjointes de développement		

Quel est le degré de succès de vos associations dans les premiers stades de la création de produits ?

Peu de progrès accomplis au regard des objectifs ☐ Objectifs partiellement atteints ☐ Objectifs atteints ☐ Objectifs dépassés ☐

5. Commercialisation de nouveaux produits

Entretenez-vous des alliances ou des partenariats soutenant vos activités de commercialisation telles que les essais cliniques, les processus régulatoires de la FDA, les ventes et marketing ?

Oui	Non

Si non, reportez-vous à la section 6

Veuillez indiquer le nombre d'alliances ciblant des activités de commercialisation ?

Qui sont vos associés dans ces alliances ?

	Nombre d'associés
Autres petites et moyennes entreprises dans votre secteur industriel (de 200 employés et moins)	
Autres grandes entreprises dans votre secteur industriel (de 200 employés et plus)	
Entreprises hors de votre secteur industriel	
Organisations contractuelles de recherche	
Consultants dans le domaine de la propriété intellectuelle, des brevets et des processus de réglementation	
Sociétés de marketing et de distribution	
Sociétés de relations publiques	

Quelle importance ont revêtue les motifs suivants dans votre décision de collaborer en vue de vos activités de commercialisation ? (cocher les cases pertinentes)

	Peu important				Important
	1	2	3	4	5
Connaissances complémentaires					
Rapidité de création de produits					
Flexibilité opérationnelle					
Financement					
Accès à des projets plus importants					
Accès à de nouveaux marchés domestiques					
Accès à de nouveaux marchés étrangers					
Amélioration de la réputation financière face au marché					
Réponse à la demande des consommateurs					

Selon quelles modalités ces rapports sont-ils généralement assurés ? (cocher les cases pertinentes)

	Oui	Non
Rencontre ou communication formelles à chaque mois au moins		
Rencontre ou communication formelles à chaque trimestre au plus		
Intégration d'un associé à votre équipe de gestion		
Intégration de vos employés à l'environnement de travail de vos associés en vue de la création d'équipes conjointes de travail		

Quel est en général le degré de succès de vos associations dans la commercialisation de nouveaux produits ?

Peu de progrès accomplis au regard des objectifs ☐ Objectifs partiellement atteints ☐ Objectifs atteints ☐ Objectifs dépassés ☐

Concernant vos associations dans le domaine de la recherche fondamentale, la découverte et le développement de médicaments d'une part et d'autre part vos associations dans le domaine des essais cliniques, du processus de réglementation de la FDA, du marketing et des ventes, ces deux domaines donnent-ils lieu à des cas de doubles emplois parmi vos associés ?

Oui	Non

Si <u>non</u>, reportez-vous à la section 6

Si oui, veuillez indiquer le type d'associés où ces doubles emplois se produisent. (cocher les cases pertinentes)

	Oui	Non
Autres petites et moyennes entreprises dans votre secteur industriel (de 200 employés et moins)		
Autres grandes entreprises dans votre secteur industriel (de plus de 200 employés)		
Universités et instituts universitaires		
Organisations de recherche gouvernementales		
Instituts de recherche privés		
Laboratoires commerciaux ou de recherche et développement		
Entreprises		
Organisations de recherche contractuelles		

6. Futures alliances

Vous attendez-vous à développer de nouvelles associations pendant les 2 ou 3 prochaines années ?

Oui	Non

Si <u>non</u>, reportez-vous à la section 7

Veuillez indiquer le type d'associés potentiels pour les premières étapes de la création de produit et pour la commercialisation. (cocher les cases pertinentes)

	Stades initiaux	Commerciali-sation
Autres petites et moyennes entreprises dans votre secteur industriel (de 200 employés ou moins)		
Autres grandes entreprises dans votre secteur industriel (plus de 200 employés)		
Universités et instituts universitaires		
Organisations gouvernementales de recherche		
Instituts privés de recherche		
Laboratoires commerciaux ou de recherche et développement		
Entreprises		
Organisations contractuelles de recherche		

7. Avantages compétitifs

Quelle importance ont les facteurs suivants dans le succès commercial de la création d'un produit nouveau ? (cocher les cases pertinentes)

	Peu important				Important
	1	2	3	4	5
Aptitude à développer des produits correspondant aux exigences du marché					
Alliances or partenariats en vue de la commercialisation de nouveaux produits					
Expertise					
Gamme de produits					
Qualité du brevet					
Plateformes technologiques					
Flexibilité opérationnelle					
Environnement légal, de politiques et réglementation					
Recherche et développement conduit dans la société					
Sous-traitance					
Gestion de projet efficace					
Profil de sécurité du produit					
Avantage concurrentiel par les coûts					

Merci de votre collaboration

Veuillez envoyer le questionnaire complété dans l'enveloppe pré-affranchie à

Helen Xia, Economy & Strategy Group, ABS, Aston University, Aston Triangle, Birmingham B4 7ET, Royaume Uni

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NEUE PRODUKTENTWICKLUNGEN IM EUROPÄISCHEN BIOTECHNOLOGIESEKTOR

Deutschland-2006 ABS

Kontaktdaten Ihrer Firma (Bitte ändern, wenn notwendig)

Label Here

1. Hintergrund

Wann wurde Ihr Unternehmen gegründet? Jahr

Wie viele Angestellte beschäftigen Sie zurzeit an Ihrem Standort?

Wie viele Vollzeitangestellte beschäftigt das Unternehmen weltweit?

Ist der Hauptmarkt Ihres Unternehmes: (Bitte ankreuzen)

Inland ☐ Europa ☐ Nordamerika ☐ Asien ☐ Andere ☐

Ist Ihr Unternehmen: (Bitte ankreuzen)

unabhängige Firma	
Muttergesellschaft/Konzernhauptsitz	
Tochtergesellschaft eines Konzerns	
Sonstiges	

Ihre Standort konzentriert sich hauptsächlich auf? (Bitte ankreuzen)

	Ja	Nein
Grundlagenforschung und Medikamentenentwicklung		
Vorklinische Entwicklung		
Klinische Entwicklung Phase I		
Klinische Entwicklung Phase II		
Klinische Entwicklung Phase III		
Herstellung		
Regulatory Support		
Marketing und Verkauf		

Wer sind Ihre Hauptkunden? (Bitte ankreuzen)

	Ja	Nein
Krankenhäuser		
Ärzte (Allgemeinmediziner)		
Andere Gesundheitsexperten		
Andere Unternehmen		
Einzelne Patienten		
Sonstiges		

Bitte geben Sie das prozentuale Wachstum Ihres Unternehmens während der letzten 3 Jahre an:

	Prozentsatz der letzten 3 Jahre
Umsatzwachstum	%

Wie viel Prozent Ihrer Beschäftigten haben einen Hochschulabschluss oder eine höhere Qualifikation %

Sind Sie ein selbständiger Unternehmensteil von: (Bitte ankreuzen)

	Ja	Nein
Universitäten oder Forschungsinstitute		
Krankenhaus oder Gesundheitsvorsorgezentrum		
Kommerzielles Unternehmen		
Sonstiges		

Haben Sie eine oder mehrere der folgenden Tätigkeiten ausgegliedert? (Bitte ankreuzen)

	Ja	Nein
Vorklinische Tests		
Klinische Versuche Phase I		
Klinische Versuche Phase II		
Klinische Versuche Phase III		
Herstellung		
Kontrollverfahren		
Marketing & Verkauf		
Öffentlichkeitsarbeit		

Hat Ihr Unternehmen in den letzten drei Jahren finanzielle Unterstützung von folgenden Institutionen erhalten? (Bitte ankreuzen)

Beteiligungsgesellschaften ☐ Staat ☐ Subventionen aus dem Ausland ☐ Sonstige ☐

2. *Forschung und Entwicklung*

	Ja	Nein
Betreiben Sie an Ihrem Standort Forschung und Entwicklung?		

