The process of developing innovative capabilities in biotechnology: The case of UK firms

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Abstract

The advent of born-global bio-tech firms signal the genesis of a new business model that is emerging in the biotechnology sector. Born globals are small firms whose knowledge supply-chain includes global resources from multiple countries. Their innovation 'ecosystems' consists of experienced scientists, science parks, academics, well-established bio-pharmaceutical firms and government institutions. The firms plan their business based on global strategic perspectives and this significantly increases their productivity and innovativeness. But surprisingly, little is known about their capability development processes in the specialised networks of the biotechnology sector. As a result, this study explores the connectivity of various elements, within their knowledge supply-chain, and how they influence their capacity to generate new scientific knowledge and technical know-how.

The study employs a multi-case approach. It examines five cases of bio-tech firms from the East Midlands region of the United Kingdom which have an entrepreneurial flair synonymous with born-global firms. The findings from within and across cases, secondary data analysis and results from a 'pilot study' led to the construction of a new conceptual framework of knowledge and innovative capability development. The model is created from the ideas of Freeman and others and it contributes to an understanding of the concepts of dynamic capabilities and network theories. The study infers that the business and social connections of small born-global biotech firms along with the building blocks of competence & goodwill trust, inter-organisational collaborations, tacit & explicit knowledge, prior learning & absorptive capacity significantly influence how they develop their innovative capabilities. The study also concludes that there is a strong connection between the building blocks. The findings of the research are invaluable to a number of stakeholders that include: other researchers, large, small firms & the central authorities particularly for their role in formulating strategies through policy-making that either help or hinder the norms of 'open science'.

Contents **Page**

Contents **Page**

Contents **Page**

List of Figures **Page**

List of Tables **Page**

Part B: Personal Development

Research articles extracted from the thesis

Research articles under review

Conference Proceedings

Declaration

Whilst registered as a candidate for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

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Dedication

I dedicate this thesis to my wife Tapiwa Simba & our two daughters Nothobeko & Sasha who have been patient with me especially for the past four years that I was working on this thesis. Their support and understanding helped me to successfully complete my study.

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Chapter 1

1. Introduction

The advent of small born-global bio-tech firms particularly in the life science sector significantly contributes to a wide range of economic effects including: the exchange of scientific knowledge, the transfer of technical know-how and the creation of jobs (Ho & Wilson, 2006). Crucially, the desire to obtain valuable resources appears to be the main driver behind the collaborative behaviours of these science-based firms (Schilling, 2008; Rafols *et al.,* 2012).

The biotechnology sector is one that is science intensive and it is dominated by small firms which are usually connected to a web of established businesses, research and academic institutions within their geographical area and they have established strong global links (Hisrich, 2012). As such, small born-global bio-tech firms have high expectations of growth and development. From that perspective, this study argues that the formation of business & social networks along with the building blocks that include: inter-organisational collaborations, competence & goodwill trust, tacit & explicit knowledge, prior learning & absorptive capacity are the necessary developmental steps for small born-global bio-tech firms. Indeed, by developing these resource-laden connections small born-global bio-tech firms have an opportunity to acquire crucial innovative capabilities. Early studies (see Schumpeter 1934's theory of innovation) closely associate entrepreneurial behaviour with innovation. In Anderson (2000); Mathews & Zander (2007) innovative and entrepreneurial firms were described as business ventures that have the vision and the flexibility needed to identify and exploit the benefits offered by existing and new overseas markets.

The extant literature on international entrepreneurship (see Oviatt & McDougall, 1994; Li & Ferreira, 2006) characterises born-global firms as enterprises which take risks, innovate and have the vision to anticipate economic events. This is necessary because in science-intensive industries, technology and firm-based capabilities evolve at a fast pace. Therefore, for born-global bio-tech firms operating in these constantly evolving market conditions, escapades that involve risk such as networking across the globe can be crucial for bridging the knowledge and capabilities gap (Ferreira *et al.,* 2010) or in enabling new resource combinations (Schumpeter, 1950). More work still needs to be done to understand the various elements that manifest in the knowledge supply-chain of small born-global bio-tech firms.

More importantly, how these elements influence the processes of developing innovative capabilities that include: scientific knowledge and technical know-how necessary for drug discoveries and the development of new clinical products respectively. As such, this study brings to light the extent to which elements/variables including: business & social networks, inter-organisational collaborations, competence & goodwill trust, tacit & explicit knowledge, prior learning & absorptive capacity within the knowledge supply-chain of small born-global bio-tech firms, operating from the East Midlands region of the United Kingdom outside the Golden Triangle of Cambridge, London & Oxford, influence their process of developing innovative capabilities. Born-global firms have global foci – a strategy formulated when the entrepreneurial ventures started trading (see Knight & Cavusgil, 1996; Madsen & Servais, 1997; Freeman *et al.,* 2010). In that sense, it is reasonable to suggest that, from inception, these types of firms enhance their ability to generate new ideas and knowledge by engaging in globalised networks (Lasserre, 2012; Thompson & Martin, 2010).

This position does not assume that born-global firms are immune to the foreign market morass including: socio-economic and political-legal environment that international businesses, in general, have to contend with when they venture into unfamiliar territories (see Hill, 2011). Nonetheless, the economic benefits of doing so outweigh the perceived risks (Willebrands *et al.,* 2012). Indeed, entrepreneurial firms in the form of born globals are able to take advantage of their business and social networks by using them as platforms in their process of acquiring strategic capabilities that include: technical know-how, fluid scientific knowledge and best practice as well as broaden the size of their market (Johnson *et al.,* 2008; Lasserre, 2007).

This assumption is consistent with Johnson & Vahlne (2009, p.1423) who claim that business relationships are essential "because they make it possible to identify and exploit opportunities". Ferreira *et al.* (2010) insist that social networks are important for an entrepreneurial firms' identification of market related opportunities and they also provide access to novel information, knowledge, innovations and physical resources. Furthermore, Mathews & Zander (2007) observe that social ties accelerate the knowledge development of entrepreneurial firms that seek to be at the fore front of new innovations. Admittedly, a firm can enhance its innovative capabilities by engaging in collaborative activities but the main issues to be addressed in this study are the connectivity of various elements and their level of influence on the process of developing those capabilities for small born-global bio-tech firms. Consistent with other researchers (Welter, 2012; Hart & Dowell, 2011; Maritan & Peteraf, 2011) the findings of this study illuminate the genesis of the sophisticated processes involved in the development of innovative capabilities of small born-global bio-tech firms.

1.1 Setting the scene

Science can be related to almost everything. Horsley (2012, p.6) claims that science is about, “discovering new things, creating life and giving reason to life and it is also the study of all that makes up the world and how it works”. As such, this study focuses on the biotechnology sector in which a number of discoveries have been adding to the better life of human beings and other species on earth.

The biotechnology sector is a business sector that is gradually growing: the sector has emerged from the basic work done by universities in science which has completely changed the way science is done. In particular, the innovations in the pharmaceuticals, food industry, and energy sectors have really transformed the sector. The sector comprises of three distinct technologies namely: DNA technology, first discovered by Boyer & Cohen in 1973, monoclonal antibody, or “Mabs” technology, first discovered by Kohler & Milstein in 1975; and protein engineering technology, developed during the 1980s (Liebeskind *et al.,* 1994, p.3). In today’s modern science, biotechnology has been classified into three broad groups: healthcare and pharmaceutical applications; industrial processes and manufacturing; and agriculture, livestock, veterinary products and aqua-culture. This study investigates multiple firms that are involved in the healthcare and pharmaceutical applications.

Clearly, the bio-tech industry is a science-based sector. It is a market that is driven by the flow of fluid scientific knowledge and technical know-how to make new innovations. Citing this heavy reliance on scientific knowledge any business that operates in this sector must make things happen by constantly generating new knowledge and ideas through collaborating with other key stakeholders (Owen-Smith & Powell, 2004; Powell & Grodal, 2005).

In the East Midlands there is overwhelming evidence of collaborative activities that have occurred and continue to occur for example, the discovery of an essential life-saving drug the flu drug – *ibuprofen* which was first discovered by Dr Stewart Adams at the Boots Nottingham laboratories in 1961 (Crocker, 2010; Graves, 2012). The life-saving magnetic resonance imaging (MRI) scanner is another example of scientific development that has originated from the science city of Nottingham.

In the 1950s Boots collaborated with an American company Upjohn to develop improved processes for the mass production of the *cortisone* drug in the United Kingdom for its domestic market (Martin, 1987). The establishment of a regional science "incubator" BioCity Nottingham (BCN) in 2003 is further evidence indicating that the region is vibrant in bio-science and it is strategically crafting a unique way of getting scientists, academic institutions and bio-entrepreneurs to talk to each other with a view to enhancing their drug discovery activities and their technological know-how for developing new clinical products (NSC, 2012).

According to Crocker (2010) and Reid (2012) in the last decade BCN has been very effective in terms of facilitating networking opportunities as well as providing discussion forums for small bio-tech firms in the East Midlands and from overseas. Evidently, it is through these networking forums that technical know-how and scientific knowledge is generated, shared, exchanged and transferred between firms (Powell & Grodal, 2005). In other words, knowledge "hubs" provide a platform that enables the development of business and social ties credited in the literature with allowing the movement of knowledge and human capital between participating firms (see Owen-Smith & Powell, 2004; Cooke, 2003; Breschi & Malebra, 2005). The current government (the Conservatives) and the EU have both made considerable efforts to develop policies aimed at enhancing R&D activities regionally (BIS, 2012).

The Prime Minister pledged to support academic institutions and businesses to engage in collaborative activities (BIS, 2011). The strategies for support that the government put forward included: investing in the best British life science ideas at an early stage; to remove regulatory barriers that small businesses face; and crucially, to open up the NHS to new innovations and new clinical trials.

Science experts Graves (2012) and Crocker (2012) claim that strategies including: the setting up of *Enterprise Zones Strategy* and the EU's *FP7 Funding Strategy* for science-related projects have resulted in the establishment of innovation network, science specific research forums, infrastructure development and an increase in research institutions e.g. the iNet, Medipark (the knowledge hub), and Pera Innovation Network. From that perspective, it makes it intriguing and fascinating to probe further the complicated actions and R&D activities that help to generate scientific knowledge and stimulate its exchange in the business and social networks of small born-global bio-tech firms. Graves (2012) stresses that business and social networks are essential for new drug discoveries, the exchange of technical know-how and the development of new clinical products in the East Midlands. By exploring the complicated collaborative actions and activities of small born-global bio-tech firms in the East Midlands region the study aims to enlighten the reader about the R&D activities of these highly productive types of ventures or firms that appear to form in high numbers throughout the region in England.

According to EMDA's 2010 report regarding the developments in the biotechnology sector; since the closure of AstraZeneca's R&D facilities in Loughborough small bio-tech firms have proliferated. The development agency highlights that the reasons for this sudden increase in the number of small bio-tech firms is directly linked to the closure of AstraZeneca's operations at its Charnwood facility in Loughborough and other R&D sites.

While these developments were happening in the East Midlands, Lund in Sweden was also closing down (EMDA, 2010). Evidently, there is a global strategic shift which is unfolding in Europe within the pharmaceutical industry. Clearly, this type of action by large pharmaceutical companies was not restricted to AstraZeneca in the East Midlands; the rationalisation of R&D facilities has been taking place internationally as the wider pharmaceuticals industry re-configures its business models and approaches to drug discovery and development (Rafols *et al.,* 2012). In their 2010 annual report AstraZeneca point out that it intends to increase its externalisation efforts to access the best, most cutting edge science, whatever its origin, with a target of 40% of its pipeline sources from outside its laboratories by 2014. It appears that the strategy of collaborating/outsourcing is very actively pursued by "Big Pharmaceuticals" (Rafols *et al.,* 2012). Swain (2012, p.12) explains this point more clearly; "the Big Pharma model is undergoing a painful evolution, moving from competition to collaboration, from one-size-fits-all to more tailored approaches, and a longer-term view of basic research".

This developing trend merits further investigation and it is the purpose of this study to inform the reader about the advent of the new ventures and in particular their collaborative activities that have resulted in the discovery of new drugs and clinical products following the worldwide operational restructuring by large pharmaceuticals.

1.2 The scope of the research

The research addresses the knowledge development processes of small born-global bio-tech firms. In particular, the work is mainly concerned with the connectivity of various elements within the knowledge supply-chain of these firms and how they influence their capacity to generate new scientific knowledge and technical know-how. In doing so, the work is limited to investigate the activities of bio-tech firms which use the East the East Midlands as their home market.

Using multiple cases, various factors/variables including; business & social networks, competence & goodwill trust, inter-organisational collaborations, explicit & tacit knowledge, prior learning & absorptive capacity are examined to understand how they are connected and their influence in the knowledge supply-chain of the research phenomenon. Empirical evidence from within and cross case analysis was subsequently utilised to modify Freeman's *et al.* (2010) conceptual framework so as to adequately explain the specific circumstances of the research phenomenon. The newly developed conceptual framework is useful to small and large organisations especially for those that are in the science-based sector where the concept of networking appears to be the cornerstone to resource acquisition, growth and firm-based development.

1.3 Aims

The broad aim of the study is to understand the effects of business & social networks, competence & goodwill trust, inter-organisational relationships, tacit & explicit knowledge, prior learning & absorptive capacity on small born-global bio-tech firms' ability to develop their innovative capabilities. It investigates the connectivity of these various elements within the knowledge supply-chain of bio-tech firms and how they influence their strategy of generating fluid scientific knowledge and technical know-how.

It is also the author's goal to make policy recommendations for political institutions and government policy-makers as they play an important in role in facilitating firm development patterns in market-oriented economies, especially in uncertain economic times (Halkier *et al.,* 2010). The attainment of the broad aims of this study is possible through the gradual achievement of the following research objectives.

1.3.1 Research objectives

Below the author outlines specific research objectives.

Objectives

- To map out the main elements of knowledge supply-chain of born-global bio-tech firms.
- To explain the connectivity of the main elements of the knowledge supply-chain of small born-global firms and the extent to which they assist their innovative capability development process.
- To contribute to the theoretical concepts of the dynamic capabilities and networking

The research uses elements of both inductive and deductive research philosophies and it assumes a qualitative research approach in the form of a multi-case research strategy. It also uses both qualitative methods and techniques including: qualitative conversations and secondary data analysis (documentary evidence), within and across case analysis. The main focus is on small born-global bio-tech firms within the East Midlands region of the United Kingdom. Yin (2003) and Stake (1995) advise that to avoid pursuing a study that has too many objectives it is necessary to determine your case(s). From that perspective, the researcher uses a technic known as *case binding* which includes: using time and place (Creswell, 2003); time and activity (Stake, 1995); and by definition and context (Huberman & Miles, 1994). Baxter & Susan (2008, p.546) supports the use of the case binding technic claiming that “binding the case will ensure that your study remains reasonable in scope”. Following a “pilot” study data is collected from a systematically selected sample of five biotechnology firms which exhibit entrepreneurial behaviours. Expert opinion is also sought from three key science research institutions within the East Midlands that have been identified as the “champions of innovation”.

The main reason for using the multi-case research approach for this study is to allow the researcher to examine the research subject(s) more closely so that rich data is collected to ensure the validity and the reliability of the research findings (Bellamy & Perri, 2009). More importantly, to demonstrate to the reader that the research findings are grounded within and across case analysis of small born-global bio-tech firms operating in the East Midlands. Results achieved in this way can be taken to be reliable (see Gerring, 2005; Huberman & Miles, 1994; Yin, 2009). Baxter & Jack (2008) insists that a multiple case-study (Yin, 2003) or a collective case-study (Stake, 1995) allows the researcher to analyse data within and across settings. Crucially, the researcher prefers this method of research in particular because the evidence it generates is considered to be robust and reliable (see Huberman & Miles, 1994; Baxter & Jack, 2008).

The market categories of born-global firms to be studied were classified by Crocker (2010) into three distinct classes as follows: (1) the *Medical Technology Markets* a term used to define companies included in the medical technology and diagnostics sector; (2) *Medical Biotechnological Markets*, i.e. pharmaceutical companies that develop drugs or manufacture medical clinical products and (3) the *Industrial Biotechnology Markets* i.e. companies that are developing, manufacturing and marketing industrial products and services based on biotechnology.

1.3.2 Research questions

The research aims to answer the following sub-questions in order to satisfy the stated research objectives located on p.9 while providing some explanations to the proposed research problem:

- What are the main elements of the knowledge supply-chain of small born-global biotech firms?

- How are the main elements of the knowledge supply-chain of small born global bio-tech firms connected and to what extent do they help or hinder their capabilities development processes?
- What are the specific interactions of small born-global bio-tech firms that lead to capability development?

The sub-question one above is designed to map out the main elements of the knowledge-supply of small born global bio-tech firms. The path for developing innovative capabilities followed by small born global bio-tech firms would say something about the connectivity of these elements with their knowledge supply-chain. Sub-questions two and three are partly related to sub-question one. Sub-question two helps to explain more specifically, about the connectivity of various elements within the knowledge supply chain of small born global bio-tech firms and the extent to which they assist/affect how they develop their innovative capabilities. Sub-question three asks for casual trends regarding more specific links or connections that are essential to how the bio-tech firms develop their innovative capabilities.

1.4 Research contribution

This section informs the reader about the contribution of this study. The contribution is in three folds. Firstly, the study brings to light the complex processes involved in the development of innovative capabilities by small born-global bio-tech firms in the East Midlands that have resulted in the development of biotechnology products. Accordingly, Smith *et al.* (2012) claim that, the East Midlands region possesses an important local concentration of pharmaceutical (R&D) activities hence, the need to highlight the actions of the key stakeholders operating in this biotechnology sector.

Secondly, the study makes a theoretical contribution by modifying Freeman's *et al.* (2010) influential conceptual model of rapid knowledge development for smaller born-global firms. The modified model is used to explain the specific situation of small born-global bio-tech firms and their ability to develop their innovative capabilities. Thirdly, the study has value to a number of stakeholders. It informs other researchers about the activities of small born-global bio-tech firms and it helps science institutions, policy-makers including: the UK government, and the EU Commission to assess whether their strategies are enabling firms to make innovations in the biotechnology sector given the amount of investment in the sector which is in the region of £5.5bn (HM Government, 2010).

The idea behind reaching a wide range of audiences was rather nicely summed up by Todtling *et al.* (2009) who understood the innovation systems model as encompassing the business sector, the science sector, and policy actors. This is consistent with Easterby *et al.* (2012, p.237) who argue in favour of research that contributes to a field of study in different ways. The scholars postulate that, "theoretical contribution is most important, and it may be supplemented by each of the others". This is in line with the way this study contributes to the field of science and business management.

1.4.1 Knowledge gap

Since collaboration in the production of scientific knowledge has become a central policy issue for governments and institutions globally (Canton *et al.,* 2005), it is surprising that only a few researchers have studied the dynamics of the capability development processes of small born-global bio-tech firms.

Other scholars (see for example Elfring & Hulsink, 2003; Johannisson, 2000; Hite & Hesterly, 2001; Rowley *et al.,* 2000; Gerard *et al.,* 2009; Demirkan & Demirkan, 2011; Powell & Grodal, 2005; Owen-Smith & Powell, 2004; Breschi & Malebra, 2005; Cooke, 2003) have carried out extensive research on the general contributions of networks for small firms. But little is known about the development processes of small born-global firms in the specialised networks of the biotechnology sector.

As such, this study fills the gap by exploring how inter-organisational collaborations of small born-global firms outside the Golden Triangle of Cambridge, London and Oxford influence their capacity to develop innovative capabilities. The study also explains the connectivity of various elements with the knowledge supply-chain of these firms. Furthermore, the study expounds how knowledge can be used by small born-global firms to not only improve their business processes but to accelerate new drug discoveries and the development of life-saving clinical products otherwise not known before. This fulfils the call for more research by Corner & Wu (2012) on how innovative capabilities in younger, emerging ventures are developed and, in particular, the processes whereby these important capabilities are born and nurtured (Zahra *et al.,* 2006).

To explain the scientific knowledge, technical know-how development processes and the activities that enable drug discoveries the study explores how prior learning influences the ability to absorb useful scientific knowledge and technical know-how through collaborating in pre-existing or newly established business and social networks.

1.4.2 Theoretical contribution

The researcher wishes to start by acknowledging Freeman's *et al.* (2010) model of rapid knowledge development for smaller born-global firms (the model is located on p.79). The scholars have made a huge contribution to the understanding of how smaller born-global firms appear to acquire/develop knowledge. Nonetheless, the researcher believes that the framework can be further modified to adequately explain the specific activities of small born-global bio-tech firms and enhance our understanding the connectivity of various elements within their knowledge supply-chain and how they influence their capacity to generate fluid scientific knowledge and new technology.

Even Freeman *et al.* (2010) recommend the need for further studies to refine their conceptual framework and its applicability to a knowledge based view (KBV), resource based view (RBV) and network perspectives. In that sense, this study builds on the significant contribution that they have made. Before a detailed discussion of the modifications to the concept of rapid knowledge development proposed by Freeman *et al.* (2010), the researcher feels that it is essential that the study evaluates the discourse regarding case-oriented studies in terms of their contribution to developing theoretical concepts.