WENN NEIN, BITTE DIREKT ZU ABSCHNITT 3

	Ja	Nein
Besitzen Sie Lizenzen über fremdes geistiges Eigentum?		
Haben Sie Lizenzen für firmeneigenes geistiges Eigentum vergeben?		

Welchen Prozentsatz Ihres Umsatzes haben Sie im Geschäftsjahr ca. für Forschung und Entwicklung ausgeben? %

Wie würden sie Ihre Forschung und Entwicklung seit 2003 beschreiben? *(Bitte nur ein Kästchen ankreuzen!)*

Kontinuierlich ☐ Gelegentlich ☐ Selten ☐

Welchen Einfluss hatten folgende Einschränkungen auf Ihre Forschungs- und Entwicklungstätigkeiten?

	Keinen Einfluss				Großen Einfluss
	1	2	3	4	5
Kapitalmangel					
Mangel an passendem Führungspersonal					
Mangel an entsprechend *qualifiziertem* Forschungs- und technischem Personal					
Mangel an entsprechend *erfahrenem* Forschungs- und technischem Personal					
Mangel an Forschungsdaten und/oder -informationen					
Schwierigkeiten geeignete Technologie zugänglich zu machen					
Informationsmangel über Märkte					
Probleme durch Markt- oder Forschungsregulierungen					
Mangel an Partnern für die Entwicklung					

4. *Frühstadium der Produktneuentwicklung*

3. *Neuentwicklung von Produkten*

Bezüglich Ihrer Patenttätigkeiten, bitte geben Sie an:

Anzahl an Patentanträge, die von diesem Standort letztes Jahr gemacht wurden	
Anzahl der Patente, die Ihr Unternehmen momentan hält	

Wie lange dauert die Neuentwicklung von Produkten durchschnittlich:

☐ Jahre

Bitte geben Sie unter Berücksichtigung Ihrer Produktpalette an wie viele Produkte Sie in jeder der folgenden Entwicklungsstufen haben.

	Anzahl der Produkte
Grundlagenforschung und –entwicklung	
Vorklinisch	
Phase I	
Phase II	
Phase III	
Im Zulassungsverfahren	
Produkte auf dem Markt	

Wie sehr stimmen Sie folgenden Aussagen zu? *(Bitte ankreuzen)*

	Stimme nicht zu				Stimme zu
	1	2	3	4	5
Wir berücksichtigen den Einfluss von Marktveränderungen auf neue Produkte regelmäßig					
Neue erworbenes Wissen wird von Angestellten aufgezeichnet und gespeichert					
Wir erkennen das Nutzen von neuem, externen Wissen an					
Angestellte unserer Firma teilen praktische Erfahrung oft					
Wir geben uns große Mühe neues externes Wissen zu ermitteln					
Wir treffen uns regelmäßig um Markttrends und neue Produkte zu besprechen					

Wie wichtig sind folgende Faktoren für Ihren Erfolg bei der Entwicklung neuer Produktideen *(Bitte ankreuzen)*

	Unwichtig				Wichtig
	1	2	3	4	5
Interne Forschung und Entwicklung					
Gute interne Kommunikation					
Gutes Projektmanagement					
Bewusstsein für Spitzenforschung					
Effektive Partnerschaften					
Gute Fähigkeiten der Beschäftigten					

Dieser Abschnitt konzentriert sich auf Ihre Grundlagenforschung, Medikamentenentwicklung und Entwicklungstätigkeiten. Bitte geben Sie an, ob Sie Partnerschaften oder Allianzen als Teil dieser Tätigkeiten haben: *(Bitte ankreuzen)*

Ja	Nein

WENN NEIN, BITTE DIREKT ZU ABSCHNITT 5

Bitte geben Sie die Gesamtzahl Ihrer Allianzen oder Partnerschaften an, die sich auf Grundlagenforschung, Medikamentenentwicklung und Entwicklung konzentrieren.

Wer sind Ihre Partner in diesen Bündnissen? *(Bitte ankreuzen)*

	Anzahl der Partner
Andere kleine Firmen aus dem gleichen Sektor (bis 200 Angestellte)	
Andere große Firmen aus dem gleichen Sektor (200+ Angestellte)	
Universitäten oder andere akademische Institute	
Staatliche Forschungsinstitute	
Private Forschungsinstitute	
Kommerzielle Labore/Forschungs- und Entwicklungsfirmen	

Wie wichtig waren die folgenden Beweggründe bei Ihrer Entscheidung bei der Grundlagenforschung, der Medikamentenentwicklung und Entwicklung zu kooperieren? *(Bitte ankreuzen)*

	Unwichtig				Sehr wichtig
	1	2	3	4	5
Zugang zum geistigen Kapital des Partners					
Erweiterung der Produktpalette für den Kunden					
Schnellere Entwicklung neuer Produkte					
Zugang zur Infrastruktur					
Erlangung betrieblicher Flexibilität					
Finanzen, z. B. Projektfinanzierung					
Zugang zu größeren Projekten					
Risikoverteilung bei Forschung & Entwicklung/ Kostenteilung bei neuen Betriebsanlagen					
Antwort auf Kundenwünsche					
Verbesserung der Kredit- & Marktglaubwürdigkeit					

Bestehen Ihre Allianzen im Allgemeinen aus: *(Bitte ankreuzen)*

	Ja	Nein
Formalen Treffen & Kommunikation mindestens einmal pro Monat		
Formalen Treffen & Kommunikation vierteljährlich oder seltener		
der Aufnahme eines Partners in Ihr Führungsteam		
der Zusammenarbeit Ihres Personals mit Ihren Partnern als gemeinsames Entwicklungsteam?		

Allgemein gesprochen, wie erfolgreich sind Ihre Allianzen im Frühstadium der Produktneuentwicklung? *(Bitte ankreuzen)*

Nur wenig Fortschritt in Richtung Ziel ☐ Ziele teilweise erreicht ☐ Ziele erreicht ☐ Ziele übertroffen ☐

5. Vermarktung neuer Produkte

Wir würden Sie jetzt gerne zu Ihren Vermarktungtätigkeiten befragen, z.B. klinische Versuche, dem Kontrollverfahren des FDA, Marketing und Verkauf, etc. Bitte geben Sie an, ob Sie Hilfe durch Allianzen oder Partnerschaften bei diesen Tätigkeiten haben: *(Bitte einkreuzen)*

Ja	Nein

WENN NEIN, BITTE DIREKT ZU ABSCHNITT 6

Bitte geben Sie die Anzahl der Allianzen an, die sich auf die kommerziellen Tätigkeiten konzentrieren, e.g klinische Versuche, Kontrollverfahren des FDA, Marketing und Verkauf, etc.?