The extant literature on case-study research offers a wide range of explanations about what constitutes theoretical contribution (Ridder *et al.*, 2009). For example Eisenhardt & Graebner (2007) express that the output of case-oriented research designs take various forms including: a new concept, theoretical construct, conceptual framework, propositions, and in other cases a mid-range theory. As such, this study proposes concepts that are deemed necessary for small born-global bio-tech firms in their process of developing innovative capabilities.

Sigglekow (2007) maintains that using rich data acquired through closely examining instances of occurrences, in cases, can inspire new ideas in theory construction. Glaser & Strauss (1967) make a strong connection between empirical reality and secondary data insisting that the connection between the two permits the development of a testable, relevant and valid theory. Consistent with this view Eisenhardt & Graebner (2007), Ridder *et al.*, (2009) agree that case studies have the potential to uncover unusual phenomena and of repeating or countering the replication of findings of other cases which eliminates alternative explanations and elaborates the emerging theory. In the same vein, Stake (2005) argues that case studies are valuable when a researcher intends to refine a theory.

It is in light of this that the study makes significant contribution by modifying Freeman's *et al.* (2010) general model of rapid knowledge development for smaller born-global firms through inferring with empirical evidence from within and across cases, results from a "pilot" study and preliminary literature review. This allows the researcher to develop a frame of reference that is testable, reliable and valid (Glaser & Strauss, 1967). The researcher believes that their model (Freeman's and others) cannot be adequately applied to the specific situations of small born-global bio-tech firms that are operating as contract research organisations (CROs) to explain specifically the key elements that influence their capacity to make innovations. From that point of view, the study modifies five of seven propositions represented on their model to increase its explanatory power (Ridder *et al.*, 2009). The original propositions on the model for rapid knowledge development for small born-global firms are identified as: relational trust, inter-firm partnerships, tacit knowledge, absorptive capacity and development of new knowledge.

But because Freeman's *et al.* (2010) inspirational model falls short of explaining the specific situations of small born-global bio-tech firms an improved model "*Knowledge and Innovative Capability Development Model*" is proposed (see figure 8 section 4.5, p.206) illustrating new concepts including: competence & goodwill trust, tacit & codified knowledge, prior learning & absorptive capacity that more closely reflect the world of a special type of small born-global bio-tech firms in the biotechnology sector.

Established and newly developed business and social networks propositions remain unchanged as part of the knowledge supply-chain of the small born-global bio-tech firms needed to facilitate the development of innovative capabilities. The new propositions are influenced by the evidence emerging from a preliminary literature review (conducted as part of the pilot study) and empirical data gathered from a detailed within case analysis of small born-global bio-tech firms from the East Midlands.
This is consistent with a number of scholars (see Yin, 2003; Stake, 1995/2005; Vaughan, 1992) who emphasise on the power of case-oriented research strategies in contributing to theory building. Sigglekow (2007) makes an important contribution suggesting that within and across case analysis significantly contributes towards honing/sharpening existing theory by identifying holes and filling them (also see Gerring, 2001; Andersen, 1993; Goertz, 2005 for discussion on theory adjustment). Crucially, the study claims that these elements can be combined into the theoretical concepts of the dynamic capabilities view and network theory to better explain their impact on the science-based sector where it is unlikely that a single individual or firm will possess all the resources and capabilities necessary to develop and implement a significant innovation (Hegedoorn, 2002; Schilling, 2010). This is consistent with the network approach which focuses on specific, well selected relationships in the innovation process with specific actors within the same innovation 'ecosystem' and beyond.

The network theory stresses the motives for engaging in collaborations such as technological complementarities or access to resources and specific knowledge, and it emphasises the role of trust and social capital for the development of networks. Thus, this research makes a huge contribution to the network theory and the dynamic capabilities view.

1.4.3 Research implications

The study is valuable to a number of key stakeholders in the biotechnology sector. It may help other researchers, bio-entrepreneurs & bio-tech firms, entrepreneurial small born-global firms, regional science institutions and policy-makers (e.g. the UK government and the European Union Commission).

Policy-makers should initiate targeted schemes that combine support for start-ups, internationalisation and innovation, mainly by providing technical and business advice, international networking opportunities with peers, suppliers and clients and access to finance in the form of subsidies, favourable loans or contacts with investors. Research collaborations in science-based sectors are vital to the development of life-saving drugs and clinical products as well as the survival of a firm in the hypercompetitive global markets. This is particularly important given the crucial role the biotechnology sector plays in saving the lives of ordinary people and its contribution to the economic development of the world markets (Hisrich, 2012). Smith & Bagchi-Sen (2006) suggests that for bio-tech firms operating in these harsh economic conditions there is greater need to develop business models and strategies that incorporate science into new product development, not only with local actors but also with geographically distant actors.

To create stakeholder awareness about whether their current strategies for networking are achieving the intended outcomes and the researcher intends to disseminate the findings of this research through research publications such as the *Science Direct, Technovation, Journal of Local Economy*, Nottingham Science City publications and by presenting at seminars on networking in biotechnology at networking forums organised by BioCity Nottingham (BCN) involving international players. The researcher also intends to work as a consultant for bio-tech firms championing the idea of working in collaborative projects highlighting its benefits to the parties involved.

1.5 Structure of the thesis

The entire thesis is divided into six main chapters which are further subdivided into various sections with subsections.

Chapter 1: Introduction

The chapter introduces the scope of the research. It sets out the research objectives and questions to be answered in the study and the reasons for undertaking it. It also provides a summary of the research sector and the structure of the thesis. In a nutshell the chapter sets the scene of the study. It outlines the research contribution. The contribution is in three parts including: theoretical contribution, knowledge about small born-global firms operating in the East Midlands and the value of the research to key policy-makers, other researchers, bio-tech firms and science experts.

Chapter 2: Literature Review

The literature review chapter provides an overview of what is known about born-global firms. The chapter shares with the reader the results of other studies that are closely related to this research.

The literature review chapter relates to the larger on-going dialogue about born-global firms and it evaluates prior studies (Copper, 2010; Marshall and Rossman, 2011). Specifically, the chapter synthesises the literature, organises it into a series of related topics and it summarises the literature by pointing out the central issues concerning born-global firms.

Chapter 3: Methodology

The methodology chapter provides a detailed discussion of the research philosophy, approach, and design. The chapter also explains the reasons for using a pilot study in this research. Crucially, this part of the study presents the epistemological positions in social science that this study takes. It also discusses the rationale for using a multi-case research strategy. Ethical considerations for the study are also discussed. It also informs the reader about the limits of the research. The methodology chapter provides a chronological account of how data for this study was collected, analysed and measured. The section also outlines how data was categorised and structured. The chapter also explains the operationalisation of the main themes of the study.

Chapter 4 Research findings

This chapter provides the research findings following within and across case analysis. Thematic analysis is used to analyse data collected from small born-global bio-tech firms. Themes are used as the unit of analysis for each case as illustrated in the new model for "*Knowledge and Innovative Capability Development"* for small born-global firms. The main propositions for the study include: business & social networks, competence & goodwill trust, inter-organisational collaborations, tacit & codified knowledge, prior learning & absorptive capacity.

The analysis draws its explanations from the data collected from case samples, preliminary literature review, and qualitative discussions. The chapter also provides findings from inferences derived from data collected for the purpose of the research. It also summarises case findings and it highlights some similarities and differences across the research sample as well as explaining their implications to the research.

Chapter 5: <u>Conclusions</u>

This is the final chapter and it is divided into three distinct sections. The first section summarises the key points of the research project taking into perspective its findings and results from within and cross case findings in chapter 4. Recommendations to key stakeholders and suggestions for future research are made.

Chapter 2

2. Literature review

To further underscore the significance of a literature review this chapter provides a critique of the literature related to small born-global bio-tech firms. The study sifts through existing data in order to examine and to provide some insights into the key themes including: the orientation of born-global bio-tech firms, their characteristics, the individual characteristics of bio-entrepreneurs, the international dimension of born-global bio-tech firms, their innovation clusters and networks and their business models. More importantly, the study informs the reader about how small born-global bio-tech firms use their business and social networks through collaborating to acquire scientific knowledge for drug discoveries and technical know-how for new clinical equipment development. This is consistent with Saunders *et al.* (2003) who believe that inductive research cannot be taken without a competent knowledge of the subject area being investigated.

Furthermore, Easterby-Smith (2012) suggests that it is essential for social science researchers to conduct a critical review of the literature in the field of their study in order to form the foundation on which to build their research. Saunders *et al.* (2007) explain that the main purpose for doing this is to develop a good understanding and an insight into relevant previous research and the trends that have emerged. To illustrate their point of view regarding the purpose of doing a literature review Saunders *et al.* (2007) utilise the example of a scientist arguing that it is important for a scientific researcher investigating the causes of cot death to read the literature to develop an understanding of the findings of other cot death researchers before they start their own research.

Following an examination of specific and related data about born-global bio-tech firms the study modifies Freeman's *et al.* (2010) propositions outlined in their model of rapid knowledge development for smaller born-global firms.

2.1 Defining born globals

The word born-global is used, in this study, to describe small firms in the bio-tech sector which engage in global collaborative activities; meaning they take part in science-related projects within and outside their immediate vicinity. Gabrielsson & Kirpalani (2004) agree that depending on the school of thought and characteristics of companies under investigation scholars have used different criteria to define born globals.

The literature is littered with different definitions of what born globals are. For example, Oviatt & McDougall (1994) define them as international ventures that seek to derive competitive advantage from the use of resources and the sale of outputs in multiple countries. Other scholars (see Knight & Cavusgil, 1996; Knight, 2001) use a variety of measures as criteria for defining these international ventures such as: the vision and strategy to become global, time of internationalisation and overseas sales volumes. Considering the different labels used to define born-globals a distinguishing feature in all their definitions is that, they adopt a global strategy evidenced by their structural dimension which encompasses various actors in multiple countries (Oviatt & McDougall, 1994). Equally, important to this discourse Oviatt & McDougall (2005) suggest that there is evidence which points to the fact that university and high-tech company spin-offs often become born globals. In spite of this observation, there still is no universal agreement to a single definition of born-globals.

In all the confusion and misconceptions regarding the definition of born-global firms, this study follows a commonly used definition of born globals which accentuates that at least 25% of their sales had to come from outside their home market in the first three years of their inception (see for example Gabrielsson and Kirpalani, 2012; Oviatt, and McDougall, 2005b; Knight and Cavusgil, 1996). Tanev (2012) insists that the majority of born-global firms advance through subsequent stages of internationalisation, collaboration with foreign partners, or undertaking of direct foreign investment (FDI). Accordingly, Ferreira *et al.* (2010) claim that irrespective of the label used to define the entrepreneurial behaviour of born-global firms, the concept is the outcome of a trend towards commercialising their products or services on a global scale. This rather new and emerging strategy of acquiring innovative capabilities which appears to be gaining momentum in the biotechnology sector can be attributed to the developments in information systems and technology, transportation, marketing and diminishing tariff and non-tariff barriers (Schilling, 2010; Lasserre 2007/2012; Ferreira *et al.,* 2010). As such, developments of this nature significantly give rise to the formation of entrepreneurial firms with an international flair from the day they start to operate.

2.2 The orientation of small born-global bio-tech firms

It is an important step for this study to construct a clear picture of born-global bio-tech firms in order to enhance our comprehension of how they became global. According to the Mandl & Celikel-Esser (2012) born-global firms are mainly set-up by former employees/industrial practitioners quitting their job and starting a business with an innovative product. Arguably, born-global bio-tech firms investigated in this study have no connection with their parent company. This is the case because the majority of the scientists who became bio-entrepreneurs were made redundant as a result of a restructuring exercise which saw the closure of AstraZeneca's R&D sites as a way of saving costs.

In that sense, they are not receiving any form of support from their former employers but they have developed local and international connections which have become part of their knowledge supply-chain. Therefore they cannot be classified as spin-offs. Nordman & Melén (2008) maintain that born-global firms can also develop as a result of academic researchers who develop an innovative product from their work in a lab. Tanev (2012) insists that managers of born-global firms proactively and aggressively compete in international markets; they take risks, and innovate. Nordman and Melén (2008) contend that regardless of their degree of international knowledge what is evident is the fact that their firms are located close to academic institutions or high-tech regions. This is evident in the all the firms sampled for this study. In Oviatt & McDougall (1997) born-global ventures are described as firms which from birth seek to maintain a leading role by utilising unique capabilities that are usually acquired from overseas actors. The dominant feature of these firms is their focus on global markets and the desire to take advantage of the opportunities that new markets offer (Knight & Cavusgil, 2004).

This observation is in line with the dated but influential remarks of Utterback & Abernathy (1975). The authors argue that the process of developing new products in young and innovative firms is fluid and dynamic and it requires a strategic approach to enable firm specific resource-building. The literature on the entrepreneurial behaviour of firms (Oviatt & McDougall, 1994; Li & Ferreira 2006) characterise born-global firms as enterprises with strong entrepreneurial behaviours including: risk taking, innovative and proactive. Admittedly, when operating in science-based industries such as the biotechnology sector it is essential that firms engage in cross border inter-organisational collaborations which present them with an opportunity to acquire unique capabilities including: technical know-how, robust business processes and advanced scientific knowledge (Barney, 1991).

In science intensive industries, technology and firm-based capabilities evolve at a fast pace therefore for small born-global bio-tech firms operating in such volatile conditions the ability to network across the globe can be crucial in bridging the knowledge and capabilities gap (Ferreira *et al.,* 2010) or in enabling new resource combinations (Schumpeter, 1950).

The primary drivers for taking this position can be attributed to entrepreneurial behaviours including: innovativeness, risk taking and the ability to spot opportunities (Ferreira *et al.,* 2010). In Lumpkin & Des (1996) innovativeness is conceptualised as a way of generating new ideas, creating novel products and services, developing new business processes and experimenting with new concepts moving away from the traditional business model. More often than not in science-based firms there is a high level of uncertainty therefore committing large volumes of resources can be seen as risk taking for small born-global bio-tech firms that are usually conceived with an international dimension to their operations (Miller & Friesen, 1982).

In this study small born-global bio-tech firms are assumed to use the network strategy by forming relationships with domestic and international partners to gain market access and to augment their core competences. In other words, they are risk takers who provide an impetus for change, innovation and they progress in economic life (Deakins & Freel 2009). Indeed, in today's fragile global economy small born-global bio-tech firms appear to have come up with the winning formulas and huge strides have been made in the biotechnology sector in terms of developing essential life-saving drugs and clinical products. For example, the discovery of revolutionary products such as treatment drugs for previously untreatable diseases; fuels and plastics produced directly from plant materials; and substances which can convert toxic and other wastes to useful materials (Liebeskind *et al.,* 1994).

Similarly, Schumpeter (1950) offers an interesting definition of this very elusive word by pointing out that, “The Schumpeterian entrepreneur changes technological possibilities, alters convention through innovative activity and, hence, move production constrains”. The next section explores the characteristics of born-global firms which then put into context how entrepreneurial firms operating in a science-based sector behave.

2.3 Characteristics of born-global bio-tech firms

The way born-global bio-tech firms operate bears some resemblance to traditional entrepreneurial firms (Standing *et al.,* 2008). Ferreira *et al.* (2010) hold that, “it may be true that to some extent these traits are also observable in purely domestic entrepreneurial firms, but because international entrepreneurial firms operate in foreign markets they are more salient”. Indeed, the majority of born-global bio-tech firms encounter operational problems similar to those of a typical entrepreneurial firm would navigate through on a daily basis. They both exhibit characteristics that can be summarised under the following key categories:

- Resources: small born-global bio-tech firms at their infant stages will have limited resource but their technological resources and intellectual capital could have the potential to generate high returns.
- Innovativeness: usually born-global bio-tech firms are small high technology ventures that heavily rely on their business and social networks to generate scientific knowledge and make crucial product developments. The emphasis on the concept of creativity advances the idea of inter-organisational collaborations that are often credited with creating a platform for knowledge sharing which results in the discovery of new drugs and life-saving clinical products.

- Products: their products are mainly science-based and require a strong financial base.
- Competitive Environment: the biotechnology sector is a highly competitive business arena therefore the commercialisation of a new invention i.e. securing a patent for the invention usually yields high returns.
- Market Share: similar to SMEs, bio-tech firms have a relatively small market share due to product awareness within their markets and in overseas markets.
- History: for every new firm there is a dearth of financial resources and management capabilities. Therefore, investors may have concerns in investing in such ventures.

There are also other organisational-related characteristics such as informal structures which are flatter in nature and they allow direct communication among the actors involved (Standing *et al.,* 2008). More importantly, entrepreneurial firms are well known for their dynamic and flexible decision-making processes. Notably, born-global bio-tech firms operate in volatile global markets (Lasserre 2012). Therefore, in order to respond to frequent changes in the market it is paramount that strategic decisions are made with the least amount of delay to improve lead time. All of the above discussed characteristics underpin success and they highlight the vital role of inter-organisational collaborations for born-global bio-tech firms as sources for strategic capabilities such as fluid scientific knowledge. In that sense, strategic alliances have never been as crucial as a source for innovative capabilities and new product development (Ohmae, 1989).

2.4 Individual capabilities of the bio-entrepreneur

In the science intensive healthcare and medical sectors innovation 'ecosystems' are the main source of economic effects that include knowledge and technical know-how (Ho & Wilson, 2006). Research labs, academic institutions, science parks, small and large organisations co-exist within the maze and they purposefully interact with each other.

Collectively, they work towards supporting technology development and the free flow of information (Bramwell *et al.,* 2012). In such complex systems of multiple relationships, significant amounts of science-related data are generated. This has huge implications for bio-entrepreneurs in the sense that, they have to effectively utilise their history and experience (antecedent influences) in science in order to identify and acquire useful knowledge that can facilitate the development of their born-global bio-tech ventures. Burns (2012) elaborates on the antecedent influences of entrepreneurs highlighting that they are shaped by their business and social connections, culture, previous employment, and educational attainment.

Considering the operational structures within small entrepreneurial firms, there is sufficient evidence to signify that their bio-entrepreneurs are actively involved in formulating their business strategies (see Gurău, *et al.,* 2010; Burns, 2012; Bessant & Tidd 2011). From that perspective, there is logic in suggesting that their personality traits are replicated in their firms (Allen, 2012). In Storey (1994) seventeen multivariate studies were reviewed to examine the effects of antecedent influences on the establishment of entrepreneurial ventures. Storey's study inferred that there is a strong association between an entrepreneur's educational attainment (prior-learning) and the development of their venture. Kuratko (2013) contends that as entrepreneurs react to a diverse, multi-faceted, and imposing array of activities, events and developments they considerably influence the development of their ventures.

Bessant & Tidd (2011) insist that the competences of owner-managers strongly influence the scope and the direction of their ventures. Karra *et al.* (2008) place strong emphasis on individual entrepreneurs in organising born-global firms. The scholars maintain that the most salient factor in rapid internationalisation of firms is not necessarily the nature of products or the market, but rather the individual characteristics of the entrepreneur. An entrepreneur's experience, skills and networks allow the firm to develop the resources that enable it to become a born global firm (Altshuler, 2012).

2.5 The International dimension of small born-global firms

Over the past three decades the concept of internationalisation has been a subject of academic debate. A number of scholars have defined it from different angles. In Johanson & Vahlne (1977) internationalisation is seen as a step-by-step process adopted by a firm in order to operate on the international scene. They posit that this strategic direction involves calculated risk. The dynamic perspective of internationalisation was given by (Welch & Luostarinen, 1988).

The scholars observed that the process of venturing or taking a firm's operations into overseas territories should involve both internal and external resources. Adding to the growing debate about the concept of internationalisation Beamish (1990, p.77) conceptualises internationalisation as a process "by which firms both increase their awareness of the direct and indirect influences of international transactions on their future, and establish and conduct transactions with other countries". Likewise, Ohmae (1998) makes an important contribution to this debate which is core to this study. He refers to business networks as key sources of capability development. Ohmae's point is that in knowledge intensive industries such as the science-based firms it is important to continuously generate new knowledge for the process of innovating to keep occurring.

Indeed, based on this perception it is reasonable to claim that for small born-global bio-tech firms there is pressure to generate scientific knowledge which can be acquired or enhanced by penetrating international business networks. The process of building a firm's innovative capabilities is exceedingly complex but at the same time rewarding in terms of acquiring unique capabilities which makes a huge difference in making new innovations (Cohen, 1994). Small born-global bio-tech firms operate in extremely hyper-competitive business environments which require the firms to react to these market conditions by positioning themselves in a way that allows them to take advantage of the opportunities offered by globalisation.

2.5.1 International entrepreneurship

The term international entrepreneurship is not new; it was first mentioned in the late 1980s. Morrow (1988) used the term to describe the many untapped foreign markets that were available to new ventures reflecting a new technological and cultural environment. McDougall (1989, p.389) described international entrepreneurship as "the development of international ventures or start-ups that, from their inception, engage in international business thus viewing their operational domain as international from the initial stages of operation". McDougall & Oviatt (2000, p.903) defined international entrepreneurship in a border sense as a, "combination of innovative, proactive and risk taking behaviour that crosses or is compared across national borders and it is intended to create value in the business". In the hyper-competitive biotechnology sector, entrepreneurial behaviour of such magnitude is very important if a firm needs to leverage its internal knowledge base and/or generate new knowledge using its external connections. Hisrich (2012) maintains that this nature of international entrepreneurship takes into account the notion of innovation, risk taking and proactive behaviour.

Ferreira *et al.* (2010) brings in a similar perspective and they insist that entrepreneurial firms that are born-global, exhibit unique characteristics that heighten their need to integrate and rely on networks to generate novel information.

2.5.2 Motivations for collaborating in science

The need for working in collaborative teams in science has been recognised ever since the professionalisation of science took place during Napoleon's time in France and later in England and Germany (Beaver & Rosen, 1978; Mattsson, 2011).

According to Mattsson (2011) the benefits of research collaborations are many including those that are related to scientific, economic and political factors. In Georghiou (1998) a distinction between direct and indirect benefits was made. Direct benefits were seen as those benefits that accrue to a firm when it has access to complementary expertise, knowledge and skills that help the firm to bridge its knowledge gaps and enhance its scientific as well as technical know-how (Mattsson, 2011). On the contrary Georghiou (1998) suggests that indirect benefits are as a result of collaborations that are driven by external goals usually political or cultural related. Indeed, in the biotechnology sector where government policies play a crucial role in creating platforms that enhance R&D, indirect benefits are a reality for all the actors involved. Consistent with Georghiou (1998), Beaver (2001) using a motivation-centred approach to explore the benefits of collaborating that motivate firms to collaborate with other firms. Table 1 on p.32 provides a comprehensive list of purposes for the collaboration of proactive business entities.

Table 1: Purposes for scientific collaborations

1.	Access to expertise
2.	To access equipment, resources or “stuff” that one does not have
3.	To improve access to financial resources
4.	To obtain prestige or visibility so as to grow professionally
5.	To improve efficiency of the firm
6.	To aid rapid progress especially for smaller firms
7.	To tackle “bigger” problems that have become global and sophisticated
8.	To enhance productivity
9.	To get to know people, to create a network
10.	To leverage internal knowledge base i.e. acquire new skills techniques to increase chances of new product discoveries
11.	To satisfy curiosity and intellectual interest
12.	To share the excitement of new discoveries with other firms
13.	To reduce mistakes and errors and to uncover any flaws in discoveries at an early stage
14.	To focus on research and development
15.	To reduce isolation by keeping abreast with developments in science, and to recharge one’s energy and excitement.
16.	To educate (a student, graduate student, or, oneself).
17.	To advance knowledge and learning
18.	For fun amusement and pleasure

Sources: Beaver, 2001; Mattsson, 2011 and author’s ideas

A different perspective concerning factors that drive inter-organisational collaborations was offered by Kazt & Martin (1997). The scholars divided the factors into four distinct categories covering: (a) financially related reasons i.e. access to financial resources and working space including science labs, office etc.; (b) social factors including reputation within the science community, developing social networks; Mattsson (2011) adds that social connections are also important here as people prefer to work in groups/teams rather than in isolation; (c) collaborations that give rise to knowledge sharing and exchange in the form of analytical skills, technical know-how and observational learning; and (d) political factors related to government initiatives to encourage scientists to work together. Sörlin, (2004) explains that collaborations taking an international dimension have been in existence even in the early days of modern science.

This observation is important to the central discussion in this thesis as it is anchored on the activities of born-global firms which operate on a global scale. As the study has already explained that born-global firms are both proactive and reactive (see Hisrich, 2012; Rasmussen & Madsen 2002; Knight & Cavusgil 2004). It is, therefore, this behaviour which motivates their desire to operate on a global scale. Entrepreneurial firms operate globally from day one to gain economies of scope. Johnson *et al.* (2008) defines economies of scope as intangible resources and capabilities including skills and technology. In Campbell & Luchs (1992) the benefits of scope are referred to as the benefits of synergy. In other words, the benefits gained by born-globals from their international collaborative partners where they complement each other to the extent that their combined effect is greater than when they operate on their own.

Table 2: Motivations for going global

Unique products and services
Competitive pressures
Unique market opportunities
Technological advantages
Economies of scale and scope
Tax benefits
Cost related benefits

Source: Adapted from Hisrich, Peters & Shepard, 2010, p. 142

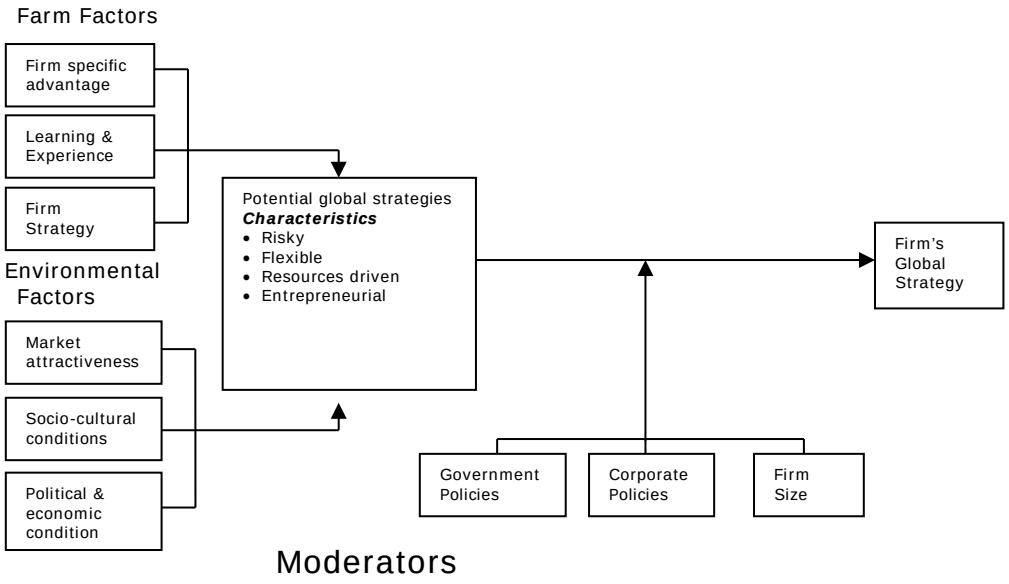
The opportunities offered by foreign markets impact on the decisions of born-global firms. Hasegawa & Noronha (2009) point out that the technological strength of countries such as China and India are opportunities that technology-based firms can take advantage of to leverage their core competences as well establish their operations at very low costs.

2.5.3 Strategic effects of going global

While trading on a global scale presents born-global bio-tech firms with a variety of new environments (Hisrich, 2012) and new ways of going to the market (Piercy, 2002) it would be naïve to ignore the new array of challenges that a firm has to deal with when establishing its operations in new territories. A number of scholars Driscoll (1995); Lasserre (2007); Johnson *et al.* (2008); Hisrich (2012) and Morrison (2011) highlight firm and environmental factors as the main factors that influence the strategic decisions of a firm intending to trade globally.

Driscoll's mode choice framework clearly outlines firm-specific advantage, experience and strategy as firm factors and demand/competition, socio-cultural conditions and political/economic conditions as environmental factors. The variable moderators were identified as follows: host/home government policies, corporate policies and firm size. Figure 1 on below neatly illustrates Driscoll's and the author's ideas.

Figure 1: Factors that influence strategic decisions of born-global firms



Source: Driscoll, 1995 and author's ideas

Similarly, when discussing international vs. domestic entrepreneurship Hisrich (2012) identified five factors that are different as follows: *economics, language stage of economic development, types of economic system, political and legal environment and language.* Furthermore, Kazt & Martin (1997) point out that the process of going global comes with increased financial burdens and administrative costs as well as costs associated with travelling from the domestic market to overseas markets. Georghiou (1998) highlights the differences in the centre of interest, research activity and policy support as real challenges for firms operating internationally. Mattsson (2011) agrees that different policies and foci in different countries have the potential to hinder the intended goals of collaborating even if the research agendas are the same. Indeed, these factors have a profound effect on how small born-global bio-tech firms enter the global stage. They give rise to market ambiguity for these proactive firms hence, the presumed importance of business and social networks (Freeman *et al.,* 2010; Johnson & Vahlne, 2009; Lasserre, 2007).

2.5.4 Risk in global markets

The risk of failure for born-global bio-tech firms operating in global markets is very high and most studies show that there is a high rate of failure for small firms ranging from 50% to 80% (see Das & Teng, 1999; Dye *et al.,* 2001; and Mol, 2000). In classical decision theory, risk is most commonly conceived as reflecting variation in the distribution of possible outcomes, their likelihoods, and their subjective values (March & Shapira, 1987). Synthesising most of the literature on risk taking behaviour Sitkin & Pablo (1992) define three important variables including: risk preference, risk perception and risk propensity. For risk preference they associate it with individual characteristics suggesting that the traits of an individual influence their actions (Brockhaus, 1980).

For risk propensity they refer to an individual's tendency to engage in risky activities and risk perception is defined as a decision maker's assessment of the risk inherent to a situation. In total it is reasonable to suggest that entrepreneurs who enjoy the challenges of venturing into global markets irrespective of the size or their resource bases are more likely to engage in risky actions than those who are risk averse (Sitkin & Pablo, 1992, Willebrands *et al.,* 2012). Given the motivations and drivers that have been outlined in Table 1 on page 32 it is reasonable to claim that the desire for born-global firms to achieve more in the way of unique capabilities can be seen to be stronger than for those firms which chose to avoid venturing into new market territories for fear of failure (McClelland, 1961). In theoretical economic literature Arrow's (1971) and Pratt's (1964) parameter of risk aversion (see Cressy, 2006), cogently indicate that there is a strong correlation between risk taking behaviour and improved business performance.

Indeed, as suggested by the standard economic theory that entrepreneurs who avoid taking risks when making investment decisions are willing to accept lower returns in exchange for less exposure to risk. The same cannot be said of those entrepreneurs who are willing to take risks in exchange for higher profit margins (Cressy, 2006; Willebrands *et al.,* 2012). On that account, it is safe to claim that the performance of small born-global bio-tech firms and the attitude of entrepreneurs may be related in several ways. Admittedly, small born-global bio-tech firms have very limited resource bases however; market opportunities offered by global markets present them with a chance to boost their economic returns through their actions. Willebrands *et al.* (2012) maintains that, "market activities inherently carry risk and will only be undertaken by those who do not shy away from it".

From the author's understanding small born-global bio-tech firms which from the day they started trading adopted a global strategy, their behaviour can be described as risky nonetheless, their expectations are to improve their innovative capabilities by having access to fluid scientific knowledge and technical know-how essential for drug discovery activities and the development of new clinical products.

2.5.5 Trust and small born-global bio-tech firms

Networks are assumed to be the main catalysts that make it possible for information to flow – is this the reality? Perhaps there are other key components that allow the exchange and transfer of knowledge to occur (Wever, 2005). The extant literature on trust reveals that trust facilitates knowledge transfer and exchange between the actors involved (see Welter, 2012; Nahapiet & Ghoshal, 1998; Tsai & Ghoshal 1998; Adler & Kwon, 2002; Inkpen & Tsang, 2005; Lui, 2009). By evaluating the discourse on trust, this section aims to develop some understanding of how small firms acquire strategic capabilities in networks through social interactions. A number of related studies have conceptualised trust as an important part of a jigsaw puzzle needed for starting and growing a new venture (Welter, 2012). Included in these studies about human resource flexibility (Zolin *et al.,* 2011), are small business relationships with venture capitalists, banks or business angels (Maxwell & Lévesque, 2011; Strätling *et al.,* 2011; Howorth & Moro, 2006). More importantly, trust is seen as a crucial aspect for the internationalisation of entrepreneurial firms which aim to take advantage of global markets (Fink & Kessler, 2010). Welter (2012) argues that in small family run businesses trust plays a central role for their prosperity. Other related studies highlight the crucial role trust plays in family businesses as a governance mechanism (Eddleston *et al.,* 2010) as well as a tool for their strategic advantage (Fink, 2010).

In other studies (see Manolova *et al.,* 2007; Puffer *et al.,* 2010; Smallbone & Welter, 2001; Yan & Manolova, 1998) trust is mainly seen as one of the key components that reduces transaction costs and risks small entrepreneurial businesses face in often uncertain and constantly changing global business environments. In the bio-tech industry today, bio-tech firms often require firms to work/engage in collaborative projects with external partners (Jones & Lichtenstein, 2008) because of their constantly changing market conditions. Indeed, in this knowledge intensive sector, firms work in inter-organisational projects where they share risks and they pool their resources to deliver joint drug discoveries and clinical products which otherwise would not have been possible when they were to go it alone (Powell *et al.,* 1996). Thus, the aspect of trust becomes crucial in such partnerships. Wong *et al.* (2008) agree that trust is a vital component in collaborative projects which strengthens as well as improves the relationships of the parties involved in a collaborative project.

In the literature on inter-organisational collaborations outside information has been credited with enabling the flow of technological developments, product innovations and enhanced business opportunities (White & Fortune, 2002; Maurer, 2009). According to Nahapiet & Ghoshal (1999) the act of trusting makes it possible to access such knowledge. Furthermore, Welter (2012, p.194) “trust is seen to assist in lowering the transaction costs of commercial actions and the risks inherent in entrepreneurship”. The concept of trust is a very elusive concept and in literature there is no single definition that has been agreed upon. The concept is defined in a number of different ways (Welter, 2012). Maurer (2009, p.630) contends that “trust is a complex and multifaceted construct”.

Co-operation and risk are the two main principal concepts that have consistently emerged when scholars explore the notion of trust (Sengun, 2009; Gambetta 1988; Curran & Judge 1995). The two principal concepts are strongly linked throughout the literature. Gambetta (1988, p.217-218) claims that in real life when we say we trust "we implicitly mean that the probability that he will perform an action which is beneficial or at least not detrimental for us to consider engaging in some form of co-operation with him". Accordingly, in Curran & Judge (1995, p.153) trust is seen as an individual's "behaviour reliance on another person under a condition of risk". From these perspectives, trust can be taken to be based on one's perception that others will behave positively towards them under conditions of risk (Gubbins & MacCurtain, 2008). Accordingly, Welter (2012) claims that trust is based on the perception of the probability that other agents will behave in a way that is expected and benevolent. Mainstream literature on trust focuses on dyadic relationships (Anderson *et al.,* 1984; Cowan & Jonard, 2004; Breschi and Malebra, 2005). De Wever *et al.* (2005) combine two dimensions of trust i.e. resiliency reflecting the extent to which trust is "resilient" rather than "fragile" (Ring, 1996) and specificity concerning the degree to which trust may exist without direct information and/or without previous interaction, simply by association (De Wever *et al.,* 2005).

From the combination of these two dimensions of trust four different types of trust were obtained and they are outlined in Table 3 below:

Table 3: Four types of trust

Dyadic Resilient Trust	This type of trust is based on frequent and direct interactions and incorporates a kind of benevolence based on those frequent contacts.
Dyadic Fragile Trust	Although this type of trust is based on frequent and direct interactions, these interactions do not cause the feeling of benevolence. This type of trust is a calculative type; there are perceptions of the immediate likelihood of rewards whether it concerns a long-term or short-term relationship.
Generalised Resilient Trust	Although this type of trust exists without much previous interaction, the feeling of benevolence is present, simply by associating.
Generalised Fragile Trust	Concerning this type of trust, there are perceptions of immediate return and not feelings of benevolence linked to the cause of the trust: association

Source: De Wever *et al.* 2005, p.1530-31

The different types of trust demonstrate that different dimensions of trust do exist that are closely related to either associations or feelings. This implies that there is a belief that trust also exists in social and business networks that are being studied in this project. Schoorman *et al.* (2007) expresses that trust is an element of dyadic relations involving the trustee and the trusted. Şengün & Önder (2012) suggest that trust is a multi-level and cross level phenomenon which exists at three different levels namely; personal, organisational and inter-organisational levels. Similarly, Welter (2012) argues that trust stems from characteristics of a community or organisation and he identifies such communities as networks, firms, associations, ethnic groups or an industry. Other scholars argue that it is multi-dimensional (see Lewicki *et al.,* 1998; Nooteboom, 2002; Schoorman *et al.,* 2007). In the same way, Igarashi *et al.* (2008) make a distinction between generalised and pluralistic trust. In Sheppard & Tuckinsky (1996) three types of trust were suggested i.e. deterrence based, knowledge based and identification based.

Şengün & Önder (2012) claim that in previous research a common distinction is made between competence and goodwill trust. It is these two types of trust that seem to be very critical for small born-global bio-tech firms which enter into strategic alliances with business partners who may have a different complementary foci at some cognitive distance (Nooteboom, 2005). In the same vein, Nooteboom & Six (2003) point to trust in competence and trust in intention as the two main aspects attached to trust that exists in organisations. Trust in competency refers to the perceptions of the trustor concerning the trustee's technical, cognitive and communicative competences (Şengün & Önder, 2012; and Nooteboom 2009). Blomqvist (1997) and Ganesan (1994) express similar views; they claim that competence trust is based on the school of thought that there is a high probability, between collaborating parties that agreed strategic objectives will be successfully accomplished which increases the reliability and the predictability of partners in a relationship.

On the other hand, Şengün & Önder, (2012) suggest that trust in intention (goodwill trust) signifies the absence of opportunism or presence of benevolence reflecting dedicated behaviour including: fully participating in knowledge exchange actives, paying attention to each other's needs and avoiding a one way flow of information (De Wever *et al.,* 2005). Blomqvist (1997) concludes that trust in intentions entails the moral obligations and the positive intentions of partner to the other and towards the relationship.

2.5.6 Global alliances

A strategic alliance is where two or more companies share resources and activities to pursue a strategy (Johnson *et al.,* 2006). Schilling (2008) insists that an alliance is a general term that can refer to any type of relationships between firms which can be short or long term and may include formally contracted agreements or can be entirely informal in nature. In science-driven businesses, especially for small born-global bio-tech firms, this kind of joint development of new strategies has gained momentum (Hisrich, 2012; Newman, 2001; Ahuja 2000). This way of doing business is mainly attributed to the globalised nature of trade together with the dynamism and rapid changes in technology that technology-based companies have to contend with in order to achieve company goals including: capability development, new product & business development and creating value for the customer through continuous innovation (Schilling, 2008; Lasserre, 2007/2012). Indeed, in the biotechnology sector there is a growing trend where research institutions, universities and science institutions are forming strategic alliances which have resulted in the development of revolutionary products. The development of life saving drugs in the medical sector is one example of this phenomenon.

Taking that into perspective, it is safe to claim that strategic alliances between businesses and research centres worldwide are the cornerstone for innovation. In particular, their ability to stimulate and provide a platform for knowledge sharing, exchange of ideas and the transfer of technologies which has the potential to bring “the new order out of the old” Standing *et al.* (2008, p. 790). In Teece (1986) it was suggested that small firms can form alliances with big firms to tap into the larger firm’s greater capital resources, distribution and marketing capabilities, or credibility.

Schilling (2010) uses the example of small biotechnology firms that form partnerships with large pharmaceutical firms for their mutual benefit. She claims that by forming an alliance pharmaceutical firms can gain access to the drug discoveries of the biotechnology companies and likewise the biotechnology company gain access to the capital resources, manufacturing & distribution capabilities of the pharmaceutical firms. Since the fragmentation of the "Big Pharma" model this has been a common occurrence in the life science sector (Rafols *et al.* 2012).

In the literature on strategic alliances it has been made clear that strategic alliances enable partners to learn from each other and develop competences (see Chan & Wang, 1994; Ohmae 1982; Freeman *et al.* (2010). According to Schilling (2008, p.160) "alliance partners may hope to transfer knowledge between firms or to combine skills and resources to jointly create new knowledge". For small born-global bio-tech firms rapid access to important complementary assets enhances their flexibility i.e. they can either commit their resources to a venture or shift them to another opportunity as they operate in multiple countries.

Alliances vary considerably in their complexities from simple, two partner alliances, to one with a number of partners sharing capabilities and expertise (Ohmae, 1989; Chang & Wang, 1994). It is also important to note that although scientific knowledge acquired from strategic alliances can be crucial, managing it has always been a challenge for small born-global bio-tech firms and yet, it is valuable for continuous innovation. Standing *et al.* (2008 p.271) posit that, "knowledge management has become a critical imperative in inter-organisational interactions as it provides short-term operational efficiencies and long-term new knowledge creation".

The process of going global for small bio-tech firms can occur in two distinct parts: First, it occurs when a firm intends to exploit or take advantage of the existing opportunities in new national markets. Second, it occurs when an ambitious firm intends to develop unique capabilities by drawing on the capabilities that exist in different parts of the world (Lasserre, 2007). In doing so, a firm is able to exploit advantages that are related to specific technological and scientific capabilities (Johnson *et al.,* 2008). In the literature on internationalisation such firms are described as born-globals, entrepreneurial firms or international new ventures (INV) that seek to derive significant competitive advantage from the use of strategic resources acquired from more than one country (Oviatt & McDougall, 1997).

The concept of going global can be analysed at different levels ranging from: firm level, industry level and national level (Cantwell, 1991). The choices and the strategic direction that an organisation pursues in a globalised marketplace are driven by a number of factors including: seeking strategic capabilities, market opportunities, market attractiveness, market conditions and as an expansion strategy (Kale & Singh, 2007; and Arova 2005). In a hyper-competitive global market bio-tech firms should seek to take advantage of the market opportunities offered by new and emerging markets. Johnson *et al.* (2008) suggest that the strategies a firm can rely upon to exploit new market opportunities in new market territories include; being unpredictable, disrupting the market, re-positioning and product diversification. Making a choice regarding the strategic direction and scope can be a challenge for managers particularly for entrepreneurial managers operating in rather ambitious small born-global bio-tech firms. Crucially, Ohmae (1982) argues that strategic alliances become a requirement for firms intending to access international markets. Similarly, Brouthers *et al.* (1995) contend that in the majority of cases strategic alliances with complementary skills significantly contribute to each other.