Wer sind Ihre Partner in diesen Bündnissen? (Bitte ankreuzen)

	Anzahl der Partner
Andere kleine Firmen aus dem gleichen Sektor (bis 200 Angestellte)	
Andere große Firmen aus dem gleichen Sektor (200+ Angestellte)	
Hersteller außerhalb Ihres Sektors	
Vertragsforschungsorganisationen (CRO)	
Beratungsunternehmen für Kontrollen, Patente & geistigem Eigentum	
Marketing- und/oder Vertriebsunternehmen	
PR-Firmen	

Wie wichtig waren die folgenden Beweggründe bei Ihrer Entscheidung bei den kommerziellen Tätigkeiten zu kooperieren? *(Bitte ankreuzen)*?

	Unwichtig				Sehr wichtig
	1	2	3	4	5
Zusätzliches Wissen					
Schnellere Entwicklung neuer Produkte					
Betriebliche Flexibilität					
Finanzen					
Zugang zu größeren Projekten					
Zugang zu anderen Märkten im Inland					
Zugang zu Märkten im Ausland					
Verbesserung der Kredit- & Marktglaubwürdigkeit					
Antwort auf Kundenwünsche					

Bestehen Ihre Allianzen im Allgemeinen aus: *(Bitte ankreuzen)*

	Ja	Nein
Formalen Treffen & Kommunikation mindestens einmal pro Monat		
Formalen Treffen & Kommunikation vierteljährlich oder seltener		
der Aufnahme eines Partners in Ihr Führungsteam		
Der Zusammenarbeit Ihres Personals mit Ihren Partnern als gemeinsames Entwicklungsteam		

Allgemein gesprochen, wie erfolgreich sind Ihre Allianzen bei dev Vermarktung der Produktneuentwicklung? *(Bitte ankreuzen)*

Nur wenig Fortschritt in Richtung Ziel ☐ Ziele teilweise erreicht ☐ Ziele erreicht ☐ Ziele übertroffen ☐

Wenn Sie nun an Ihre **Partnerschaften/Allianzen im Bereich der Grundlagenforschung, Medikamentenentwicklung und Entwicklung;** und Ihre **Partnerschaften/Allianzen im Bereich der klinischen Versuche, dem Kontrollverfahren des FDA und Marketing und Verkauf**.

Überschneiden sich Ihre Allianzen in diesen beiden Bereichen? *(Bitte ankreuzen)*	**Ja**	**Nein**

WENN NEIN, BITTE DIREKT ZU ABSCHNITT 6

Wenn ja, geben Sie bitte die Art des Partners an, bei dem die Allianz sich überschneidet *(Bitte ankreuzen)*

	Ja	Nein
Andere kleine Firmen aus dem gleichen Sektor		
Andere große Firmen aus dem gleichen Sektor (200+ Angestellte)		
Universitäten oder andere akademische Institute		
Staatliche Forschungsinstitute		
Private Forschungsinstitute		
Kommerzielle Labore/Forschungs- und Entwicklungsfirmen		
Hersteller		
Vertragsforschungsorganisationen (CRO)		

6. Zukünftige Allianzen

Rechnen Sie mit neuen Partnerschaften während der nächsten 2-3 Geschäftsjahre? *(Bitte ankreuzen)*	Ja	Nein

WENN NEIN, BITTE DIREKT ZU ABSCHNITT 7

Bitte geben Sie die Art potentieller Partner Sie für Ihre Entwicklung im frühen Stadium und bei der Vermarktung an: *(Bitte ankreuzen)*

	Früh-stadium	Vermar kt-ung
Andere kleine Firmen aus dem gleichen Sektor (bis 200 Angestellte)		
Andere große Firmen aus dem gleichen Sektor (200+ Angestellte)		
Universitäten oder andere akademische Institute		
Staatliche Forschungsinstitute		
Private Forschungsinstitute		
Kommerzielle Labore/Forschungs- und Entwicklungsfirmen		
Hersteller		
Vertragsforschungsorganisationen (CRO)		

7. Wettbewerbsvorteile

Wie sehr tragen die folgenden Faktoren zum kommerziellen Erfolgs ihrer Produktneuentwicklung: (*Bitte ankreuzen*)

	Trägt nicht dazu bei				Trägt sehr dazu bei
	1	2	3	4	5
Fähigkeit neue Produkte zu entwickeln um Marktanforderungen gerecht zu werden					
Allianzen/Partnerschaften, die sich auf die Vermarktung des neuen Produktes spezialisieren					
Spezialisiertes Fachwissen					
Produktpalette					
Patentqualität					
Plattformtechnologien					
Betriebliche Flexibilität					
Rechtliches, Kontroll- und strategisches Umfeld					
Betriebsinterne Forschung und Entwicklung					
Produktionsverlagerung					
Effektive Führungsabläufe					
Produktsicherheit					
Kostenvorteile					

Vielen Dank für Ihre Hilfe

Bitte senden Sie den ausgefüllten Fragebogen in dem portofreiem Rückumschlag an

Helen Xia, Economy & Strategy Group, ABS, Aston University,
Aston Triangle, Birmingham B4 7ET, UK
Tel: +44 (0)121 242 3158; Fax: +44 (0)121 242 3326

Control variables

To capture other factors that are predictably associated with firms' number of exploratory alliances, and isolate the effect of a biopharmaceutical firm's potential absorptive capacity on its number of exploratory alliances, we control a number of possible confounding effects including firm size, age, ownership, primary markets and strategic focus/orientation. Firm size and age are the most commonly used control variables in the studies focusing on the biotechnology industry (cf. Quintana-Garcia and Benavides-Velasco, 2004; Gregory et. al., 2001). A biotech firm's success might be a positive function of the age (experience) and size as a measure of the strength of the company (Quintana-Garcia and Benavides-Velasco, 2004). Also it is important to note that a biopharmaceutical firm's ownership, primary markets, strategic orientation/focus (i.e. Deeds and Hill, 1996; George et al., 2001; Maurer and Ebers, 2006), are seen as important background factors to its alliances activities. Additionally, We center the resulting control variables, in particular main markets and strategic orientation/focus to reduce the potential threat of collinearity (Aiken and West, 1991).

Firm characteristics

Firm age is measured as the age of the firm from incorporation (Coombs and Deeds, 2000), assuming that older firms are more likely to have more products in development and have entered more alliances (Sqrensen and Stuart, 2000). In fact, given that all the biopharmaceutical companies included in our target group are fully dedicated biotechnology firms, it is appropriate to calculate their age since incorporation (Sqrensen and Stuart, 2000).