As such, for science-based firms, especially the small born-global bio-tech firms that have limited resources venturing into new territories through strategic alliances gives them access to scientific knowledge and technical know-how. Furthermore, McDougall & Oviatt (2003) claim that networks provide a platform for risk taking entrepreneurial firms to access global markets and the types of relationships significantly influence the choice of the overseas market more than their psychic distance. The social and business networks provide numerous benefits for born-global firms and they equally pose challenges and risks for them. In the literature on international ventures Brouthers *et al.* (1995) stress that despite the risk associated with the social and business networks, it is often necessary for firms to enter into strategic alliances to boost their resource bases. Nohria & Garcia-Pont (1991) contend that strategic alliances are formed to accelerate the acquisition of strategic capabilities more rapidly. From that perspective, it is reasonable to claim that strategic alliances of born-global firms in the global markets are the cornerstone to resource acquisition.

In Lin & Chen (2002, p.2) strategic alliance are defined as “an inter-organisational co-operative arrangement over a given economic space and time for the attainment of some strategic objectives”. Inter-organisational alliances have become more common due to the liberalisation of international markets and the accelerating pace of technological change (Das & Kumar, 2007). In the life science sector this kind of joint development of new strategies has dominated the industry. In particular, their ability to stimulate and provide a platform for knowledge sharing, exchange of ideas and the transfer of technologies which has the potential to bring “the new order out of the old” (Standing *et al.,* 2008, p.790).

Furthermore, Das & Kumar (2007) claim that strategic alliances can be used as a platform for sharing costs and research and development (R&D), for accelerating the introduction of new products in the global marketplace, for gaining access to resources and as a source for strategic capabilities including: new technology and information from partner firms. Similarly, Chan & Wong (1994) express that strategic alliances are used to share costs and risks and to penetrate new markets. In alliances, trust is an important component underpinning the development of enduring a business relationship. In a study involving 37 companies from 11 different countries aimed at understanding the importance of strategic alliances Kanter (1994) concluded that trust was fundamental to the success of an alliance. Scholarship on entrepreneurial behaviour Oviatt & McDougall (1994); Li & Ferreira (2006) characterises born-global firms as firms with strong entrepreneurial behaviours. Admittedly, when operating in science-based industries it is essential that firms engage in collaborative activities thus giving themselves an opportunity to absorb unique capabilities including: robust business processes, advanced scientific knowledge and new ways of going to the market (Barney, 1991).

In science intensive industries, technology and firm-based capabilities evolve at a fast pace. Therefore, for bio-tech firms immersed in such volatile conditions the ability to network across the globe can be crucial in bridging the knowledge and capabilities gaps (Ferreira *et al.,* 2010) or in enabling new resource combinations (Schumpeter, 1950). The primary drivers for taking this position can be attributed to entrepreneurial behaviours including: innovativeness, risk taking and the ability to spot opportunities (Ferreira *et al.,* 2010). In Lumpkin & Des (1996) innovativeness is conceptualised as a new way of generating new ideas, creating novel products and services, developing new business processes and experimenting with new concepts moving away from the traditional business methods. More often than not in science-based firms there is a high level of uncertainty.

Therefore, committing large volumes of resources can be seen as risk taking for small firms that usually have limited resources (Miller & Friesen, 1982). According to Schumpeter (1950) entrepreneurs who are successful have the ability to spot a market opportunity and they shift economic resources to take advantage of those opportunities (Drejer, 2004). In this study bio-tech firms are assumed to use the network strategy by forming relationships with their international partners to gain market access and to augment their core competences.

2.6 Innovation clusters and networks

In Carayannis & Wang (2008 p.65), innovative clusters are defined as "concentrations of interrelated innovative agents located in a specific geographic area". Clusters are mainly shaped by organisational structures, geographic scope, density, breadth and depth and the special characteristics of population, culture and technology (Chesbrough, 2006; Carayannis & Wang, 2008).

Effective and productive clusters are those that are complementary to innovative activities, selective in network development, and, more importantly, effective in knowledge sharing and technological transfer (Owen-Smith & Powell, 2004). It is also important to acknowledge the differences in innovative clusters and innovative networks. Carayannis & Wang (2008) identify three significant ways in which innovative clusters and innovative networks differ. Firstly, the scholars claim that innovative clusters cut across many clusters and sectors. Secondly, they maintain that usually clusters are formed and developed as a result of linkages or connected firms in a value chain (OECD, 1999). Thirdly, they suggest that all organisations that have a relationship in a dominant sector, for instance, the biotechnology sector, share a dominant technology in that cluster to produce novel products (OECD, 1999).

Innovative networks on the other hand, link several value chains at the same time (Malebra & Breschi, 2005). The difference between innovative clusters and innovative networks is that the later share more complementary science knowledge than common technology (OECD, 1999). Innovative networks have common features such as flexibility and are less bonded which makes them different from clusters. Notably, in a cluster the main players are more likely to remain the same over time and Carayannis & Wang (2008) suggest that unless one or more key factors that include technology have evolved in that time. Contrary, in innovative networks members are likely to depend on the project. This has become common occurrence in the biotechnology sector in which small born-global bio-tech firms engage in multiple projects both locally, nationally or internationally. Cooke (2003) agrees with this observation and he contends that key players in an innovative network are known to partner with the best performers of a sector regardless of their locations.

According to Carayannis & Wang (2008) innovative networks are less sensitive to density due to the fact that an innovative network achieves its ideal network at any particular number of relationships. The number of relationships in a network is heavily dependent on the nature of technology and managerial capacity (Todtling *et al.,* 2009). Given the variations in innovative clusters and networks, it is clear that there is an element of competiveness and synergy among the firms or nodes involved. Central to the purpose of this study is the fact that innovative networks accelerate innovations and technological development. It is also important to note that clusters and networks have their own advantages and constraints.

Owen-Smith & Powell (2004) contend that there are certain factors that favour clusters, for example, they suggest that knowledge sharing and technological transfer are more prevalent in innovative clusters as opposed to innovative networks. In innovative networks these factors cannot easily replace many complex inter-linkages in clusters, on the one hand. On the other hand, innovative clusters have the capacity to bring novel information and new ideas to a firm. This is particularly important for small born-global bio-tech firms due to the fact that their industry is knowledge-based and requires them to constantly update their knowledge bases in order to improve their innovative capabilities and to develop their business processes.

2.6.1 The business networks of born-global firms

According to Holm *et al.* (1996) business relationships are entities that can be analysed entirely on their own but they can be better understood when looked at in context rather than in isolation. Therefore, in the literature on business networks the cooperation in relationships with the parties and the dyadic relationship has been considered within the context of the direct exchange network surrounding the dyad (Achrol *et al.,* 1983; Anderson *et al*., 1994; Kogut *et al.,* 1992).

Scholarship on inter-organisational collaborations acknowledges that firms seeking value-generating resources should venture beyond their immediate proximity and develop strong relationships. This is because it is through the networks they have that they may have access to and subsequently acquire those strategic resources (Ireland *et al,* 2002; Tsai, 2001; Cooke 2003; Owen-Smith & Powell, 2004; Freeman *et al.,* 2010; and Ferreira *et al.,* 2009). Taking the social exchange perspective on dyadic relations within social exchange networks the assumption here is that dyadic relationships can be used to analyse cooperation in business relationships within business networks (Anderson *et al.,* 1994).

Networks are defined as a set of nodes (persons, organisations) linked by a set of social, friendship of a specific type (Cooke, 2001; Breschi & Malebra, 2005). They are distinct from hierarchical or market relationships in their reliance on reciprocity, collaboration, complementary independence and orientation towards mutual gain. Breschi & Malebra (2005, p.47) suggests that, “resource pooling, risk sharing and the formation of critical masses provide incentive to create a group of interlinked agents”. Adding to the growing discourse on business relationships a recent study by Johnson & Vahlne (2009) provide two core arguments. Firstly, it stresses that markets are networks of relationships where firms are connected to each other in different formats including complex and visible patterns. This perspective is critical in understanding the collaborative activities of entrepreneurial firms or small born-global bio-tech firms. Secondly, it suggests that relationships at organisational level facilitate learning and the potential to build trust and commitment of the parties involved. These can be seen as the pre-conditions for capability development for small born-global bio-tech firms.

The theory on social exchange clearly demonstrates the differences between relations that have a positive connection and the ones that have a negative connection. In those relations where there is a positive connection the flow and exchange of information is bi-directional whereas, in those with a negative connection information flows in one direction (Cooke, 2003; Ahuja, 2000). The underlying assumption of the business network concept is that the co-ordination of activities between parties involved in a business relationship has to take place within a wider network context (Anderson *et al.,* 1994). Accordingly, in connected business relationships along the value-chain business networks are conceived which provide a platform for learning through social exchange overtime for bio-tech firms (Anderson *et al.,* 1994).

Stanek (2004) emphasises that a network can often be superior for a stand-alone firm due to its greater knowledge diversity and a pool of talent found within. Furthermore, Freeman & Cavusgil (2007) claim that strong *camaraderie* is found to exist between smaller born-global firms and their foreign customers and is frequently based on long standing past associations of the senior management team. From that perspective, trust-like relationships exist by default in established networks which is the bedrock of inter-organisational partnerships. Moreover, established networks can lead to newly-formed business and social networks (Freeman *et al.,* 2010). This occurrence can be witnessed in well-developed business networks including: Basel area, Boston metropolitan area and Cambridge cluster. From the perspective of these well-developed business networks, it is possible for entrepreneurial or born-global firms to develop and supplement their core competences and at the same time take advantage of new market opportunities.

Admittedly, one of the ways in which a firm can successfully exploit global markets is by augmenting its core competences through business networks thereby creating new opportunities. When analysing the globalisation of R&D Lasserre (2007) stressed that firms can learn about different markets, different problem-solving techniques, and different competitors. Consequently, the rapid diffusion of that learning throughout the entire firm is significantly enhanced by creating international networks of laboratories. Indeed, in science-based businesses the ability to leverage core competences across geographic units and product business units help firms to achieve economies of scale and scope, important for successful international diversification and access to international talent (Hitt *et al.,* 1998; Johnson *et al.,* 2006). International social and business partnerships create new scientific knowledge for small born-global bio-tech firms however; managing that knowledge can be a challenge.

Hughes *et al.* (2009) suggest that because knowledge exists in the minds of the knower, it makes it very difficult, for small firms, in particular those whose resources are very thinly spread, to ensure that it is retained within their firms. Daud & Yusoff (2010) claim that knowledge management (KM) is a process which involves organising knowledge that has been created within the firm or acquired from strategic alliances and applying it in such a way that allows it to become formalised and accessible for future use. In international business partnerships, the management of knowledge acquired externally is a very complex process for born-global bio-tech firms and it requires diligence due to constant changes in science technology which is vital for making disruptive innovations and improvements to business processes.

Indeed, this is crucial for small born-global bio-tech firms which may require technological capabilities to leverage their rather limited resources in order to produce innovative products as well as develop their businesses. Accordingly, in connected business relationships along the value-chain business networks are conceived providing a platform for learning through social exchange overtime for born-global bio-tech firms (Anderson, *et al.,* 1994). In regional networks including: Basel area, Boston metropolitan area and Cambridge cluster, inter-organisational collaborations make it possible for all the firms involved in a network to pursue a collective regional strategy that has the potential to not only enhance regional innovations but also raise the economic prospects of the whole nation (Owen-Smith & Powell, 2004).

2.6.2 The social networks of born-global firms

In management research on social capital it is largely agreed that social capital is beneficial for the success of networks (see De Wever *et al.,* 2005; Jeffries & Reed, 2000). Accordingly, the literature on social capital is in total agreement that social capital contributes to a firm's functioning in a number of ways. In Nahapiet & Ghoshal (1998) and Tsai & Ghoshal (1998) for instance, it is argued that social capital embedded in a firm saves as a conduit facilitating and enabling the positive conditions for the exchange of knowledge and the combination of resources to occur.

De Wever *et al.* (2005) identified the conditions as follows:

- the access to partners for combining and exchanging resources;
- the anticipation of the value of interaction (will it prove worthwhile?); and,
- the motivation to combine and exchange resources

This implies that for small born-global bio-tech firms their social networks can be vital for strategic resource acquisition through inter-organisational collaborations. As a valuable resource, social capital has been the main focus of interest by researchers from a wide range of disciplines. It has been defined by many scholars from different perspectives. For example, Lin (2001) and others, Bourdieu (1986) define social capital as a resource available in one's network of relationships. Pretty & Ward (2001) detailed four core aspects of social capital: (1) relations of trust; (2) reciprocities and exchanges; (3) common rules, norms and sanctions; and (4) connectedness in networks and groups. Inkpen & Tsang (2005) argue that social capital is the aggregate of resources embedded within, and derived from the network of relationships processed by an individual or organisation.

This therefore makes the social connections of small born-global firms essential as sources for scientific knowledge and technological know-how. Bourdieu (1986); Nahapiet & Ghoshal (1998) and Wever *et al.* (2005, p.1525) broadly define "social capital as the sum of the actual and potential resources embedded within, available through and derived from the network of relationships possessed by an individual or social unit". A number of scholars view social capital as a multi-dimensional construct that can facilitate action for an organisation (see Putnam, 1993; Nahapiet & Ghoshal, 1998; Galunic & Moran, 2000; Bolino *et al.,* 2002; Batjargal, 2003; De Wever *et al.,* 2005). As a multi-dimensional construct three prominent dimensions are mainly identified in literature as follows:

(a) *Structural dimension* – it is composed of network ties and the overall configuration of those ties (Burt, 2002; Wever *et al.,* 2005)
(b) *Relational dimension* - focuses on trust, trustworthiness, norms and obligations in a network (Fukuyama, 1995; Coleman, 1990; Putnam, 1993)
(c) *Cognitive dimension* - refers to those resources providing "shared representations, interpretations, and systems of meaning among parties'' (Nahapiet & Ghoshal, 1998, p.244).

This is consistent with strategy scholars regarding social capital as both ties between cluster members and other ('remote') firms (Harrison, 1992; 1994; Saxenian, 1994) and the overall industry network structure (Storper & Harrison, 1991). As such, the central proposition of social capital within network environments is that network relationships constitute a valuable resource for the conduct of social affairs which provides the participant with a relational "credit". The wider field of network theory recently experienced an upsurge of interest in the dynamics of networks (Baum *et al.*, 2003; Snijders, 2001).

Assessing the embeddedness view of social capital from a different angle (Polanyi, 1956) defines social capital as the on-going contextualisation of economic activity in social relations. Hence, embeddedness theories focus both on social relations and individuals, as well as the outcomes of their interactions, by differentiating structural and relational embeddedness (Adler & Kwon, 2002; Gabbay & Leenders, 1999; Granovetter, 1982; Nahapiet & Ghoshal, 1998). Specifically, Baker (1990) argues that social capital derives from the social structure of the network.

Hence the form and the design of the network relations themselves are considered as resources that allow the actors to generate value. Therefore, social capital comprises both the network and the assets that may be mobilised through the network. Whether it is regarded as relational or embedded, sociology and management scholars are increasingly using social capital and network theory to examine and analyse the entrepreneurial and managerial issues of firms' internationalisation process (Burt, 1992, 2004; Han, 2006; Jones and Coviello, 2005; Tsai, 2001). This study follows the same pattern.

The direct and indirect benefits of social capital are supported by prior research (Etemad, 2004) and this brings a new perspective and contributes to the body of international entrepreneurship research. Specifically, it was proposed theoretically (Oviatt & McDougall, 2005), and found empirically (Sharma & Blomstermo, 2003) that firms' social capital can influence firms' international expansion and performance. For example, most of the studies documented a positive impact of social capital and network ties on international start-ups, new ventures and SMEs' performance (Arenius, 2005; Dana *et al.,* 1999; Johanson & Vahlne, 2003; 2006; McDougall *et al.,* 2003; McNaughton & Bell, 1999; Oviatt & McDougall, 1994; Oviatt & McDougall, 2005).

Most of these studies mainly focus on the use of social capital for international new ventures (INVs) and/or Born-global firms which make analysing social capital a vital step in the process of this research.

2.6.3 The cognitive distance of born globals

A firm's ability to generate new knowledge and ideas is directly linked to its ambition of developing strategic alliances in a given geographic area or even beyond in order to supplement its internal research and development (R&D) capacity. Su *et al.* (2009, p.312) indicate that, "A firm's R&D capability reflects its ability to generate new scientific discoveries and technological breakthroughs". Successful clusters such as the Cambridge cluster, Silicon Valley and the Boston metropolitan area are well known for their innovative capabilities and their push towards inter-organisational corporations and the sharing of ideas in those close knit communities (DTI, 2004). Powell & Grodal (2005) suggest that diversity is an essential condition which is facilitated by firms coming together and sharing capabilities, specialities, ideas and best practice.

The concept of cognitive distance emanates from a social constructivist view of knowledge, which advances the idea of perception, interpretation, understanding and value judgment. It entails mental constructions on the basis of mental categories that are developed in interacting with the physical and social world (Pittaway, 2000). At organisational level cognitive structures constitute absorptive capacity which relates to the idea of exploring knowledge (Lichtenthaler & Lichtenthaler, 2009). Accordingly, Nooteboom (2005) suggests that when absorptive capacity is aligned with organisational goals and aims not only does it enable organisational cognition, but also constrains what gives rise to organisational myopia that can only be compensated for by interacting with other firms which may have a different complementary foci at some cognitive distance.

Therefore, it is reasonable to claim that the business and social connections of born-global bio-tech firms give them a new purpose for inter-organisational collaboration and the need for them to make a trade-off between their original identity in terms of clear focus and the wide scope of their core competences (Schilling, 2008; Nooteboom, 1992, 2004, 2009; Johnson *et al.,* 2006). In the context of network dynamics the analysis of optimal cognitive distance has huge implications for small born-global bio-tech firms in terms of the period their alliances are likely to last (Wuyts *et al.,* 2005). According to Nooteboom (2005) cognitive distance between firms can be reduced in proportion to the life time of an alliance, particularly in cases where the alliance is restricted to a group of firms.

Strategic alliances are usually developed between firms that share the same values and have high levels of trust (Şengün & Önder, 2012). Under those circumstances there is the danger of dependency syndrome which leads to reduced innovation activities (Cooke, 2001). Crucially, Nooteboom (2005) identified variables that have an impact on the absorptive capacity of firms including: educational facilities, research and development (R&D) in firms, government R&D activities and the transfer of outcomes to firms. There are also other variables that include knowledge diversity and cognitive distance in the network, the life time of an alliance and external linkages such as international links that can be seen as catalysts to innovation as they supply novel information inflows. This underscores the impact of cognitive distance and knowledge diversity on the innovative capabilities of small born-global bio-tech firms.

2.6.4 Regional networks

Regional clusters consist of a number of different innovative networks and they all have varying types of relationships. The construction of social networks such as the ones mentioned above has a huge impact on the economic outcomes of a region.

This is mainly impacted upon by the flow of information in these different networks (Granovetter, 2005). It is often assumed that strong ties in social networks usually yield high flows of information and data. More importantly, to knowledge-sharing due to shared common values, aims, trust and the use of a common language for communication (Melkas & Harmaakorpi, 2008). On the other hand, weak ties have been described, by a number of authors (Granovetter, 2005; Burt 2004; Zaheer & Bell, 2005), as productive for innovation to flourish because they are credited with allowing the flow of quality information or data directly to individuals in seemingly weak ties as opposed to strong ties.

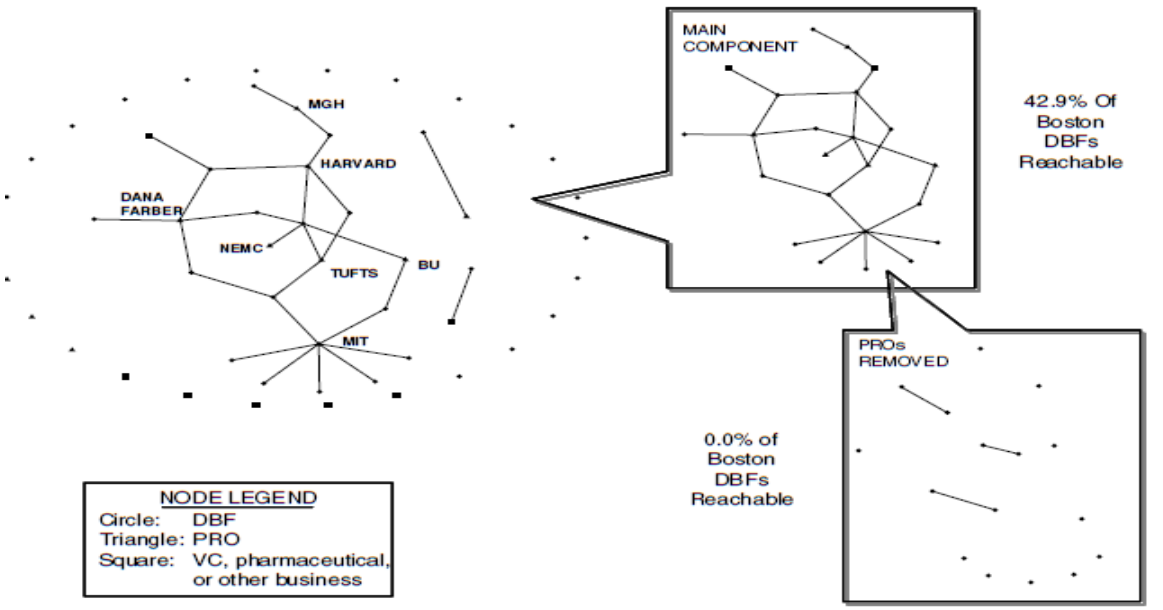
Furthermore, Burt (2004, p.349) argues that "in weak ties innovations are likely to be identified in strategic positions within the highly populated network structures". On that account, it is safe to claim that in populated regional networks where those strategic positions can be identified, small born-global bio-tech firms are presented with an opportunity to acquire essential knowledge which underpins innovation, growth and business development. It is, however, naive for the author to claim that these positions are easy to identify in these densely populated networks. This made complex by the fact that knowledge transfer has to take place between research institutions, academics and partners from different disciplines on the same level (Owen-Smith & Powell, 2004).

2.6.5 Biotechnology in Boston

Porter *et al.* (2005, p.261) in their study about "*the institutional embeddedness of high-tech regions"* use the example of the USA leading biotechnology clusters – the Boston Metropolitan area, the San Francisco Bay Area and the San Diego County which came into existence following a joint effort from both public and private institutions to scientific and technical advancement (Owen-Smith *et al.,* 2002). To examine the concept of clusters in the biotechnology sector Owen-Smith *et al.* (2002) use the Boston and Massachusetts metropolitan areas.

The Boston metropolitan area which is home to one of the largest concentrations of the dedicated bio-tech firms in the world (Porter *et al*., 2005) is of particular interest. The metropolitan area is famous for its well-known and established institutions that include public research centres and universities such as Harvard, MIT, and Tufts. In addition to that rich array of renowned institutions, the area is house to research hospitals that include Massachusetts General Brigham and Women's and medical research institutes such as Dana Farber Cancer Centre (Porter *et al.,* 2005). These institutions have over the years produced revolutionary life-saving drugs as well as innovative business processes. Figure 2 below neatly demonstrates a geographical layout of these clusters in the Boston area.

Figure 2: Boston Contractual Networks



Source: Owen-Smith & Powell, 2004, p. 1

During the 1990s, the Boston cluster embarked on a drive to promote bio-entrepreneurs, the metropolitan area developed a group of investors (venture capitalists) whose sole purpose was to provide financial support to bio-tech start-up firms (Powell *et al.,* 2002). This proved to be a key development due to the fact that funding enabled organisations to engage in R&D activities achieve their goals without the costs of the project as their least worry.

Furthermore, the institutional diversity of organisations that populate the Boston region offered organisations the possibility to closely examine the effects that node demographics have on innovation (Owen-Smith & Powell, 2004). Indeed, the Boston clusters create an environment which facilitates knowledge-sharing hence, the expectation of the firms within the cluster, to be innovative in their processes which underpin new product development (Powell *et al.,* 2002).

2.6.6 R&D and open science

Similar to Owen-Smith's *et al.* (2002) open innovation concept Porter *et al.* (2005) identified the key features of a cluster as the predominance of research institutions committed to the norms of open science. The norm being that, research is debated in seminars, published, and subsequently publications are patented. According to Porter and others the Boston metropolitan area's emphasis on open science allows ideas to be debated, honed and utilised by others. Similarly, Rafols *et al.* (2012, p.8) suggest that, "open science is based on the pursuit of priority, for example to claim credit for discovery and to hasten diffusion of knowledge, and as such encourages the rapid disclosure of research findings in scientific journals". Given the emphasis on open science in the Boston cluster it is safe to conclude that, the development of vital life-saving drugs can be enhanced. This is in line with Steffenson *et al.* (2008, p.322) who contend that the "open innovation" concept is "regarded as the hallmark of most innovative firms".

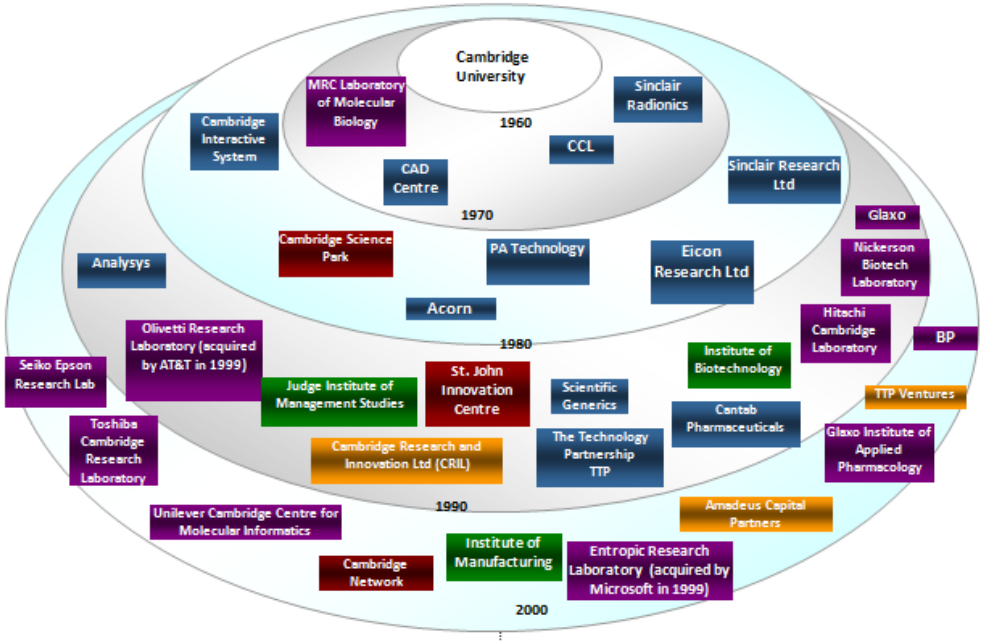
Furthermore, Porter *et al.* (2005) expressed that the commercial world of biotechnology in the Boston metropolitan area was made possible by a combination of the intellectual capital of clinical researchers and research academics. In addition to that, a number of researchers (Owen-Smith & Powell, 2006; & Porter *et al.,* 2005) attribute the growth of biotechnology in Boston to the complementary multiple knowledge networks that connect the world's best universities, hospitals and science-driven companies. Crucially, Porter *et al.* (2005) maintain that the most important lesson learnt from their study about the biotechnology community within the Boston metropolitan area is that, the community's productive capabilities deeply depend on inter-organisational collaboration and open science.

According to Khanna (2012, p.1088) 'innovation has always been the backbone and the underlying strength of the pharmaceutical industry'. Productive R&D activities, within a network provide the ideas and products for future development. In Taks *et al.* (2012) it is suggested that, for knowledge-intensive firms which have insufficient internal knowledge bases for generating innovative capabilities, collaborating with external R&D partners is the way forward. Indeed, for born-global bio-tech firms global R&D networks are vital sources of new ideas and technology. Synthesising recent literature (see Taks, *et al.,* 2012; Gassmann *et al.,* 2010; Gurau, *et al.* 2010, Hardwick, *et al.,* 2013) there is an agreement that innovation 'ecosystems' in the bio-pharmaceutical industry are continuing to expand. In that context, the R&D activities of firms involved in the sector should be viewed in an increasingly global context. Howells *et al.,* (2012, p.142) insist that, "the research and knowledge boundaries of the firm are becoming more open, porous and indistinct". Scholars Hardwick *et al.* (2013); Tolstoy & Agndal (2010) hold that, the ability to make new discoveries in the biotechnology sector is directly anchored on collective efforts through collaboration.

Innovative capabilities in the bio-pharmaceutical industry are widely dispersed in networks and new scientific knowledge is created by accessing complementary assets.

2.6.7 Cambridge clusters

Figure 3: The Cambridge Network



There are a lot of factors that contribute to the formation of successful clusters. According to the *Cambridge Cluster Report* published in 2004, the St. John's Innovation Centre has been home to a large number of innovation-based start-ups since the 1980s. The centre has also been credited with the creation of wealth for business parks and science institutions as indicated by the diversity of the business community within its cluster (see figure 3 above). One of the notable features of the Cambridge cluster is its ability to nature the entrepreneurial spirit and in particular, the belief in a shared common purpose in the entire business community. The cluster is also well known for its emphasis for promoting enterprise and entrepreneurship just like the open science concept promoted in the Boston region.

This is achieved in a number of ways that include: multiple networking communities (as illustrated in figure 3 on p.62), formal and informal mentoring programmes, inclusion of entrepreneurship teaching at the University and establishment of the Cambridge University Entrepreneurship Centre (The Cambridge Cluster Report, 2004). For a period spanning over six hundred years Cambridge has gradually transformed. In addition to St. John's Innovation Centre the city is also home to Cambridge University, Newton, Rutherford, Turing, Crick and Watson seemed destined to continue its primary existence as a seat of learning. In the last forty years, similar to the Boston metropolitan area, the Cambridge cluster has emerged as the epicentre of one of the world class renowned cluster of technology and innovation-based companies in Europe and a cluster that other regions aim to emulate.

Indeed, we have noticed the model being replicated throughout the regions in the UK, the M1 corridor which encompasses Nottingham, Sheffield and Leeds. One of the main envisaged reasons for promoting clusters and networks is to drive regional prosperity. In a similar fashion the MIT has been instrumental in designing the Route 128 Cluster and Stanford University to Silicon Valley. The Cambridge cluster has performed a significant role in transforming the city and the surrounding area from a medieval centre of learning to a great educational centre and wealth creation knowledge-based business nexus (The Cambridge Cluster Report, 2004). Increasingly, there is a common purpose within the business community and commitment to innovation and entrepreneurship at the University – all which are complementary to its world class science base (The Cambridge Cluster Report, 2004). Over the last decade the cluster has acted as a magnet attracting supportive infrastructure comprising of a number of key players such as venture capitalist firms (VCs), banks and patent agents among other stakeholders. Such a development has been crucial in fostering an open culture in which innovation strives.

Like in any other clusters or networks, collaborations are fundamental steps that a firm needs to take in order to access novel information inflows.

2.7 Born-globals' business models

According to Chesbrough (2008) a business model is a useful framework to link technical decisions to economic outcomes and the term is usually applied in the context of entrepreneurial firms. In the biotechnology sector bio-entrepreneurs need a framework that can help them to have a good understanding of what their firms are capable of achieving (Christensen & Overdorf, 2000).

If small born-global bio-tech firms apply the open business model effectively it forces them to consider the integrative nature of their business activities in an open innovation perspective. As this study has already demonstrated, networks are critical steps for small born-global bio-tech firms to access knowledge. Davey *et al*. (2010) suggest that an open business model's great strength, as a planning tool, is that it focuses attention on how the elements of the system fit into a working practice as a whole. Admittedly, the way in which most small born-global bio-tech firms conduct their businesses can sometimes act as a barrier preventing them from engaging with other firms or knowledge centres thereby restricting access to knowledge.

Accordingly, Leydesdorff & Meyer (2003) suggests that "economic exchange intellectual organisation and geographical constraints can all be considered as different dynamics that interact in the complex system that constitutes a knowledge-based economy". Chesbrough (2008 p.64) claims that in such situations "technological managers must expand their perspectives to find an appropriate business model to capture value from that technology". A business model according to Davey *et al*. (2010) has two key functions: it creates and it captures a portion of that value.

Davey and others argue that a business model captures value by establishing a unique resource, asset or proposition within a series of activities which may involve networking. Aligning that to small born-global bio-tech firms it is reasonable to claim that open models make it possible for bio-entrepreneurs to acquire many more ideas given their links with a variety of external concepts. To this end, Chesbrough (2006) suggests that open business models that are successful create heuristic logic connecting technical potential to economic value.

2.7.1 Dynamic capabilities

The dynamic capabilities view builds on the resource-based view, which sees a firm as a bundle of static resources (McKelvie & Davidsson, 2009). According to Grant (1991), the resource-based view is based on the idea that rival firms possess varied resource repositories. Following the realisation of the static nature of the resource based view, scholars have emphasised the dynamic capabilities view since the late 1990s (Teece *et al.*, 1997; Narayanan *et al.*, 2009; and Dixon *et al.*, 2010). The dynamic capabilities based view sees a firm as a constant belt of novel information inflows. It highlights a firm's ability to adopt a flexible business model, which allows it to react to uncertainty and disruptive technology. McKelvie & Davidsson (2009, p.36) argue that, "dynamic capabilities can be seen as those processes where resources are acquired, integrated, transformed or reconfigured to generate new value-creating firm-based activities".

Autio *et al.* (2010) interpret dynamic capabilities as a firm's capacity to deploy strategic resources and improve business processes with purpose in order to achieve its goals. Accordingly, Nelson & Winter (1982) and Winter (2003) collectively agree that dynamic capabilities are routines or repetitive patterns that are project based involving multiple firms.

From these analyses, there is evidence of a growing body of researchers who agree that dynamic capabilities have an impact on a firm's capacity to innovate (Wheeler, 2002; Teece, 2007; Narayanan *et al.*, 2009; and George *et al*, 2009). Visser (2009) highlights a strong relationship between diverse knowledge networks and innovative capabilities. Easterby-Smith *et al.* (2009) insists that dynamic capabilities are a response to the need for change or new opportunities. Their observation is very useful for small born-global bio-tech firms which are faced with changing market conditions which require constant knowledge generation and business re-engineering.

Dixon *et al.* (2010) argue that for a firm to be able to respond to changing market conditions; there is need to make fundamental transformations in its organisational processes, the allocation of resources and operations. The crucial part of dynamic capabilities for small born-global bio-tech firms is their ability to strategically facilitate the allocation and utilisation of their resources with a view to make crucial innovations (Teece *et al.*, 1997; Nooteboom, 2009). These resources can take various forms of economic effects including human capital, technological capital, knowledge-based capital, and tangible-asset-based capital (Easterby-Smith *et al.*, 2009). Since the introduction of the dynamic capabilities theory by Teece, Pisano and Shuen in 1997, many scholars have emphasised the operational (zero level) and the dynamic nature of capabilities (Eisenhardt & Martin, 2000 and Winter, 2002/05) and heterogeneous learning of firms (Cobbett, 2007). Building on these typologies, Ambrosini *et al.* (2009) proposes three levels of capability development including: incremental, renewal, and regenerative capabilities. Notably, the strategy of regenerative dynamic capabilities (Easterby-Smith *et al.*, 2009) is important because of its ability to completely overhaul existing business processes and adapt to new business processes that open new channels for novel information inflows.

It is assumed that “organisations can have several different kinds of dynamic capabilities such as idea generation capabilities, market disruptiveness capabilities, new product development capabilities, marketing capabilities or new process development capabilities” (Easterby-Smith *et al.,* 2009, p.4). Furthermore Teece (2007, p.1319) suggests that “the capacity to sense and shape opportunities and threats, to seize opportunities, and to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise’s intangible and tangible assets”. In the context of the biotechnology sector in which constant novel information inflows are crucial towards drug discovery and the development of new clinical products, it is important to reconstruct existing business processes in order to strategically position the firm on course to achieve its corporate objectives. The literature on organisational management (Mullins, 2006 and Torrington *et al.,* 2005) emphasises the need for top management to take a lead in shaping business processes and gearing the business towards achieving its strategic goals. Developing innovative capabilities requires a lot of input from bio-entrepreneurs in providing vision and purpose and for identifying the types of capabilities to be sought after.

Martin *et al.* (2011) examine the process of dynamic capability development in large pharmaceutical firms and makes similar conclusions that top managers are the key drivers in terms of strategic intent. Narayanan *et al.* (2009) found that senior managers play a major role in the development of capabilities by imprinting an organisation with their specific cognitive orientation and then orchestrating the multi-level organisational routines necessary for actualisation of a capability. More importantly, their inspirational study identified key underlying processes and mechanisms that are pertinent to small born-global bio-tech firms in terms of capability development and these processes were identified as: research and development (R&D) strategies, knowledge transfer processes, and knowledge exploring mechanisms.

This highlights the impact of dynamic capabilities on the innovative capabilities of born-globals, bio-entrepreneurs or bio-tech firms and the capacity to make innovations.

2.7.2 The global R&D networks of born-global bio-tech firms

Networks consist of a number of positions or nodes occupied by individuals, firms, academic institutions, the central and local authorities (Bessant & Tidd, 2011). They are distinct from hierarchical or market relationships in their reliance on reciprocity, collaboration, complementary independence and orientation towards mutual gain. Thus, the global R&D networks of born-global firms provide them with four key benefits that include: proximity to markets, access to geographical clusters of knowledge creation and development, learning and access to low cost and good quality scientists and engineers (Taks, *et al.* 2011; Lasserre, 2012). It is increasingly becoming clear, in the life science sector, that companies cannot do everything from R&D to product commercialisation and this condition has considerably contributed to the establishment of innovation 'ecosystems' (Ernst & Young, 2012).

In the literature the concepts underpinning the chain and the network are well-represented and they have, for a long-time, occupied a central position in the field of business management studies however, in the recent past innovation 'ecosystems' as a new concept appear to be gaining momentum. In their working paper about how global technology start-ups access modern business ecosystems Tahvanainen & Steinert (2013) suggest that an ecosystem is 'a network of networks, converging entire industries and technologies into complex, interwoven and global economic structures'. Innovation 'ecosystems' or networks are designed to facilitate inter-dependence and close co-operation amongst individuals, investors, research institutions and labs (Bramwell, 2012). In actual fact, they increase productivity and innovation.

Jackson (2011) maintains that innovation 'ecosystems' are sustainable when they provide the assets and resources essential for building relationships between partners. Johnson's & Vahlne's (2009) study concerning business relationships provides two core arguments. Firstly, the study suggests that markets are networks of relationships where firms are connected to each other in different formats including complex and visible patterns. Secondly, the study draws attention to the fact that relationships developed at an organisational level facilitate learning and the potential to develop trust. This is crucial for the resource-impecunious born-global bio-tech firms which rely, to a greater extent, on innovation 'ecosystems' to jointly develop new science technology and life-saving drugs for economic development. Gurau *et al.* (2010, p.348) contend that, 'biopharmaceutical firms require a large amount of resources for survival and development'.

2.7.3 Bio-entrepreneurial Learning & Experience

Effective entrepreneurs are exceptional learners (Smilor, 1997). Learning as concept is a very broad topic and it is by no means fully explored in this study. It is partially covered in this thesis to inform the debate on entrepreneurial learning and absorptive capacity (AC). In Huczynski & Buchanan (2007, p.107) learning is described as the "process of acquiring knowledge through experience which leads to an enduring change in behaviour". From that perspective, the most effective strategies for recognising new scientific knowledge for bio-entrepreneurs are informed, to a large extent, by their prior-learning and experience in life science (Simba, 2013). Similarly, King & Lakhani (2011) agree that there is an association between individual learning and the stock of prior-related knowledge one holds. Continuing in the same vein, Huczynski & Buchanan (2007) discuss procedural and declarative learning. The scholars express that procedural learning or 'know how' is concerned with one's ability to carry out skilled actions. They also insist that declarative learning or 'know that' is one's ability to store factual knowledge.

Furthermore, Kolb (1984, p.26) expounds the underlying principles of experimental learning stating that, “ideas are not fixed and immutable elements of thoughts but, are formed and re-formed through experience”. Scholarship on entrepreneurial learning collectively acknowledge that experimental learning is a process which attempts to explain how entrepreneurs acquire knowledge and enact new behaviours in recognising and acting on opportunities as well as organising and managing their born-global bio-tech firms (see Petkova, 2008; Cobbett, 2007; Toiviainen, 2003; Cope, 2005). Deakins & Freel (1998) and Sarasvathy (2001) collectively claim that the majority of learning that occurs within an entrepreneurial context takes the form of an experiment. Schilling (2010) discusses experimentation that takes place in innovation ‘ecosystems’. She maintains that the process of experimenting is an important step in the development process of science-based firms as it enables them to test what works and what doesn’t. Similarly, Petkova (2008) presents a model of *entrepreneurial learning from performance errors* with a view to extend the psychology models of error-based learning. Petkova’s (2008, p.4) model proposes that entrepreneurs,’ “prior knowledge and cognitive biases can perform a significant role at each stage of the learning process and may determine whether the processes of error-detection and error-correction that leads to learning will actually occur”.

Schilling’s and Petkova’s propositions have huge implications for born-global bio-tech firms as they are directly intertwined in their mental modes of learning particularly, their bio-entrepreneurs. Using Kolb’s (1984) view of learning by trying different configurations until one finds a combination that works, Cobbett (2005) makes a convincing argument. He argues that ‘cognitive mechanisms’ or the mental processes through which entrepreneurs acquire, store, transform, and use information are the output of individual learning.