Firm size is constructed with the total amount of employees, which is a measure of size that has been used in many other studies (cf. Rothaermel and Deeds, 2004; Quintana-Garcia and Benavides-Velasco, 2004). A good deal of literature has considered the relationship between firm size and innovation (Kamien and Schwarz, 1982), therefore, it is

used in the data analysis as control variable to separate it possible effects from those of absorptive capacity. On the other hand, firm size is often measured in revenues or market share as well; however, most biotechnology firms do not have a positive revenue stream at this point. Thus, measuring firm size in terms of employees provides a reasonable alternative (Shan et al, 1994). We then square the variable to test the argument that the effect of firm size on the number of exploratory alliances exhibits diminishing marginal returns.

We further control firms' ***ownership*** status by including a dummy variable which indicates whether the firm is independent or not (1=independent). Ownership may affect firms' international operations and the resources available to them (Zahra et al, 2000). Researchers suggest that significant differences exist between independent and corporate biotech ventures due to differences in their resource base and capabilities (Zahra and George, 1999). In addition, the difference between independent and corporate biopharmaceutical ventures in their strategic choices and technological strategies have also been reported (Zahra, 1996).

Main market variables: Buzzell and Gale (1987) indicated that companies differ in their definitions of served markets, a factor that favoured the use of survey data. We control biopharmaceutical firms' primary markets (e.g. Shan, 1990; Zahra et al, 2000) by three proxies, i.e. regional market (coded as 1), foreign market (coded as 1), external market (coded as 1).

Strategic focus: A firm's strategic focus is an important control variable when attempting to isolate the effect of a biopharmaceutical firm's potential absorptive capacity on its number of exploratory. We measure a biopharmaceutical firm's strategic focus according to its new product development pipeline (e.g. Rzakhanov, 2004). A set of dummy variables has been defined by us to monitor firms' strategic focus, i.e. basic R&D and pre-clinical trial, clinical trials, manufacture, regulatory support, marketing and sales.

Finally, considering there may be regional and institutional effects on the number of exploratory alliances firms entered, we create an indicator variable for the EU (1 = EU firms) and the US firms to further capture these differences. (i.e. Nooteboom et al, 2006; Rothaermel and Dees, 2006).

Appendix 3: Data Summary

Variable Description	Definition	US		EU		UK		France		Germany		Total	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Firm age*	Firm age measured in years	**15.88**	13.295	**12.08**	11.531	13.73	11.103	8.09	7.551	11.69	13.232	13.64	12.411
No. of employees*	No. of employees per firm	**65.0**	101.246	**35.0**	68.014	45.44	87.162	17.82	22.546	27.90	46.051	46.81	84.044
National market*	% of firms focus on national market	**39.2**	0.490	**49.5**	0.501	51.5	0.502	45.7	0.505	50.0	0.504	45.3	0.498
European market*	% of firms focus on European market	**47.6**	0.501	**74.7**	0.436	73.7	0.442	82.9	0.382	71.4	0.455	63.5	0.482
North American market *	% of firms focus on north American market	**78.3**	0.414	**43.4**	0.497	58.6	0.495	45.7	0.505	31.4	0.468	57.8	0.495
Asian market*	% of firms focus on Asian market	**32.9**	0.471	**21.4**	0.411	28.3	0.453	31.4	0.471	11.4	0.320	26.1	0.440
Other markets*	% of firms focus on other market	**16.1**	0.369	**6.5**	0.247	12.1	0.328	8.6	0.284	1.4	0.120	10.4	0.306
Independent company	Dummy (%offirms)	88.1	0.325	80.3	0.399	72.7	0.448	91.2	0.288	85.7	0.352	83.5	0.371
Parent or group headquarter	Dummy (%offirms)	3.5	0.184	4.3	0.202	5.1	0.220	0.0	0.000	5.7	0.234	3.9	0.195
Subsidiary	Dummy (%offirms)	8.4	0.278	12.8	0.334	21.2	0.411	8.8	0.288	8.6	0.282	10.9	0.313
Others	Dummy (%offirms)	0.7	0.084	0.7	0.081	2.0	0.141	.0	0.000	.0	0.000	0.7	0.082
Basic R&D*	Dummy (%offirms)	**66.7**	0.473	**46.8**	0.500	44.3	0.499	57.6	0.502	43.7	0.499	55.1	0.498
Pre-clinical dev.*	Dummy (%offirms)	**60.4**	0.491	**37.1**	0.484	38.1	0.488	36.4	0.489	36.6	0.485	46.8	0.500
Clinical phaseI*	Dummy (%offirms)	**51.4**	0.502	**22.9**	0.421	22.7	0.421	27.3	0.452	21.1	0.411	34.8	0.477
Clinical phaseII*	Dummy (%offirms)	**41.7**	0.495	**18.3**	0.388	18.6	0.391	24.2	0.435	15.5	0.364	28.1	0.450
Clinical phaseIII*	Dummy (%offirms)	**30.8**	0.463	**10.2**	0.304	13.4	0.342	12.5	0.336	7.0	0.258	18.8	0.391
Manufactory*	Dummy (%offirms)	**58.3**	0.495	**46.6**	0.500	47.4	0.502	33.3	0.479	52.1	0.503	51.5	0.501
Regulatory support*	Dummy (%offirms)	**61.1**	0.489	**18.7**	0.391	29.9	0.460	24.2	0.435	8.5	0.280	36.4	0.482
Marketing & sales*	Dummy (%offirms)	**41.0**	0.494	**51.9**	0.501	53.6	0.501	39.4	0.496	56.3	0.499	47.3	0.500
Sales growth	% growth of sales over the last 3 years per firm	51.3	1.097	64.4	1.472	64.1	1.439	72.9	1.080	61.5	1.659	59.5	1.342
Employee skills	% of employees with a degree or higher qualification per firm	87.0	1.817	66.9	0.291	67.2	0.314	83.3	0.254	58.8	0.242	68.8	0.280
Spin-off universities or research institute*	Dummy (%offirms)	**31.2**	0.465	**21.2**	0.409	34.0	0.476	47.1	0.507	0.0	0.000	25.2	0.435
Spin-off hospitals or healthcare centers	Dummy (%offirms)	1.4	0.120	2.3	0.150	1.1	0.103	8.8	0.288	0.0	0.000	1.9	0.138
Spin-off commercial company*	Dummy (%offirms)	**13.8**	0.346	**31.4**	0.465	13.8	0.347	26.5	0.448	45.7	0.502	24.2	0.429
Spin-off others*	Dummy (%offirms)	**4.3**	0.205	**9.6**	0.295	7.4	0.264	17.6	0.387	7.1	0.259	7.4	0.263
Venture capital companies	Dummy (%offirms)	47.2	0.502	47.0	0.501	37.3	0.487	44.4	0.506	56.8	0.501	47.1	0.500
From Government*	Dummy (%offirms)	**46.7**	0.501	**65.8**	0.476	60.0	0.493	74.1	0.447	65.9	0.479	57.7	0.495
Overseas funding	Dummy (%offirms)	14.0	0.349	13.0	0.337	24.0	0.430	7.4	0.267	6.8	0.255	13.5	0.342
Other financial support*	Dummy (%offirms)	**53.3**	0.501	**29.9**	0.460	28.0	0.452	33.3	0.480	29.5	0.462	39.9	0.491
Whether or not carry out R&D*	Dummy (%offirms)	**95.0**	0.219	**90.1**	0.300	89.5	0.309	91.2	0.288	90.0	0.302	92.1	0.270
License in*	Dummy (%offirms)	**72.2**	0.450	**59.7**	0.492	58.8	0.495	76.7	0.430	52.4	0.503	65.0	0.478
License out*	Dummy (%offirms)	**62.4**	0.486	**42.3**	0.495	52.3	0.502	40.0	0.498	36.5	0.485	50.9	0.501