2.7.4 Absorptive Capacity (AC)

An understanding of the concept of AC at a firm level is essential to how this study explains the significance of learning by individual entrepreneurs to how born-global bio-tech firms develop their innovative capabilities. According to Cohen & Levinthal (1990) AC is the ability of a firm to recognise, assimilate and apply external knowledge. In Zahra & George (2002) a clear distinction between potential and realised AC was made. Potential AC was related to knowledge acquisition and assimilation capabilities and realised AC was associated with knowledge transformation and exploitation. Lichtenthaler & Lichtenthaler (2009) conceptualises AC as the ability to explore external knowledge. King & Lakhani (2011, p.2) introduce the notion of 'adoption capacity' which means the ability of a firm to adopt ideas from external connections. This is consistent with Cope (2005, p.481) who maintains that individuals transform (using cognitive properties) their experiences (situative) into new knowledge.

Furthermore, Lichtenthaler & Lichtenthaler (2009) claim that new knowledge acquired from outside the firm (in innovation 'ecosystems') becomes useful when it is integrated with internal knowledge bases. A recent study by Jones *et al.* (2010) presents the idea of generative learning in global networks stressing that it is a critical step that informs the accumulation of specific and useful knowledge. Tidd & Bessant (2011) contend that AC is about accumulated learning and the embedding of capabilities. Crucially, in Cope *&* Down (2010, p.4) a strong link is constructed 'between the outcomes of learning (information, knowledge, expertise) that impact on the entrepreneur's cognitive frameworks and the participative process by which these socio-cognitive resources are acquired'.

The dated but inspirational works by a number of scholars (see Estes, 1970; Ellis, 1965; Bower & Hilgard, 1981) highlight that an individual's learning is cumulative and that learning performance is enhanced when the primary goal of learning (to understand the new knowledge to be acquired) is related to what the individual already know. Cohen & Levinthal (1990) also make a crucial point suggesting that AC is a by-product of prior-innovation and problem solving which is dependent on individual ACs of members of an organisation.

When individual ACs of members in a firm and the firm's ability to value, assimilate and commercially utilise new external knowledge are combined Lane *et al.* (2006) and Kim (1993) collectively agree that the duality modifies mental modes. In other words, the dualism modifies assumptions about the lived world. This is a fundamental point to make in the sense that, for global-oriented born-globals their bio-entrepreneur's/owner-manager's prior-learning and science-related experience can modify their cognitive biases which plays a decisive role in their economic development given that they source scientific knowledge in multiple countries. Indeed, sourcing knowledge from established or newly developed business or social networks (innovation 'ecosystems') domestically and in other countries consequently lead to a point of 'knowledge saturation' hence sifting, sorting and decoding useful information requires prior-learning and industry-specific experience.

2.7.5 The innovation 'ecosystems' of bio-tech firms

The process of developing innovative capabilities is directly anchored on the greater connectivity and enhanced collaborations in the life science's innovation 'ecosystems' described by Booth (2009, p.705) as a 'brave new world'. The connectivity and collaboration between various actors within the East Midlands network can be seen as performing a key part in the process of ensuring continued development of scientific knowledge and technical know-how by providing financial support and infrastructure.

BCN provides firms with specialised premises which have state of the art lab equipment while Nottingham City Council (NCC) and Mobius provide seed funding to promising ventures. A similar observation was made by Laine *et al.* (2008), the scholars maintain that, at the core of innovation 'ecosystems' are firms and enterprises which are involved in innovative collaborations with academic institutions and investors. A convincing argument concerning the logic behind facilitating the development of innovation 'ecosystems' was made by Hautamäki (2007) arguing that the 'ecosystems' approach places great emphasis on close co-operation and a culture of creativity which refers to adventurism, entrepreneurship and innovativeness.

Adner (2006) insists that an innovation 'ecosystem' facilitates integration risks of having the solution adopted across the value-chain. This is consistent with Bramwell *et al.* (2012) conceptualisation of an innovation 'ecosystem' approach. The scholars see it as a sophisticated way of holistically looking at mechanisms that interact within an economic system. Crucially, for policy makers such innovation systems will enable them to pay close attention to the collaborative, the inter-dependent nature of the innovation processes and to identify the best means of stimulating productive networks and relationships within and across disciplines and sectors of comparative advantage' (Bramwell *et al.,* 2012, p.49). Additionally, Wolfe *et al.* (2011a) describes the regional knowledge 'ecosystem' approach insisting that it leverages regional infrastructures with a view to stimulate/support regional innovation processes through the collaborations of multiple partners that include: research and academic institutions, investors, other firms and investors.

2.7.6 Government R&D support

Government support to promote innovations in the biotechnology sector can be justified by a clear theoretical economic rationale (Kang & Park, 2012). Scientists have argued for government intervention to cushion R&D costs as the financial crisis has made it difficult to maintain the "big Pharma" model (Rafols *et al.,* 2012). The state support in the form of funded research can be vital in increasing innovation and innovation-related activities (Schilling, 2008; Romijn & Albaladejo, 2002). According to Kang & Park (2012) governments can encourage innovation and economic prosperity by supporting R&D projects that have the potential to generate social capital. A study in the US by Block & Keller (2008) which was based on the top 100 innovations recognised in the *R&D Magazine* covering the period from the 1970s to 2006 showed that about 90% of American firms that produced award winning innovations were supported by the American government through its funding pot.

A number of scholars investigated the relationship between government funding and innovation. Using small Israel firms Lach (2002) found a strong link between government related spending on R&D and innovation. Hall & Bagchi-Sen (2007) focussed their study on US biotechnology companies and they found a strong association between government funding for research and technical know-how with the intensity of R&D activities. Even studies that have been undertaken across diverse manufacturing sectors show a positive correlation between R&D resources and firms' innovation performances (see Belussi *et al.,* 2010; Hall & Bagchi-Sen 2002, 2007; Hitt & Tyler, 1991; Parthasarthy & Hammond, 2002). Cohen & Levinthal (1990) and Visser (2009) highlight that firm-level R&D resources significantly boost a firm's capacity to recognise, assimilate and apply new knowledge which underpins innovations. Kang & Lee (2008) pointed out that a lack of experienced and qualified technical personnel may severely impact on firm innovation.

Other studies also show that government-engineered networks have stimulated inter-organisational collaborations which are used by the parties involved to promote innovations (Kang & Park, 2012). As has already been mentioned in this study the Golden triangle of Cambridge, London and Oxford was designed to promote innovation and economic prosperity. In the USA the Boston Metropolitan area is another example of the federal efforts to promote innovation. In sum, it can be argued that funding plays an important role in research-based science firms and government institutions are a key part in that process. Their support strategies such as the introduction of science parks and incubators can be a catalyst to the development of innovative products and services.

2.8 Conceptual framework

In Santori (1970) a concept is described as a word or phrase which captures the common features of a particular class of empirical phenomenon. From that perspective, revising Freeman's *et al.* (2010) rapid knowledge development concept will ensure the precision of the findings of this study. A theory is a "way of seeing and thinking about the world rather than an abstract representation of it. As such, it is seen as the "lens" one uses in observation than a mirror of nature" (Alvesson & Deetz, 2000, p.37). The role of theory in this research study is to direct attention, organise experience and enable useful responses (Alvesson & Deetz, 2000). Theory also plays a crucial part in social science by analysing and exposing the hiatus between the actual and the possible, between the existing order of contradictions and a potential future state (Held, 1980). In Bellamy & Perri (2009) framing concepts in case-oriented research (COR) is seriously considered to vital. Bellamy & Perri argue that the research procedure enable researchers to draw warranted inferences from their data.

In that sense, the modification of Freeman's *et al.* (2010) model of rapid knowledge development for born-global firms enabled the author to make stronger inferences with the data emanating from small born-global bio-tech firms in the East Midlands in England and come to a set of conclusions that can be trusted.

2.8.1 Internationalisation theories

Scholarship on the internationalisation of small firms is littered with various models aimed at explaining their internationalisation processes. From early on Johnson & Vahlne (1977) developed the inspirational Uppsala internationalisation model (U-model) and it became a widely used model in business management. The model was based on the assumption that an enterprise develops in foreign markets by adopting a process which evolves incrementally in stages "progressing like rings in the water" to use Bhowmick's (2004, p.760) felicitous description. Put in a different way, the enterprise passes from one stage to another as it acquires more and more international experience as well as deepening its resource commitments. In the late 1970s and the beginning of the 80s there was a surge of behavioural and process-oriented internationalisation theories that were developed around the same time as the Uppsala theory (e.g. Bilkey & Tesar, 1977; Reid, 1981). According to Nordman (2009) the innovation-related internationalisation theories and models regarded the development of export activities as either innovation-adoption cycles or export development learning curves. A close examination of the Uppsala theory and the innovation theories depicts that the theories adopt an incremental stages approach to export development and generally support the notion of psychic distance. Arguably, both schools attribute the gradual pattern of export development to two things: firm's knowledge deficiency and the uncertainty associated with the decision to acquire resources from multiples countries (Ghanatabadi, 2005).

The main difference between behavioural internationalisation process theories described by the two schools of research is that: the Uppsala theory is less bound to time and space concerns and, therefore, can be said to be more general. More so, the theory offers a more in-depth discussion about the dynamics of knowledge and learning than the other theories (Andersen, 1993). Perhaps as a consequence of these differences, the innovation theories have not been as commonly used in research on international business and international marketing.

Expeditiously moving forward, in 1997 Teece, Pisano, and Shuen proposed the dynamic capabilities theory, they defined the theory as “the ability to integrate, build, and reconfigure internal and external competences to address rapidly-changing environments”. The dynamic capabilities view is based on the notion that externally acquired capabilities are an attempt to bridge a firm’s capability gaps by adopting a process approach: and by acting as a buffer between firm resources and the changing business environment (Teece *et al.,* 1997). According to Helfat & Peteraf (2003) dynamic resources help a firm to adjust its resource mix thereby enhancing its innovative capabilities which underpins its ability to make new innovations. In that sense, the dynamic capabilities model enriched the authors understanding of the process of developing innovative capabilities.

A further contribution in this regard was made by Karlsen (2007). The scholar proposed a conceptual framework that explains the pace at which born-global firms internationalise. Karlsen’s model proposes that personal experience, personal networks, industry globality and product characteristics influence a firm’s knowledge development and the pace of its internationalisation. More recently, Freeman *et al.* (2010) proposed an inspirational model for rapid knowledge development for smaller born-global firms.

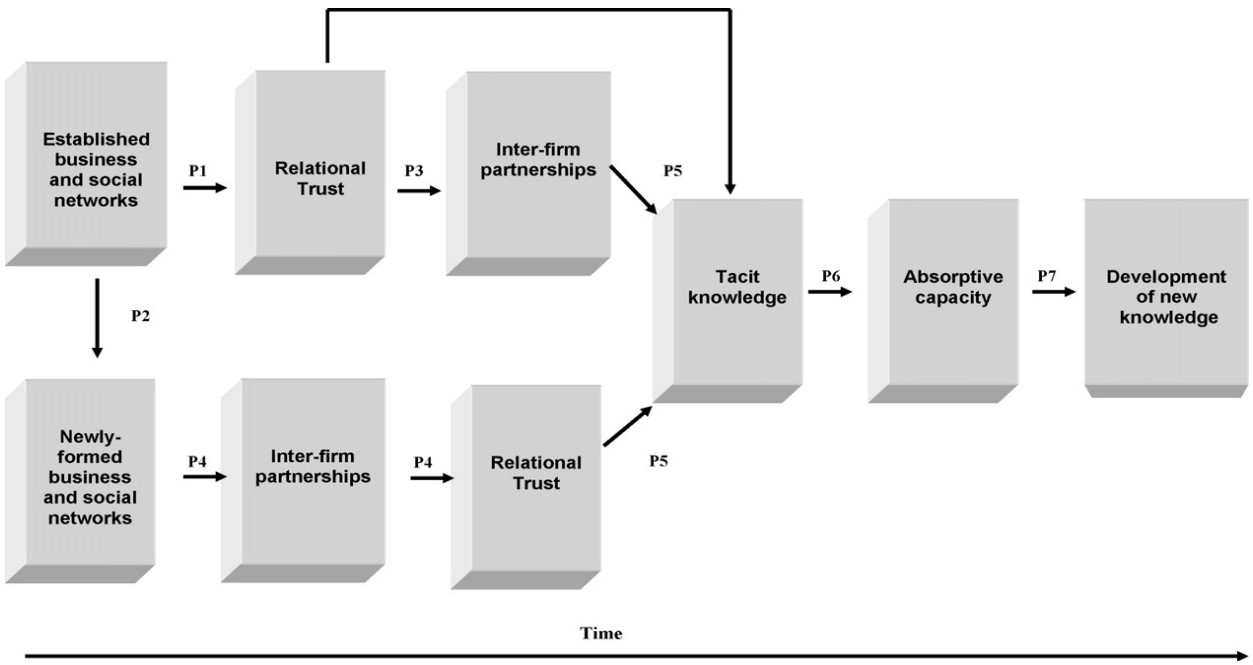
Freeman's and others model which has some similarities with the dynamic capabilities concept extends the resource-based view (RBV) and network theory. Their theory specified the level of interaction required for the development of the new knowledge process to occur in rapidly internationalising smaller born-global firms. The author was attracted to adopt their inspirational model for the purpose of this study. The move was based on the fact that Freeman's and others model contained appropriate variables within the knowledge supply-chain of smaller born-global firms that could be easily applied to small born global bio-tech firms. On that account, the theorisation of the key concepts for this study is fundamental in terms of structuring and shaping it. Perhaps the last word on this can be left to Gerring (2005) who insists that the process of concept formation is a fraught exercise which includes a set of choices that may have no best solution but rather a range of more or less acceptable alternatives.

2.8.2 The rapid knowledge development model

In the following section the author outlines Freeman *et al.* (2010) proposed model of rapid knowledge development as well as presents the rationale for modifying the their framework so that it suits the needs of this particular study. Freeman's, *et al.* (2010) model addresses how tacit knowledge is integrated and transferred quickly through the international supply chains of smaller born-global firms. Their model is influential in the study of new emerging small firms that appear to be internationally-oriented with a view to take advantage of the capability development opportunities offered by global markets. Figure 4 at the bottom of p.79 neatly illustrates the main variables contained in Freeman's and others conceptual framework. Their model illustrates the rapid internationalisation of smaller firms. The scholars suggest that managers can use both pre-existing and newly formed relationships, to quickly and proactively develop new knowledge for rapid commercialisation of their products.

Freeman *et al.* (2010) maintain that, proactive, advanced relationship-building capability is based around locating partners with technological knowledge with a view to ensuring ease of sharing knowledge. Their study explores the development of trust and inter-firm partnerships in established and newly formed networks and how these lead to tacit knowledge, absorptive capacity and new knowledge generation. The scholars explain why knowledge-sharing is able to proceed quickly. They acknowledge that shared ‘‘technological knowledge’’ allows rapid transfer and development of new knowledge and the drive to commercialise a product before a competitor. The scholars also agree that technological knowledge promotes the ‘‘mutual need’’ (co-dependency) to act quickly. They claim that, as an outcome of the born-global manager’s ability to locate new partners through existing networks, new international links may be quickly developed, with internationalisation being an outcome.

Figure 4: *A Model of Rapid Knowledge Development: The Smaller Born-global Firm*



Sources: Freeman, Hutching and Lazaris, 2010, p.76

The model makes the following seven propositions for the rapid internationalising born-global firm:

Proposition 1: The early internationalising smaller born-global firms build relational trust through long standing, pre-existing connections accessed through established network partners.

Proposition 2: Newly-formed networks in early internationalising smaller born-global firms are based on long standing, pre-existing connections accessed through established network partners

Proposition 3: Strong inter-firm partnerships in early internationalising smaller born-global firms are based on relational trust developed through established network partners.

Proposition 4: Relational trust-like outcomes in early internationalising smaller born-global firms is based on inter-firm partnerships built through newly-formed networks developed through established network partners.

Proposition 5: Relational trust and relational trust-like outcomes in early internationalising smaller born-global suppliers develops tacit knowledge between customers and their firms.

Proposition 6: Tacit knowledge amongst early internalising smaller born-global firms increases absorptive capacity.

Proposition 7: Absorptive capacity generates new knowledge in the international supply-chain for early internationalising smaller born-global firms.

Based on Freeman's and others' central argument it is clear to see that in general their model is a very powerful tool for analysing smaller born-global firms and it significantly adds to earlier international business theories such as KBV and network theory. Interestingly, it explains the building blocks of networks, inter-firm partnerships, trust, tacit knowledge, and absorptive capacity of developing new knowledge in the international supply-chain of early internationalising smaller born-global firms.

In that sense, the model illustrates some key variables that are useful for this study hence the need to modify it so that it is used to explain the knowledge and the capacity of small born-global bio-tech firms to make crucial innovations. The main idea is not to undermine the categorisation of the concepts contained in Freeman's and others' model of rapid knowledge development but rather, to adapt the model with a view to maximise its applicability. Learning from Gerring's 2001; Turnbull's (1987); Anderson's (1983) and Bhowmick's (2004) critical analyses of the stages models it is sensible to adjust a theory so that it reflects the specific circumstances surrounding the research phenomenon. Collectively, the scholars acknowledge that *contextual range* i.e. the scope, reach and stretch of a concept determines whether it needs to be adjusted to accommodate or to maximise its performance. Indeed, when examining specific units of a phenomenon e.g. born-global bio-tech firms being examined for this study, their *contextual range* can be a decisive factor in terms of the extent to which the new conceptual framework can be generalised (Gerring, 2001; Santori, 1970).

2.8.3 Justification for selecting conceptual framework

The process of developing innovative capabilities for born-global bio-tech firms is so complex. The firms are involved in sophisticated relationships with other firms, science and academic institutions. In order to investigate their complicated situation Freeman's *et al.* (2010) model of rapid knowledge development for smaller firms was selected because it explains how international ventures rapidly develop knowledge. Its emphasis on the mechanisms involved in generating knowledge for smaller born-global firms made it attractive to the researcher. Specifically, the variables contained in the framework were adaptable to fit the specific circumstances of the research phenomenon.

This is consistent with Santori (1970) who insist that concepts are most useful when they have large powers of discrimination; that is when they allow us to determine clearly for their purposes for a specific research project. Gerring (1999) share the same views and he argues that the "field utility" of a concept may be more important than its theoretical utility.

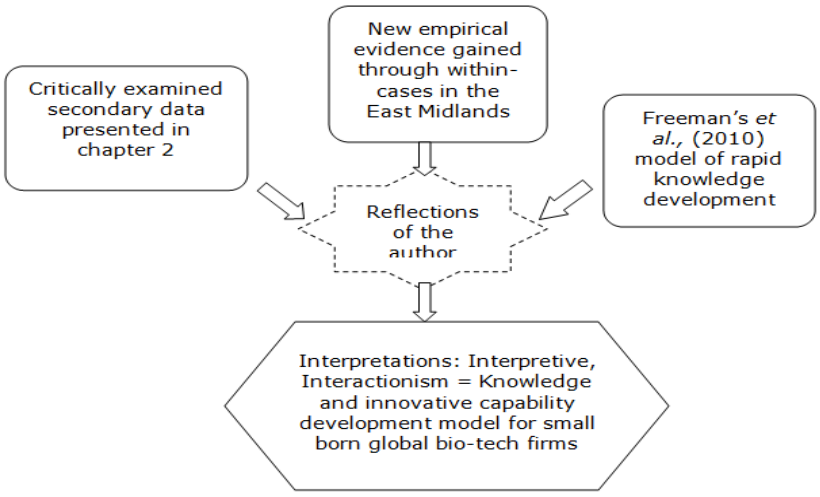
2.8.4 Rationale for adjusting conceptual framework

By the time the researcher became aware that Freeman's, Hutching's & Lazaris's model of rapid knowledge development for smaller born-global firms could be relevant for explaining the knowledge supply-chain of small born-global bio-tech firms, a sizeable store of data had been absorbed making it relatively easy to assess the applicability of the model. The researcher's awareness that Freeman's, Hutching's and Lazaris's model contained some of the key concepts was significantly enhanced when he was collecting, sifting, sorting and analysing data related to born globals (Irvine & Gaffikin, 2006). The results of the preliminary study influenced the theory construction process of the final study. Following this thorough "soul searching" phase the researcher was convinced that some of Freeman's *et al.* (2010) variables on their *Rapid Knowledge Development Model for Smaller Born-global Firms* were very useful for this study. The model was subsequently modified with a view to improve its applicability. In doing so the author utilised emerging theories from the literature, results from a "pilot" study and empirical evidence emanating from a detailed analysis of five small born-global bio-tech firms sampled from the East Midlands region which is part of the growing M1 Corridor in the UK. In light of the new empirical evidence the model is then adjusted so that it becomes a more suitable description of the actions (behaviours) of the small born-global biotech firms whose actions are greatly influenced by world activities. Gerring (2001) supports theory adjustment suggesting that changes in the social world imply the dynamic nature of concepts.

Collier & Mahoney (1993, p.845) express similar views and they insist that "as scholars seek to apply their models and hypotheses to more cases in the effort to achieve broader knowledge, they must often adapt their categories to fit new context". In other words, concepts are not static. They have to be manipulated to take into account the world's changing terrain and how people make sense of things happening around them (Weber, 1905/1949). Andersen (1993, p.214) makes more sense of all of this and he argues that, "it is hard to imagine that a theory could be evaluated to be entirely satisfactory by all criteria".

The theory development process diagram represented in figure 5 below neatly illustrates how new empirical evidence, secondary data and the researcher's understanding of Freeman's, Hutching's and Lazaris's model informed his perceptions and comprehension of the impact of business and social networks on the innovative capabilities of small born-global bio-tech firms. This led to the development of a robust "*Knowledge and Innovative Capability Development Model"* that captures the key themes offered by new evidence emerging from a close examination of multiple cases of small born-global biotech firms, "pilot" study results and from the secondary data presented in this chapter.

Figure 5: The theory developing process



Source: Irvine and Gaffikin, 2006, p.134, including author's ideas

Following an in-depth and rigorous process for developing a frame of reference for this study outlined above the author contributes to the development of new theory by proposing a comprehensive and improved conceptual framework for this study located in section 5.5 under research findings in chapter 4 on p.206 of this thesis.

Chapter 3

3. Methodology

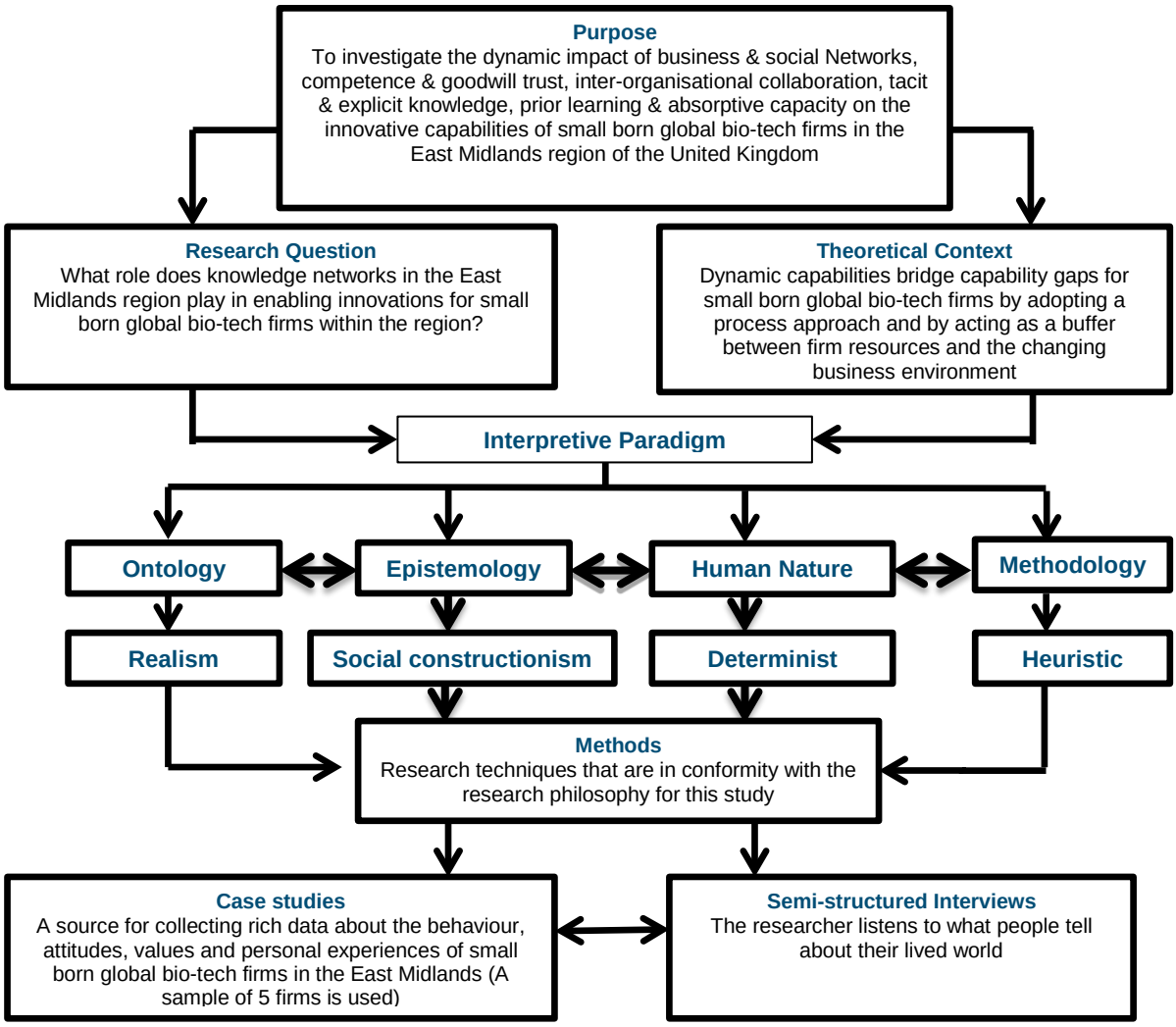
Methodology refers to the theory of how research should be undertaken, including the theoretical and philosophical assumptions upon which research is based and the implications for the methods adopted (Saunders *et al.,* 2012). On that account, this chapter provides a detailed discussion of the research philosophy, research approach, research design, and research ethics.

3.1 Research philosophy

Philosophy of science deals with "the nature of the phenomenon examined (ontology) and methods for understanding it (epistemology)" (Bechara & Van de Ven, 2007, p.36). Variations in ontology, epistemology are defined by different paradigms. Easterby-Smith *et al.* (2012) claim that, most of the debates among philosophers' concern matters of ontology and epistemology. Conducting research is understood to be an original investigation of a phenomenon which is undertaken to gain knowledge and understanding (Mahmoud, 2009). As such, this study aims to gain an understanding of the collaborative actions of small born-global bio-tech firms and the connectivity of various elements contained in their knowledge supply-chain. In Burns (2002, p.47) research is defined as a "systematic investigation to find answers to a problem".

In the same vein, Eldabi *et al.* (2002) agree that when undertaking any type of a research, it is important that a study follows a methodology which is well-defined. This is consistent with Hussey & Hussey (1997) who maintains that there are several ways in which research can be classified. Figure 6 p.86 provides a research map outlining the methodological paradigm for this study.

Figure 6: Research Paradigm



Source: Author's view & ideas

Hussey & Hussey (1997) suggest that research can be classified according to the reasons for conducting the study i.e. the purpose of the study – given on figure 6. Secondly, they claim that research can be classified according to the research methods used by the researcher to collect and analyse data i.e. the process of the research. Thirdly, the scholars maintain that research can be classified from the perspective of the direction which it has followed. In other words, is the study moving from the general to the specific or vice-versa, i.e. what is the logic of the research? Lastly, they argue that research can be classified according to whether there is a particular issue/problem to be investigated or to fill a knowledge gap by contributing to a body of knowledge.

The last classification neatly summarises how this thesis is organised. Creswell (2014) makes an important contribution to the debate regarding choosing an appropriate research method by suggesting that the choice of a particular research method is mainly depended on the research philosophy or research paradigm (presented on p.86) that a researcher follows in order to conduct research. In that sense, it therefore makes it essential to have an understanding of the philosophical issues of research including: understanding various statements that deal with; (1) the search for truth and (2) how the issues are reflected in the accomplishment of the aims of the research being undertaken. Easterby-Smith *et al.* (2002, p.87) proposes three convincing reasons why it is essential to understand philosophical issues by insisting that:

> *There are at least three reasons why an understanding of philosophical issues is very useful. First, since it can help to clarify research designs. Second, knowledge of philosophy can help the researcher to recognise which designs will work and which will not. It should enable a researcher to avoid going up too many blind alleys and should indicate the limitations of particular approaches. Third, knowledge of philosophy can help the researcher identify, and even create, designs that may be outside his or her past experience. And it may also suggest how to adapt research designs according to the constraints of different subject of knowledge structures.*

Other scholars (Burrell & Morgan, 1979; Chua, 1986; Laughlin, 1995) agree that given the nature of the world in most studies the process of research makes two assumptions namely, explicit and implicit. Mahmoud (2009) and Easterby-Smith *et al.* (2012) acknowledge that assumptions can be made based on the nature of social science and the nature of society. Burrell & Morgan (1979) suggest that assumptions are related to ontology, epistemology, human nature and methodology. Epistemology and ontology assumptions have direct implications for the research methods chosen for this study. Particularly, for the methods that underpin how the collaborative activities of small born-global bio-tech firms are investigated including: an examination of how the knowledge pertaining to the business and social world of small born-global firm is created, acquired, and used in the firm.

3.1.1 Subjective and objective dimensions

The subjective view follows that social phenomena are created from the perceptions and consequent actions of the social actors while the objective view takes the position that social entities exist eternally to social actors (Saunders *et al.,* 2007). This study uses the lens of a subjective view because the goal is to understand how social actors (e.g. small born-global bio-tech firms) engage with the social world (e.g. their social and business connections). This is consistent with Remenyi *et al.* (1998, p.35) who emphasises the necessity to study "the details of the situation in order to understand the reality or perhaps a reality working against them".

Saunders *et al.* (2012) maintains that social phenomena are created from the perception and consequent actions of social actors. As social interactions between actors are continual social phenomena are in a constant state of revision. In that sense, this research studies the details of the knowledge supply-chain of born-global bio-tech firms with a view to understand the connectivity of various elements within the knowledge supply-chain. Crucially, how they influence the development of innovative capabilities. Burrell & Morgan (1979) proposes a model of organisational analysis which classifies sociological theories along two orthogonal dimensions. The scholars classified the two theories as regulation vs. change and subjectivity vs. objectivity. Their classification distinctively divides sociology into four paradigm clusters. Noticeably, their classifications highlight internal consistency under each paradigm, in terms of assumptions about individuals, groups, societies, goals of study and accepted forms of evidence. As such, the following section of the study discusses the research philosophy (assumptions about human beings), approach and design (case study strategy) explaining different forms of reasoning that can be deployed to gain a better understanding of the phenomena being studied (Bassey, 1990).

3.1.2 Epistemology

Epistemology refers to the branch of philosophy concerned with studying the nature of knowledge and justification (Bryman, 2008). According to Saunders *et al.* (2012) epistemology concerns what constitutes acceptable knowledge in a field of study. Bryman & Bell (2007) insist that epistemology is concerned with the issue of knowledge that is or ought to be considered to be relevant to a discipline. Proctor (2005) maintains that it is concerned with how a researcher can know things.

Saunders *et al.* (2012) discusses two fundamental epistemological positions in social science that include: interpretivism and the philosophy of positivism. The scholars suggest that a positivist is a researcher who adopts the philosophical stance of a natural scientist. According to Gill & Johnson (2010) a positivist prefers collecting data about observable reality and searches for regularities and casual relationships from the data with a view to create law-like generalisations like those produced by scientists. This study does not follow the traditions of a positivist.

Interpretivism is philosophical approach which is mainly associated with social scientists. The interpretivist approach takes the view that the social world of business and management is far too complex to lend itself to theorising by definite ‘laws’ in the same way as the physical science (Saunders, *et al*. 2012. The study of the social world requires a research procedure that reflects the distinctiveness of humans against the natural science (Bryman, 2008). In that sense, this study is heavily influenced by the traditions of interpretivism. According to Cohen *et al.* (2007) researchers who adopt this research approach share a view that the subject matter of the social sciences (e.g. born-global bio-tech firms and their knowledge supply chain) is fundamentally different from that of the natural sciences.

Consistent with this Farquhar (2012) maintains that interpretive traditions are concerned with grasping individual and unique truths with an emphasis on understanding or *verstehen,* as described by Weber (1947). Denzin (1983) makes more sense regarding this debate and he defines interpretive interactionism as: “the study and imputation of meaning, motive, intention, emotion and feeling, as these mental and interactive states are experienced and organised by interacting individuals” (p.129). Clearly, the interpretive research approach is related to data gathering, generating solid descriptions and interpretations allowing theory building. In this study the central phenomena for enquiry are the situations small born-global bio-tech firms construct e.g. their collaborative actions and how they give meaning to how various elements impact on their ability to make drug discoveries. In other words, the inquiry is about the inter-relationship or the connectivity of key variables/factors that include: business and social networks, inter-organisational collaborations, competence & goodwill trust, tacit & explicit knowledge, prior learning & absorptive capacity within the knowledge supply-chain of small born global bio-tech firms. Additionally, the study intends to explain how the linkages between these variables help or hinder the process of developing their innovative capabilities such as scientific knowledge development and technical know-how.

The traditions of an interpretivist which include phenomenology (Remenyi *et al.,* 1998), hermeneutics and social constructionism (Easterby-Smith *et al.,* 2012; Bryman, 2008) are based on the belief that humans interpret the world that they inhabit and attribute meaning to it (Farquhar, 2012). According to Creswell (2014) constructivism or social constructivism are often associated with interpretivism. In that sense, this study assumes a social constructivists view because it seeks an understanding of how small born global firms develop their innovative capabilities as well as comprehending the interplay of various elements that manifest in their knowledge supply-chain.

It takes the view that bio-entrepreneurs develop subjective meanings of their experiences – i.e. meanings directed towards business and social networks, inter-organisational collaborations and absorptive capacity for example. These meanings are varied and multiple as such, the intentions of the study are to look for the complexities or similarities of views as opposed to narrowing meanings to a few ideas. In that respect, the main goal of the research is to rely as much as possible on the participants' views concerning how they develop their innovative capabilities. The study also intends to interpret or make sense of the meanings small born global bio-tech firms attach to the world they live in. From that perspective, rather than to commence the study with a theory as with the philosophy of positivism, this study inductively develops a pattern of meanings with regards to the variables within the knowledge supply-chain of small born-global bio-tech firms.

The discussion of the concept of constructivism by Crotty (1998) identified several assumptions that have informed the philosophical approach for this study. Crotty expressed that: (1) humans beings construct meanings as they engage with the world they are interpreting as such, qualitative researchers utilise open-ended questions so that the participants can share their views, (2) humans engage with their world and make sense of it based on their social perspectives. Similarly, Creswell (2014) suggests that in order to interpret the actions of the social actors researcher should seek to understand the context or setting of the participants through visiting this context and gathering information personally. Lastly, Crotty (1998) suggests that the basic generation of meaning is always social, arising in and out of interaction with a human community. According to Saunders *et al.* (2012) the process of a qualitative researcher should largely be inductive. Admittedly, this study is of a qualitative nature and this approach allowed the study to generate meanings attached to the social world of small born-global bio-tech firms.

To sum up the approach adopted by this particular study Table 4 below neatly summarises the characteristics of an interpretivist that have considerably contributed to attainment of the main goals of this research study.

Table 4: The characteristics of an interpretivist

Element	Description
Understanding	Reality is viewed as socially embedded and it exists with the mind. It is fluid and changing and multiples realities are presumed
Subjectivity	This involves interpreting the meanings and actions of the actors (small born-global bio-tech firms) according to their subjective frame of reference.
Subjective	Knowledge is constructed and shared in signs and symbols recognised by members of a culture. Research encompasses researcher's own views and how they have been constructed.
Setting	The emphasis is on natural setting, and the subject of research is not removed from what surrounds it in everyday life. It involves an in-depth investigation
Holistic	To interpret a phenomenon the researcher must look at its parts in terms of its whole and in terms of its parts
Rich insight	By exploring in detail the researcher can gain a much fuller understanding of the phenomenon.

Sources: compiled from Creswell (2007), Saunders *et al.* (2007), Gribich (2007), Lee & Lings (2008); and Farquhar (2012)

3.1.3 Ontology

Ontology refers to "theories of being or existence and the ways in which our existence is shaped by the nature of knowledge" (Aitchison, 2003, p.196). Coghlan & Brannick (2005, p.10); Bryman & Bell (2007, p.25) define ontology as "the nature of the world". Bryman & Bell (2007) argues that questions of social ontology must be linked to issues concerning the conduct of business research. Proctor (2005) insists that ontology increases the need to answer questions regarding the nature of reality and is linked with the assumption of the kind of things that are found in the world. Contribution to this debate Bryman (2008) adds that, the central point of orientation for ontological considerations relates to the question of whether social entities can and should be considered objective entities that have a reality external to social actors, or whether they can and should be considered social constructions built up from the perceptions and social actions of social actors.

In Johnson & Duberley (2000) the objective view of ontology is described as assuming that social and natural reality existed before human consciousness while subjectivist ontology takes it for granted that what we consider to be reality is an output of the human cognitive process. Bryman & Bell (2007, p.22) adds that, “ontological assumptions and commitments will feed into the ways in which research questions are formulated and research is carried out”.

In Saunders *et al.* (2012) two aspects of ontology that have their devotees among business and management researchers namely: objectivism and constructionism were discussed. The scholars highlight that objectivism represents the position that social entities exist in reality external to and independent to social actors. According to Docherty *et al.* (2002) researchers who adopt this position try to isolate variables when testing a theory. They measure a given effect and offer a quantitative result in relation to a single outcome. This approach has been criticised for its lack of depth and richness (Robson, 2002). An objectivist ontology position assumes an objective form of knowledge, to measure relationships using quantitative research. Clearly, this study utilises qualitative techniques to measure and to explain the connectivity of various elements with the knowledge supply-chain as opposed to quantitative measures.

The constructionism position is an ontological position that asserts that social phenomena and their meanings are constantly being brought into being by social actors (Saunders *et al.* 2012). This position challenges the suggestion that “categories such as organisation and culture are pre-given and therefore confront social actors as external realities that they have no role in fashioning” (Bryman & Bell, 2007, p. 792). This position also accepts a degree of interaction between the researchers and the subject of the research to form an agreed, informed construction through dialectical exchange (Denzin & Lincoln, 1994).

Saunders *et al.* (2009) maintains that this approach is used when the researcher seeks some patterns in reality and looks forward to drawing a conclusion; in this case it is concerned with building theory which is central to the wishes of the researcher. This study is sturdily aligned to the main purpose of this approach which aims to describe, analyse and understand the impact of various elements, the behaviour of individuals and/or groups of people/firms from the perspective of the subject being studied (Myers, 1997).

Those who advocate this constructionist ontology suggest that it has many advantages: it helps the researcher to ask the right questions and even gives him/her additional confidence in his/her conclusions (King *et al.,* 1994), it has the purpose of allowing important social phenomena to be investigated by immersing the investigator for prolonged amounts of time (Slavin, 1992) and it rejects the idea that one reality is founded regardless of the influence of individual people (Allan, 1998). These advantages do not mean that this position does not have any disadvantages. According to Allan (1998) and Creswell (2004) the results of qualitative research give rise to questions regarding their generalisability to other situations or a larger population, because qualitative data is difficult to test for statistical significance.

The research reported here is constructionist in its ontology. It focuses on the discovery and exploration of the social phenomena to assert how social entities - born-global bio-tech firms value and evaluate their business and social connections, competence and goodwill trust, prior knowledge and their absorptive capacity and the impact of their linkages on their ability to make new drug discoveries. In order to discover and explore their knowledge supply-chain some form of interaction between the researcher and the subject of the research was necessary. This enabled the researcher to seek some patterns in reality and look forward to drawing a conclusion.

3.2 Research logic

An important consideration in creating the foundations of a research is whether the study is using an inductive or a deductive approach. In order to maintain the coherence of this study this section addresses the fundamental differences between these two approaches of logic and how they relate to the reasoning in this study. Farquhar (2012) makes an important point regarding the use of an inductive or a deductive approach to doing research. She argues that, if a researcher knows the shape (inductive, deductive or elements of both) that their study should take, it significantly reduces running the danger of making mistakes regarding its structure and overall integrity. Consistent with this Saunders *et al.* (2012) emphasises that, the degree to which a researcher is clear about the theory they are using, from the onset of their study, it becomes less difficult for them to address questions concerning its design. The scholars claim that this is often portrayed as two approaches based upon a researcher's reasoning. As such, this study evaluates inductive and deductive approaches as they have influenced the reasoning underpinning how theory was developed. Additionally, the study explores ethnography and grounded theory because the research methods have a direct relationship with research logic assumed for this study.

3.2.1 Inductive and deductive approaches

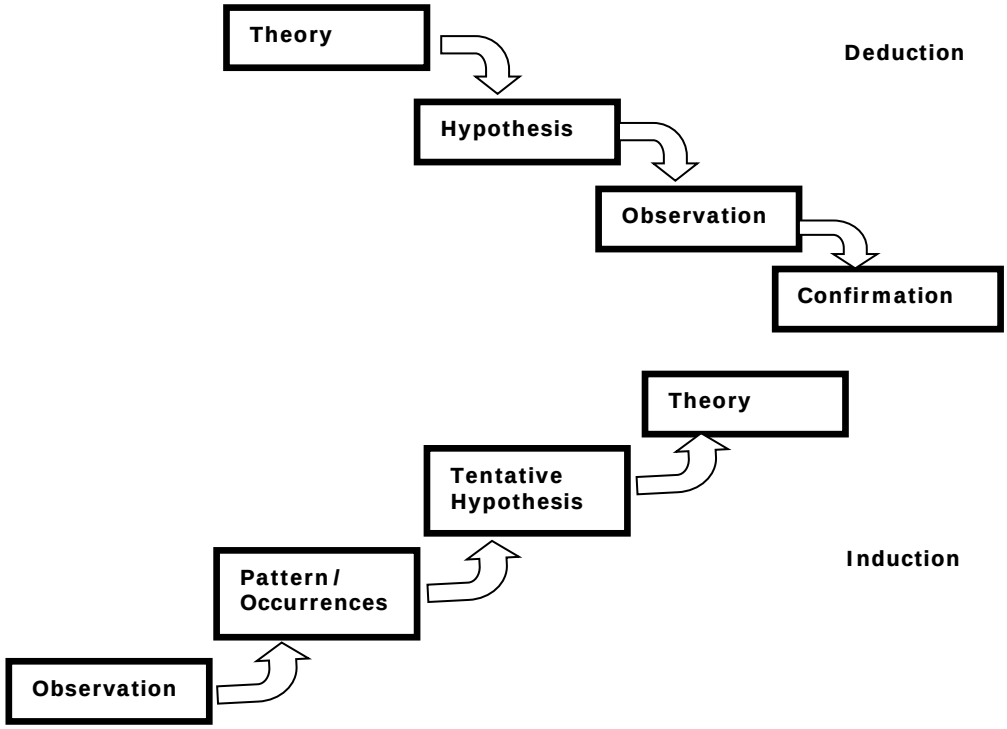
The study borrows aspects of a deductive approach with an inductive approach being very much prominent. This is consistent with Perry (1998, p.788) who argues that "it is unlikely that any researcher could genuinely separate the two processes of induction and deduction". According to Collis & Hussey (2003, p.15) inductive research is a study in which theory developed from the observation of empirically generated reality; i.e. "general inferences are induced from particular instances". From that perspective, the study exhibits processes of induction; it starts with a problem which is identified as an investigation of how small born-global bio-tech firms develop their innovative capabilities.