Source: Author's Survey

Variable Description	Definition	US		EU		UK		France		Germany		Total	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
R&D Intensity	R&D spending as a percentage of total turnover	45.1	0.337	41.7	0.344	38.5	0.360	55.5	0.363	40.0	0.296	43.2	0.341
Continuously	Dummy (%of firms)	88.1	0.325	86.0	0.348	86.0	0.349	93.3	0.254	82.3	0.385	86.9	0.339
Lack of capital	Dummy (%of firms)	55.6	0.499	58.9	0.493	55.4	0.500	54.8	0.506	63.3	0.486	57.5	0.495
Lack of suitable managerial staff	Dummy (%of firms)	17.7	0.383	19.1	0.394	18.5	0.391	20.0	0.407	19.0	0.396	18.5	0.389
Lack of suitably-qualified research and technical staff	Dummy (%of firms)	19.8	0.400	17.2	0.378	24.1	0.430	3.3	0.183	19.0	0.396	18.3	0.387
Lack of suitably-experienced research and technical staff*	Dummy (%of firms)	**26.5**	0.443	**18.2**	0.387	29.6	0.459	3.3	0.183	17.7	0.385	21.8	0.413
Lack of research data and / or information	Dummy (%of firms)	13.7	0.346	11.9	0.324	16.3	0.371	6.7	0.254	11.5	0.321	12.7	0.333
Difficulty in accessing appropriate technology	Dummy (%of firms)	15.4	0.362	16.7	0.374	17.1	0.379	10.3	0.310	19.4	0.398	16.1	0.368
Lack of information about markets	Dummy (%of firms)	16.0	0.368	21.7	0.413	22.2	0.418	30.0	0.466	17.5	0.383	19.3	0.395
Problems caused by market or research regulation*	Dummy (%of firms)	**14.1**	0.349	**22.9**	0.421	20.0	0.403	27.6	0.455	22.6	0.422	19.1	0.394
Lack of development partners*	Dummy (%of firms)	**32.6**	0.470	**20.0**	0.401	25.9	0.441	13.8	0.351	19.0	0.396	25.4	0.436
No. of patents currently*	No of patent (s) per firm	**53.10**	114.627	**20.21**	54.776	20.38	42.729	22.48	78.321	18.94	57.302	33.79	86.155
New product development cycle*	New product dev. cycle measured by year	**6.21**	7.506	**4.27**	3.339	4.30	3.542	4.54	3.366	4.09	3.047	5.08	5.551
No. of products in basic R&D*	per firm	**6.49**	19.798	**3.36**	6.231	3.26	3.441	4.65	10.541	2.84	5.147	4.77	14.128
No. of products in pre-clinical dev.*	per firm	**2.05**	4.056	**0.72**	1.259	0.98	1.492	0.84	1.375	0.50	0.978	1.32	2.943
No. of products in clinical PhaseI*	per firm	**0.67**	1.081	**0.25**	0.612	0.34	0.779	0.28	0.614	0.17	0.461	0.44	0.878
No. of products in clinical PhaseII*	per firm	**0.59**	1.084	**0.19**	0.619	0.34	0.885	0.20	0.577	0.08	0.337	0.37	0.880
No. of products in clinical PhaseIII*	per firm	**0.38**	0.806	**0.09**	0.345	0.16	0.462	0.00	0.000	0.07	0.314	0.22	0.613
No. of products awaiting regulation approval	per firm	0.30	1.084	0.37	1.044	0.34	0.762	0.36	1.604	0.41	0.931	0.34	1.061
No. of products in the market	per firm	91.08	869.132	110.55	1493332	319.77	2588132	6.56	29.903	6.75	19.967	101.67	1246274
Market monitoring capability	Dummy (%of firms)	68.6	0.466	63.7	0.482	58.2	0.496	58.6	0.501	69.7	0.463	65.8	0.475
Knowledge management capability	Dummy (%of firms)	63.3	0.484	63.3	0.483	63.3	0.485	58.6	0.501	65.2	0.480	63.3	0.483
Knowledge monitoring capability	Dummy (%of firms)	87.9	0.328	87.8	0.328	83.5	0.373	93.1	0.258	88.4	0.323	87.8	0.328
Internal communication capability	Dummy (%of firms)	78.4	0.413	73.1	0.445	73.3	0.445	71.4	0.460	73.5	0.444	75.3	0.432
Internal R&D capability	Dummy (%of firms)	84.2	0.366	83.3	0.374	87.5	0.333	86.2	0.351	79.4	0.407	83.7	0.370
Internal communication	Dummy (%of firms)	85.5	0.353	90.4	0.295	87.4	0.334	86.2	0.351	94.1	0.237	88.3	0.322
Good project management	Dummy (%of firms)	79.7	0.404	84.0	0.368	87.5	0.333	71.4	0.460	86.8	0.341	82.2	0.383
Awareness of leading edge research*	Dummy (%of firms)	**76.1**	0.428	**60.3**	0.491	67.8	0.470	74.1	0.447	50.0	0.504	67.1	0.471
Effective partnerships*	Dummy (%of firms)	**61.6**	0.488	**75.5**	0.431	67.0	0.473	86.2	0.351	76.5	0.427	69.6	0.461

Source: Author's Survey

Variable Description	Definition	US		EU		UK		France		Germany		Total	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Employees' skills	Dummy (%offirms)	91.2	0.284	90.7	0.291	88.6	0.319	85.7	0.356	94.1	0.237	90.9	0.287
No. of exploratory alliances	per firm	3.04	4.181	2.58	3.869	2.27	3.009	3.07	3.906	2.79	4.846	2.78	4.007
Small start-ups	per firm	0.74	1.163	2.08	11.935	3.98	20.516	0.65	0.745	1.41	1.861	1.46	8.798
Large pharma	per firm	0.88	1.079	0.79	1.367	0.89	1.683	0.75	1.372	0.74	1.094	0.83	1.242
Univ. or other academia	per firm	1.58	2.243	1.79	3.010	2.09	4.030	1.30	1.261	1.83	2.802	1.69	2.683
Government research organisations	per firm	0.41	0.923	0.47	1.078	0.38	1.431	0.50	0.688	0.51	0.951	0.44	1.008
Private research institutes	per firm	0.22	0.556	0.16	0.430	0.08	0.267	0.15	0.366	0.23	0.547	0.19	0.491
Commercial laboratories/R&D enterprises	per firm	0.58	1.265	0.36	1.213	0.55	1.814	0.00	0.000	0.43	0.917	0.46	1.239
To access partners' intellectual capital	Dummy (%offirms)	56.0	0.499	56.2	0.498	53.8	0.503	63.2	0.496	54.3	0.505	56.1	0.497
To expand the range of products offered to customers	Dummy (%offirms)	44.1	0.499	50.1	0.502	50.0	0.505	33.3	0.485	58.8	0.500	47.2	0.501
To increase the speed of new product dev.	Dummy (%offirms)	63.7	0.483	77.4	0.420	64.8	0.482	80.0	0.410	85.7	0.355	71.1	0.454
To access infrastructure	Dummy (%offirms)	50.5	0.503	49.1	0.502	49.1	0.505	55.0	0.510	45.7	0.505	49.7	0.501
To achieve operational flexibility	Dummy (%offirms)	44.3	0.500	39.6	0.491	39.6	0.494	50.0	0.514	34.3	0.482	41.7	0.494
To access finance, e.g. project-funding*	Dummy (%offirms)	**56.0**	0.499	**41.8**	0.496	49.1	0.505	30.0	0.470	42.9	0.502	48.3	0.501
To access larger projects	Dummy (%offirms)	26.7	0.445	37.2	0.486	26.4	0.445	42.1	0.507	42.9	0.502	32.4	0.469
To spread R&D risks/costs of new equipment	Dummy (%offirms)	46.7	0.502	35.9	0.482	30.2	0.463	63.2	0.496	25.7	0.443	40.8	0.493
To respond to customers	Dummy (%offirms)	31.5	0.467	36.3	0.483	32.1	0.471	29.4	0.470	42.9	0.502	34.1	0.475
To improve financial and market credibility*	Dummy (%offirms)	**66.7**	0.474	**36.0**	0.482	62.3	0.489	16.7	0.383	25.7	0.443	50.2	0.501
Communicate monthly	Dummy (%offirms)	67.0	0.473	57.1	0.497	62.3	0.489	60.0	0.503	51.4	0.507	61.7	0.487
Communicate quarterly	Dummy (%offirms)	53.2	0.502	48.5	0.502	54.7	0.503	50.0	0.513	42.9	0.502	50.7	0.501
Include partners in the management team	Dummy (%offirms)	20.2	0.404	17.2	0.379	22.6	0.423	25.0	0.444	8.6	0.284	18.6	0.390
Staff working with partners as a joint development team	Dummy (%offirms)	70.2	0.460	60.2	0.492	56.6	0.500	45.0	0.510	71.4	0.458	64.9	0.479
Made little progress towards objectives *	Dummy (%offirms)	**4.3**	0.203	**0.0**	0.000	0.0	0.000	0.0	0.000	0.0	0.000	2.0	0.140
Partially-achieved objectives	Dummy (%offirms)	38.3	0.489	46.5	0.501	33.3	0.476	45.0	0.510	57.1	0.502	42.7	0.496
Achieved progress	Dummy (%offirms)	53.2	0.502	50.4	0.502	60.8	0.493	50.0	0.513	42.9	0.502	51.7	0.501
Surpassed progress	Dummy (%offirms)	5.3	0.226	5.6	0.230	5.9	0.238	15.0	0.366	0.0	0.000	5.4	0.227
No. Of exploitation alliances	No of alliance (s) per firm	2.18	5.643	2.03	7.049	2.83	9.366	1.82	4.579	0.97	2.511	2.10	6.467
Partner with small start-ups	per firm	0.68	1.229	1.59	5.597	2.21	8.517	1.73	3.771	0.88	1.111	1.12	4.005
Partner with large pharma	per firm	0.68	0.858	0.76	1.331	1.03	1.926	0.55	0.688	0.65	0.862	0.72	1.106
Partner with manu. outside the industry	per firm	0.33	0.596	0.34	0.841	0.71	1.169	0.00	0.000	0.18	0.529	0.33	0.722

Source: Author's Survey

Variable Description	Definition	US		EU		UK		France		Germany		Total	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Partner with government research organisations	per firm	1.00	1.136	0.61	1.411	1.06	2.076	0.27	0.647	0.38	0.619	0.82	1.284
Partner with regulatory/patents/intellectual property consultancies	per firm	0.60	0.773	0.80	2.069	1.36	3.160	0.18	0.405	0.63	0.806	0.70	1.530
Partner with marketing/distribution companies	per firm	1.43	7.628	0.79	1.745	0.79	2.176	0.27	0.467	1.12	1.764	1.12	5.609
Partner with PR companies*	per firm	**0.44**	0.590	**0.21**	0.488	0.32	0.535	0.09	0.302	0.18	0.529	0.33	0.553
To access complementary knowledge	Dummy (%offirms)	76.2	0.429	67.2	0.474	79.4	0.410	54.5	0.522	62.5	0.500	71.9	0.452
To increase the speed of new product dev.	Dummy (%offirms)	69.8	0.463	71.8	0.454	79.4	0.410	27.3	0.467	93.8	0.250	70.8	0.457
To achieve operational flexibility*	Dummy (%offirms)	**66.1**	0.477	**48.3**	0.504	54.5	0.506	45.5	0.522	43.8	0.512	57.6	0.496
To access finance	Dummy (%offirms)	50.8	0.504	46.2	0.503	54.3	0.505	27.3	0.467	50.0	0.516	48.6	0.502
To access larger projects	Dummy (%offirms)	28.6	0.455	24.9	0.437	15.6	0.369	30.0	0.483	31.3	0.479	26.9	0.445
To access new markets	Dummy (%offirms)	32.3	0.471	21.7	0.416	9.1	0.292	36.4	0.505	25.0	0.447	27.2	0.447
To access overseas markets*	Dummy (%offirms)	**41.9**	0.497	**65.1**	0.481	62.9	0.490	72.7	0.467	62.5	0.500	53.2	0.501
To improve financial and market credibility	Dummy (%offirms)	64.5	0.482	48.3	0.504	60.6	0.496	45.5	0.522	37.5	0.500	56.7	0.498
To respond customers	Dummy (%offirms)	32.3	0.471	42.8	0.499	37.5	0.492	40.0	0.516	50.0	0.516	37.3	0.486
Communicate monthly	Dummy (%offirms)	62.5	0.488	49.6	0.503	56.4	0.502	46.2	0.519	46.4	0.508	55.7	0.498
Communicate quarterly	Dummy (%offirms)	50.0	0.504	52.9	0.502	56.4	0.502	53.8	0.519	50.0	0.509	51.5	0.501
Include partners in the management team	Dummy (%offirms)	22.2	0.419	14.1	0.350	28.2	0.456	15.4	0.376	3.6	0.189	18.0	0.385
Staff working with partners as a joint development team*	Dummy (%offirms)	**73.6**	0.444	**43.1**	0.498	51.3	0.506	7.7	0.277	53.6	0.508	57.6	0.496
Made little progress towards objectives	Dummy (%offirms)	2.9	0.170	3.4	0.184	0.0	0.000	7.7	0.277	3.8	0.196	3.2	0.177
Partially-achieved objectives	Dummy (%offirms)	44.1	0.500	37.4	0.487	24.3	0.435	30.8	0.480	50.0	0.510	40.6	0.493
Achieved progress	Dummy (%offirms)	54.4	0.502	54.9	0.501	73.0	0.450	53.8	0.519	42.3	0.504	54.6	0.500
Surpassed progress	Dummy (%offirms)	2.9	0.170	6.0	0.240	2.7	0.164	15.4	0.376	3.8	0.196	4.6	0.210
Alliance overlap*	Dummy (%offirms)	**56.9**	0.499	**31.6**	0.468	45.9	0.505	16.7	0.389	28.0	0.458	44.2	0.498
Small start-ups	Dummy (%offirms)	43.6	0.502	52.4	0.509	50.0	0.514	100.0	0.000	44.4	0.527	47.2	0.503
Large pharma	Dummy (%offirms)	51.3	0.506	52.7	0.509	55.6	0.511	0.0	0.000	62.5	0.518	51.9	0.504
Universities or other academic institutes	Dummy (%offirms)	61.5	0.493	50.0	0.511	55.6	0.511	50.0	0.707	42.9	0.535	57.2	0.499
Government research organisations	Dummy (%offirms)	30.8	0.468	19.4	0.404	27.8	0.461	50.0	0.707	0.0	0.000	26.5	0.445
Private research institutes*	Dummy (%offirms)	**12.8**	0.339	**0.0**	0.000	0.0	0.000	0.0	0.000	0.0	0.000	8.0	0.273
Commercial laboratories/R&D enterprises	Dummy (%offirms)	38.5	0.493	22.3	0.425	22.2	0.428	0.0	0.000	28.6	0.488	32.3	0.471
Manufacturers	Dummy (%offirms)	35.9	0.486	39.0	0.498	44.4	0.511	0.0	0.000	42.9	0.535	37.1	0.487
CROs*	Dummy (%offirms)	**51.3**	0.506	**27.9**	0.458	44.4	0.511	0.0	0.000	14.3	0.378	42.4	0.498

Source: Author's Survey

Appendix 4: Results of Chapter 7

Table 7.5: Ordinal Probit Regression Model of Transformation Dimension of RACAP

Table 7.5.1: Market Monitoring Capability (General model)

Dependent Variable (Market monitoring capability)	Coef.
No. of Exploratory Alliances	-0.006
R&D Intensity (Percentage)	0.010
Employee Skills (Percentage)	-0.260
Continuous R&D activities	0.942***
Firm Characteristics	
Firm Age	0.006
No. of Employees	-0.014~
No. of Employees Square	0.000*
Ownership Status (Independent Company)	-0.118
Market Characteristics	
Regional Market	0.044
Foreign Market	-0.107
External Market	0.177
Strategic Profile	
Basic R&D and Pre-clinical Dev.	-0.525*
Clinical Trials (Phase I, II, III)	-0.013
Manufactory	-0.191
Regulatory support	0.250
Marketing & sales	0.120
Nationality (euus)	-0.454*
_cut1	-1.489
_cut2	-0.603
No. of obs = 230 Wald chi2(23) =	29.48*

Source: Author's Survey

~ P<0.1
*P<0.05
** P < 0.01
*** P <0.001

Table 7.5.1.1: Market Monitoring Capability (General model with interacting terms)

Dependent Variable (Market monitoring capability)	Coef.
No. of Exploratory Alliances	-0.102
R&D Intensity (Percentage)	-0.137
Employee Skills (Percentage)	-0.615
Continuous R&D activities	0.916
Interaction Terms	
No. of Exploratory Alliances and R&D Intensity	-0.086
Employee Skills and No. of Exploratory Alliances	0.120
Continuous R&D activities and No. of Exploratory Alliances	0.066
Employee Skills and Continuous R&D activities	-0.125
Employee Skills and R&D Intensity	0.431
Continuous R&D activities and R&D Intensity	0.042
Firm Characteristics	
Firm Age	0.006
No. of Employees	-0.014~
No. of Employees Square	0.000*
Ownership Status (Independent Company)	-0.118
Market Characteristics	
Regional Market	0.057
Foreign Market	-0.091
External Market	0.126
Strategic Profile	
Basic R&D and Pre-clinical Dev.	-0.496*
Clinical Trials (Phase I, II, III)	0.014
Manufactory	-0.161
Regulatory support	0.261
Marketing & sales	0.137
Nationality (euus)	-0.481*
_cut1	-1.685
_cut2	-0.789
No. of obs = 230 Wald chi2(23) = =	40.21*

Source: Author's Survey

~ P<0.1
*P<0.05
** P < 0.01
*** P <0.001

Table 7.5.2: Knowledge Management Capability (General model)

Dependent Variable (Knowledge management capability)	Coef.
No. of Exploratory Alliances	-0.006
R&D Intensity (Percentage)	-0.107
Employee Skills (Percentage)	-0.340
Continuous R&D activities	0.468~
Firm Characteristics	
Firm Age	-0.016~
No. of Employees	0.000
No. of Employees Square	0.000
Ownership Status (Independent Company)	-0.021
Market Characteristics	
Regional Market	0.213
Foreign Market	-0.267
External Market	0.276
Strategic Profile	
Basic R&D and Pre-clinical Dev.	0.483*
Clinical Trials (Phase I, II, III)	-0.148
Manufactory	-0.066
Regulatory support	0.551**
Marketing & sales	-0.106
Nationality (euus)	0.062
_cut1	-0.690
_cut2	0.049
No. of obs = 233	Wald chi2(23) = 33.12*

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 7.5.2.1: Knowledge Management Capability (General model with interacting terms)

Dependent Variable (Knowledge management capability)	Coef.
No. of Exploratory Alliances	0.010
R&D Intensity (Percentage)	1.063
Employee Skills (Percentage)	-0.366
Continuous R&D activities	-0.237
Interaction Terms	
No. of Exploratory Alliances and R&D Intensity	0.044
Employee Skills and No. of Exploratory Alliances	-0.096
Continuous R&D activities and No. of Exploratory Alliances	0.025
Employee Skills and Continuous R&D activities	1.065
Employee Skills and R&D Intensity	-1.593
Continuous R&D activities and R&D Intensity	-0.109
Firm Characteristics	
Firm Age	-0.014~
No. of Employees	0.001
No. of Employees Square	0.000
Ownership Status (Independent Company)	-0.025
Market Characteristics	
Regional Market	0.206
Foreign Market	-0.283
External Market	0.353~
Strategic Profile	
Basic R&D and Pre-clinical Dev.	0.440*
Clinical Trials (Phase I, II, III)	-0.164
Manufactory	-0.094
Regulatory support	0.547**
Marketing & sales	-0.128
Nationality (euus)	0.096
_cut1	-0.753
_cut2	-0.005
No. of obs = 233	Wald chi2(23) = 38.50*

Source: Author's Survey
~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 7.53: Knowledge Monitoring Capability (General model)

Dependent Variable (Knowledge monitoring capability)	Coef.
No. of Exploratory Alliances	0.183**
R&D Intensity (Percentage)	-0.009
Employee Skills (Percentage)	0.101
Continuous R&D activities	-0.219
Firm Characteristics	
Firm Age	-0.003
No. of Employees	0.002
No. of Employees Square	0.000
Ownership Status (Independent Company)	0.462
Market Characteristics	
Regional Market	0.196
Foreign Market	-0.121
External Market	0.254
Strategic Profile	
Basic R&D and Pre-clinical Dev.	0.626*
Clinical Trials (Phase I, II, III)	0.014
Manufactory	0.364
Regulatory support	-0.110
Marketing & sales	0.142
Nationality (euus)	-0.308
_cut1	-0.982
_cut2	0.011
No. of obs = 233	Wald chi2(23) = 28.89*

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 7.53.1: Knowledge Monitoring Capability (General model with interacting terms)

Dependent Variable (Knowledge monitoring capability)	Coef.
No. of Exploratory Alliances	-0.053
R&D Intensity (Percentage)	-4.242*
Employee Skills (Percentage)	-0.254
Continuous R&D activities	-0.627
Interaction Terms	
No. of Exploratory Alliances and R&D Intensity	-0.479**
Employee Skills and No. of Exploratory Alliances	-0.255
Continuous R&D activities and No. of Exploratory Alliances	0.762**
Employee Skills and Continuous R&D activities	-0.992
Employee Skills and R&D Intensity	3.180~
Continuous R&D activities and R&D Intensity	2.410*
Firm Characteristics	
Firm Age	-0.009
No. of Employees	0.000
No. of Employees Square	0.000
Ownership Status (Independent Company)	0.489
Market Characteristics	
Regional Market	0.247
Foreign Market	-0.043
External Market	0.266
Strategic Profile	
Basic R&D and Pre-clinical Dev.	0.797*
Clinical Trials (Phase I, II, III)	0.164
Manufactory	0.338
Regulatory support	-0.137
Marketing & sales	0.163
Nationality (euus)	-0.496
_cut1	-2.114
_cut2	-1.072
No. of obs = 233	Wald chi2(23) = 60.27***

Source: Author's Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

7.5.4: Internal Communication Capability (General model)

Dependent Variable (Internal communication capability)	Coef.
No. of Exploratory Alliances	-0.001
R&D Intensity (Percentage)	0.073
Employee Skills (Percentage)	0.752*
Continuous R&D activities	0.056
Firm Characteristics	
Firm Age	-0.003
No. of Employees	-0.001
No. of Employees Square	0.000
Ownership Status (Independent Company)	-0.140
Market Characteristics	
Regional Market	-0.023
Foreign Market	0.001
External Market	-0.482*
Strategic Profile	
Basic R&D and Pre-clinical Dev.	-0.114
Clinical Trials (Phase I, II, III)	0.065
Manufactory	0.159
Regulatory support	0.098
Marketing & sales	-0.019
Nationality (euus)	-0.312
_cut1	-1.552
_cut2	-0.573
No. of obs = 230	Wald chi2(23) = 20.34

Source: Author's Survey

* ρ <0.05

7.5.4.1: Internal Communication Capability (General model with interacting terms)

Dependent Variable (Internal communication capability)	Coef.
No. of Exploratory Alliances	0.140
R&D Intensity (Percentage)	-0.482
Employee Skills (Percentage)	0.944
Continuous R&D activities	-0.085
Interaction Terms	
No. of Exploratory Alliances and R&D Intensity	0.002
Employee Skills and No. of Exploratory Alliances	-0.095
Continuous R&D activities and No. of Exploratory Alliances	-0.081
Employee Skills and Continuous R&D activities	0.137
Employee Skills and R&D Intensity	-0.153
Continuous R&D activities and R&D Intensity	0.737
Firm Characteristics	
Firm Age	-0.004
No. of Employees	-0.001
No. of Employees Square	0.000
Ownership Status (Independent Company)	-0.182
Market Characteristics	
Regional Market	-0.031
Foreign Market	-0.011
External Market	-0.442*
Strategic Profile	
Basic R&D and Pre-clinical Dev.	-0.153
Clinical Trials (Phase I, II, III)	0.031
Manufactory	0.145
Regulatory support	0.094
Marketing & sales	-0.039
Nationality (euus)	-0.292
_cut1	-1.564
_cut2	-0.571
No. of obs = 230	Wald chi2(23) = 25.07

Source: Author's Survey

* ρ <0.05

Table 7.6: Zero-inflated Negative Binominal Regression Model of Exploitation Dimension of RACAP

Table 7.6.1: General Model

Dependent Variable (No. of patent)	Coef.
No. of Exploratory Alliances	0.209
R&D Intensity (Percentage)	0.836*
Employee Skills (Percentage)	-0.785~
Continuous R&D activities	0.290
Firm Characteristics	
Firm Age	0.013
No. of Employees	0.010***
No. of Employees Square	0.000*
Ownership Status (Independent Company)	-0.470
Market Characteristics	
Regional Market	0.083
Foreign Market	-0.681**
External Market	0.690***
Strategic Profile	
Basic R&D and Pre-clinical Dev.	0.563*
Clinical Trials (Phase I, II, III)	0.697**
Manufactory	-0.162
Regulatory support	0.346
Marketing & sales	-0.407*
Nationality (euus)	-0.420*
cons	2.199***
No. of obs = 221	Wald chi2(23) = 290.84***

Source: Authors' Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001

Table 7.6.2: General Model with Interacting Terms

Dependent Variable (No. of patent)	Coef.
No. of Exploratory Alliances	-0.105
R&D Intensity (Percentage)	0.652
Employee Skills (Percentage)	0.844
Continuous R&D activities	1.036
Interaction Terms	
No. of Exploratory Alliances and R&D Intensity	0.062
Employee Skills and No. of Exploratory Alliances	0.083
Continuous R&D activities and No. of Exploratory Alliances	0.037
Employee Skills and Continuous R&D activities	-1.431
Employee Skills and R&D Intensity	-1.783
Continuous R&D activities and R&D Intensity	1.513
Firm Characteristics	
Firm Age	0.015
No. of Employees	0.012***
No. of Employees Square	0.000**
Ownership Status (Independent Company)	-0.248
Market Characteristics	
Regional Market	0.146
Foreign Market	-0.657**
External Market	0.735***
Strategic Profile	
Basic R&D and Pre-clinical Dev.	0.562*
Clinical Trials (Phase I, II, III)	0.642**
Manufactory	-0.122
Regulatory support	0.351
Marketing & sales	-0.368~
Nationality (euus)	-0.339
cons	1.022
No. of obs = 221	Wald chi2(23) = 265.66***

Source: Authors' Survey

~ ρ <0.1
* ρ <0.05
** ρ <0.01
*** ρ <0.001