Theory then emerges through that process of enquiry. This way of doing research is consistent with Eisenhardt & Graebner (2007) who point out that the question is framed in terms of the importance of the phenomenon being studied and the lack of plausibility of the existing theory. Saunders *et al.* (2007) agree that using an inductive approach, theory would follow rather than the other way around as with deductive approach.

Maylor & Blackmon (2005) suggest that in some cases the goal is to generate theory from the data which is achieved by looking for instances where a pattern is beginning to emerge and that advocates for inductive research. Processes of deduction in this study can be identified when the researcher adopts theories contained in Freeman's *et al.* (2010) model of rapid knowledge development for smaller born-global bio-tech firms to assess the ones that hold in terms of explaining the specific situation of small born-global bio-tech firms in the East Midlands. This is supported by Richards (1993, p.40) who suggests that "both (prior theory and theory emerging from the data) are always involved almost simultaneously".

On that account, it is therefore "impossible to go theory free in any study". Using co-ordinated designs (both induction and deduction) is also consistent with Miles & Huberman (1994) who advise against favouring one extreme in multi-case research designs. Miles & Huberman claim that "tightly co-ordinated designs yield more economical, comparable and potentially generalisable findings and they are less case-sensitive and they allow bending data out of contextual shape to answer cross-case analytic question" (p.17). Figure 7 on p.97 neatly illustrates a visual representation of deduction and induction processes that were adopted for the purpose of this study.

Figure 7: Induction and Deduction



Source: Farquhar 2012, p.24

The research benefited by using both elements of induction and deduction. As Perry (1998) puts it, a pure induction potentially prevents a researcher from enjoying the use of existing theory and a pure deduction restrict a researcher from developing new and useful theory. Parkhe (1993, p.256) emphatically dismisses following a purely inductive or deductive approach arguing that it is untenable and not necessary because the process of on-going theory development requires "continuous interplay" between induction and deduction. Indeed, the use of both elements of induction and deduction was very instrumental to this research in that the researcher was able to satisfy the third objective stated as:

"*To contribute to the theoretical concepts of the dynamic capabilities and networking*"

Admittedly, the refined conceptual framework based on the insights from case studies was used as additional evidence to triangulate on the external reality of small born-global bio-tech firms in terms of their capacity to generate scientific knowledge. This also informed the types of research questions for the main study. Perry (1998, p.970) explains this more fully:

> *Prior theory informs all main data collection equally and theory is generated from all cases in one operation of cross-case data analysis across all the main cases.*

Based on this assumption, it is safe to claim that theory has a key role to perform in case-study oriented research (COR). For this study, theory was developed from secondary data, within case analysis and the data from the "pilot" study this can be seen as the first stage of the theory development process. Perry (1998) makes a strong argument in favour of a two stage theory construction process. Perry argues that the position is consistent with the realism paradigm's search for realities than regularities, for analytical generalisation as opposed to statistical generalisation (Farquhar, 2012; Yin, 2009). In concluding the debate on induction and deduction Emory & Cooper (1991, p.62) stress that "fact and theory (induction and deduction) are each necessary for the other to be of value".

3.2.2 Ethnography

Ethnography emanates from the field of anthropology and it is firmly grounded in the inductive approach (Saunders *et al.,* 2003). The research approach was chosen because of its ability to allow the researcher to engage with the subject under the microscope i.e. the researcher was invited to attend seminars on partnering held at various venues throughout the East Midlands. Engaging with the research subject this way enabled the researcher to collect rich data which significantly enhanced his understanding of their actions when are seeking business partners.

This is consistent with Saunders *et al.* (2003) who suggest that interacting with the subject is very important for qualitative researchers as they are able to interpret the social world the subjects inhibit and the way in which they interpret it. Remenyi *et al.* (1998) add that ethnography is used in business and management research because it allows a deeper understanding of organisational culture. Farquhar (2012) advises that although the research technique takes more time it is worthwhile as it helps to gain detailed insight into the research question/problem. Crucially, the research technique was chosen because of its ability to allow flexibility i.e. it enabled the researcher to respond to changes in the way small born-global firms engage with their partners in their search for scientific knowledge and technical know-how.

3.3 Research design

According to Churchill (1999 p.45) a research design is the "framework or plan for collecting and analysing data", and he also adds that, "it is a blue print that we ought to follow in completing a study". The chronologies of key data were constructed for each case; this is consistent with existing research focused upon new venture processes (Santos & Eisenhardt, 2009). Furthermore, data were collected through what Van de Ven (2007) calls 'conversations' with the entrepreneurs consistent with the researcher's practitioner engagement approach which helps to identify the participant's view of a phenomenon. Data gathering sessions are considered conversations instead of interviews, given the interactive engagement between the researcher and the practitioner in the research process (Van de Ven, 2007). To illuminate the various aspects of this research the following research methods are adopted. Other instruments that could be used for data collection are also discussed.

3.3.1 Case-study method

According to Ellram (1996, p.93) the case-study method is "one of the least understood" and yet it "remains one of the most challenging of all social science endeavours" (Yin, 2009, p.3).

But it is one of the most widely used in business management studies (Voss *et al.,* 2002). In the literature concerning the contribution of case studies towards developing theory there is a range of understandings from various scholars (see Farquhar, 2012; Sigglekow 2007; Yin 2009; Stake 2005; Eisenhardt & Graebner, 2007). The understandings considerably vary, from one end; case studies are seen as essential to researchers because they provide them with the opportunity to uncover new ideas and develop new concepts which help to construct new theory. On the other end of the scale case studies can be used to challenge, confirm, refine, sharpen, modify, revise, expand or to extend existing theory.

The later contribution of case-study research is consistent with the aims of this study. The study aims to modify concepts outlined on the influential model proposed by Freeman's *et al.* (2010) – see figure 4 p.79. The main reason for doing this is to enable the study to comprehensively explain the connectivity and the influence of business and social networks along various elements that include: trust, inter-organisational collaborations, knowledge, learning and absorptive capacity that are part of the knowledge supply-chain of small born-global bio-tech firms.

The aims of the inductive case-study research strategy adopted for this study are not entirely unique. Ridder *et al.* (2009) aggregate the potential theoretical contributions of case based research as seen by other scholars. Table 5 below summarises various notions associated with a case-oriented approach by different scholars as follows:

Table 5: Theoretical contribution from inductive case-study research

Scholars	Theoretical Contribution
Eisenhardt (1989b); Eisenhardt & Graebner (2007)	To develop concepts, theoretical constructs, conceptual frameworks, propositions, or a mid-term range theory. Reveal an unusual phenomenon, replicate or counter the replication of findings in other cases, eliminate alternative explanations, elaborate emergent theory
Flyvbjerg (2004) Miles & Huberman (1994) Sigglekow (2007	Generate & test hypothesis Ground a construct empirically in a new context Generate new ideas to build theory Provide a violation of theory Sharpen existing theory Get closer to theoretical constructs and illustrate casual mechanisms
Stake (2005)	Refine theory Suggest complications for further investigation Establish the limits of generalisation
Vaughan (1995)	Contradict or confirm theory Create new hypothesis Add detail to the theory, model or concept Specify theory more fully
Yin (2003/2009)	Confirm, challenge, expand, explore, extend, generalise, modify theory Revise original theoretical propositions Build theory by making significant theoretical breakthrough Develop hypothesis and propositions for further enquiry

Source: Ridder *et al.,* 2009, p.144

The cases for this study are carefully chosen primarily for the following reasons: (1) to understand the world of small born-global bio-tech firms and (2) to contribute to theoretical concepts of dynamic capabilities view and the network theory. A dated but still relevant study by Eckstein (1975) identified five ways in which case material can be useful as follows: configurative idiographic studies, descriptive configurative studies, heuristics case studies, plausible probes and critical case studies. In light of this, the study was mainly interested in *heuristic case-study types* because choosing cases in this way enabled study to develop some theoretical concepts which were instrumental in explaining the level of influence business and social networks along with various elements have on small born-global bio-tech firms' capacity to generate crucial scientific knowledge and new technology.

Similarly, Mitchell (1983) distinguishes heuristic case studies from configurative idiographic and disciplined configurative studies arguing that they are deliberately chosen in order to develop theory. Eckstein (1975, p.104) explains this point more fully:

> *The heuristic case-study is deliberately used to stimulate the imagination towards discerning important general problems and possible theoretical solutions.... Such studies, unlike configurative idiographic ones, tie directly into theory building and therefore are less concerned with the overall concrete configurations that with potentially generalisable relations between aspects of them; they also tie into theory building less passively and fortuitously than does disciplined configurative study because the potential generalisable relations do not just turn up but are deliberately sort out.*

Indeed, after assessing the applicability of Freeman's *et al.* (2010) model of rapid knowledge development for smaller born-global firms the intention was to deliberately modify the framework using evidence from secondary data and empirical evidence from born-global firms operating from the East Midlands and develop a frame of reference that adequately reflects their world. Developing theory in this way was described in literature as plausible because it is based on findings that are grounded in the literature (see Saunders *et al.,* 2003; Glaser & Strauss, 1967) and in-depth case analysis (also see Eisenhardt, 1989; Bellamy & Perri, 2009). The case-study method is multi discipline; historically it was used by clinicians to understand the "person in particular" (Runyan, 1982) and in education it is used to help students to understand a concept (Cohen *et al.,* 2007), in law using a case law and in political science using case reports (Creswell, 2007). Further Creswell (2007) claims that because of its popularity in social science the case-study approach is familiar to social scientists and as such for the purpose of this study, which can be categorised within the discipline of business management, the research approach is used to construct a deeper understanding of the new types of business ventures and how they perceive their world.

According to Yin (2009, p.18) a case-study research "is an empirical enquiry that investigates a contemporary phenomenon in depth and within its real life context, especially when the boundaries between phenomenon and context are clearly evident". Similarly, Robson (2002, p. 178) defines a case-study as "a strategy for doing research which involves an empirical investigation of a particular phenomenon with its real life context using multiple sources of evidence". Cohen *et al.* (2007) explains that a case-study is a specific instance that is frequently designed to illustrate a more general principle. Accordingly, Nisbet & Watt (1984, p.72) contend that a case-study is "the study of an instance in action". As such, this study examines multiple small born-global bio-tech firms in networks. Cohen *et al.* (2007, p.253) makes a strong case for using case-study research and they point out that:

> *Case studies can establish cause and effect and one of their strengths is that they observe effects in real contexts, recognising that context is a powerful determinant of both cause and effects*

It is therefore based on these attributes of a case-oriented approach that makes it attractive to use for the purpose this study which investigates the *cause* (collaborating/networking, trust, collaboration, prior learning & absorptive capacity) and the *effect* (innovative capabilities) of small born-global bio-tech firms. Bellamy & Perri (2009) suggests that case based studies may be particularly useful, for example, in systematically tracing the origins and nature of social changes that occur in specific settings, because they are particularly sensitive to context. Yin (2003) also highlights the importance of context, adding that, within a case-study, the boundaries between phenomenon being studied and the context within which it is being are not clearly evident. From that perspective, the use of small born-global bio-tech firms in the East Midlands region as case studies ensures that the research problem: *"The process of developing of innovative capabilities in biotechnology: The case of UK firms"* is fully examined to understand how the firms perceive the world that surrounds them.

Leedy & Ormrod (2001, p.149) make an important observation and they comment that, case studies attempt to learn “more about a little known or poorly understood situation”. Indeed, not very much is known about the collaborative actions of small born-global bio-tech firms in the East Midlands region as such, this research strategy enables the reader to learn more about these sophisticated types of new firms. This point of view is supported by a number of scholars. Cohen *et al.* (2007, p.153) argue that “contexts are unique and dynamic hence case studies investigate and report complex dynamic and unfolding interactions of events and human relations and other factors in a unique setting”. Miles & Huberman (1994) suggest that researchers should use qualitative research designs when there is a clear need for a deeper understanding, local contextualisation, causal inference, and exposing the points of view of the people understudy. This is consistent with Farquhar (2012) who argues that using case-study research allows the researcher to gain particular understanding or insight into whatever they may have chosen to study which is usually a contemporary phenomenon.

Similarly, Denscombe (2007) sees the logic behind using a case-study strategy and he argues that the researcher is able to gain valuable insight into a phenomenon that can have wider implications which could not have come to light when one is using a survey approach. In the same spirit, Bellamy & Perri (2011) agree that case-based studies help researchers to deal with detail, variety and complexity, and allow them to probe into the rich depths of social life more easily than do variable-oriented research designs. The multi-case-study approach was chosen for this study because of its ability to generate answers to the questions “why?” as well as the “what?” and “how?” (Farquhar, 2012) and these questions are outlined in chapter 1 of this study under research questions section 1.3.2 on p.10-11.

Additionally, Cohen *et al.* (2007) claim that “case studies strive to portray “what it is like” to be in a particular situation to catch the close up reality of what Geert (1873b) described as “thick description” of participants lived experiences of thoughts about and feelings for a situation. Yin (2009) affirms that to answer the question “why” one would probably need to do a multiple case-study. The essential tactic and a characteristic of case-study research is its use of several sources of data within each source (Saunders *et al.,* 2007; Yin, 2009; Farquhar, 2012). Easterby-Smith *et al.* (2012) claim that case methods allow researchers to generate huge piles of data presenting them with the opportunity to make interpretations they want. Data of this nature can include both primary and secondary data sources. In that sense, it makes the case studies strategy useful to the researcher because the intention is to answer questions that include:

- What are the main elements of the knowledge supply-chain of small born- global biotech firms?
- How are the main elements of the knowledge supply-chain of small born global bio-tech firms connected and to what extent do they help or hinder their capabilities development processes?
- What are the specific interactions of small born-global bio-tech firms that lead to capability development?

These questions are answered by drawing upon an array of documentary information and detailed within and across case analyses of small born-global bio-tech firms. Specifically, the sources of data for this study consist of internal documentation, biotechnology sector reports (secondary) and 24 qualitative interviews. This study is of an explanatory as well as of a descriptive nature - the research is attempting to draw explanatory and descriptive inferences about the impact of networks on the ability of small born-global bio-tech firms to generate innovative capabilities.

The explanatory aspect of the research is aimed at explaining the collaborative behaviour of small born-global bio-tech firms and the level of influence of various elements within their knowledge supply-chain. The descriptive aspect of the study is aimed at describing what is happening in the complicated world of each firm and how these various elements are connected in their knowledge supply-chain. Farquhar (2012) contends that case-study research is suitable for descriptive, explanatory and exploratory types of research. This is consistent with Saunders *et al.* (2007) who agree that in studies of an explanatory and exploratory nature the case-study strategy is the most appropriate way of conducting research. Various data collection methods such as qualitative interviews, secondary data analysis and observations are adopted with the view to answer the main research problem stated as:

"*The process of developing innovative capabilities in biotechnology: The case of UK firms"*

Triangulation is one of a number of advantages that this study has gained from using a multi-case approach. Indeed, multiple data sources outlined above have been employed to collect data for analysis. Yin (2003) suggests that a single and a multiple case strategy are two techniques that can be used to represent either a critical, extreme or unique case and to establish whether the findings in one case are occurring in other cases respectively. Evidently, the East Midlands biotechnology sector is a unique situation because of its science tradition that was recognised by the European Commission hence its acquired status of the "science city" of Europe (see NSC publication, 2012). The study incorporates multiple cases, i.e. five small born-global bio-tech firms are investigated in order to generate sufficient data with a view to increase the strength of the conclusions that are made regarding their collaborative actions.

This is consistent with Farquhar (2012) who favours the use of multiples cases stressing that they enable the researcher to explore the phenomenon in a number of different instances. Furthermore, Bryman (2004) argues that multiple case strategies allow the researcher to access a range and a depth of information. Farquhar (2012) cautiously stresses that when using more than one case data, each case needs to meet the quality criteria and it should address any concerns through triangulation to put a case forward for the relevance of the research findings. From that perspective, the criteria for the research sample of this study are clearly outlined in section 3.4.2. For example, a firm that fits the criteria should exhibit the characteristics of a born-global venture (entrepreneurial, risk taking and ambitious) with up to 50 employees, engaging in collaborative activities within the East Midlands region and overseas. More so, Yin (2003) suggests that a multiple case strategy is preferable to a single case and in cases where a researcher uses a single case there is need for a strong justification for doing so.

The researcher is aware of the inherent limits of this research approach including: the rationale for choosing the cases, the possible need for additional resources and the amount of time involved. Nonetheless, the benefits that accrue by using this strategy outweigh the reasons for not using it for this particular study. In his paper *"What a case-study is for and what is it good for"* Gerring (2004) suggests that using a case-study approach is effective when a researcher aims to elucidate features of a larger class of a similar phenomenon. Benbasat *et al.* (1987) express similar thoughts and they claim that a case methodology is clearly useful when a natural setting or a focus on contemporary events is needed. Accordingly, Bellamy & Perri (2011, p.264) affirm that "accuracy, or the virtue of capturing the significance of as much of the available empirical information as possible, and so explaining or interpreting as many aspects of the cases studied as possible".

Furthermore, the extent to which the research findings of this study can be generalised is traded off for accuracy; reliability and the validity of the results. Yin (2009) makes a strong case regarding the generalisability of case-based research arguing that it is achieved through the findings being generalised to theoretical propositions. He called this *analytical generalisation* denoting a process where generalisation takes place from data to theory rather than to population. In light of the new empirical evidence from case analysis and secondary data analysis, the study makes theoretical contributions to the dynamic capabilities concept and the network theory by modifying Freeman's *et al.* (2010) propositions on their model concerning rapid knowledge development for smaller born-global firms. Miles & Huberman (1994) observe that in *analytic generalisation*, the findings are considered of being congruent with or connected to prior theory.

The theoretical propositions for this study are closely connected to the dynamic capabilities theory initially developed by Teece *et al.* (1997). Table 6 below presents more practical considerations for using multiple cases highlighting their benefits including: validity and accuracy (Farquhar, 2012).

Table 6: Choice and number of cases

Choice	**Advantages**	**Disadvantages**
Single case	Depth, insight, revelatory and unique	Evolving boundaries of case, arguments for credibility and contribution of findings
Multiple case	*Stronger arguments for "validity" of study, evidence is often considered more compelling, the theory is better grounded, the findings are more accurate*	*Less depth, possible need for additional resources, robust rationale for choice of cases e.g. compare and contrast*
Longitudinal case(s)	Ideal for tracking changing conditions over a period of time	Requires significant commitment and it requires a lot of resources

Sources: compiled from Farquhar (2012); Eisenhardt & Graebner (2007) and Voss *et al.* (2002)

Given the benefits that accrue by using multiple cases the researcher is confident about the accuracy, reliability and validity of the conclusions that he makes from his inferences with the data collected from small born-global bio-tech firms. Yin (2009, p.61) makes a strong case for using multiple cases arguing that even using a "two-case" design the chances of doing a good case will be better than a single case design. Meredith (1998) claims that case-study research has two outstanding strengths which includes; studying the phenomenon in its natural setting and meaningful, relevant theory is generated from the understanding gained through actual practice and that the strategy enables the researcher to answer the questions *why* and *how* with a relatively fuller understanding of the nature and complexity of the complete phenomenon. Accordingly, this makes this strategy more appropriate to this study because the aim is to make a theoretical contribution in addition to filling a gap in the literature concerning innovative capabilities of small born-global bio-tech firms. This is supported by Easterby-Smith *et al.* (2012) who claim that good research designs need to contribute to theory. Farquhar (2012) suggests that case-study research is ideal for looking at research questions which are closely connected to their context or situation. From that perspective, this makes the strategy more appealing for this research.

3.4 Data collection and analysis methods

According to Huberman & Miles (2002) "qualitative data analysis is essentially about detection and the tasks of defining, categorising, theorising, explaining, exploring and mapping are fundamental to the analyst's role" (p.309). In that sense, the inductive and deductive designs, that are used to collect data for analysis, allow the study to detect and to perform in-depth analysis within and across cases (Perry, 1998; Huberman & Miles 1994). Specifically, within and across case techniques are used to develop ideas and theories about the collaborative activities of small born-global bio-tech firms.

More importantly, the techniques help the research to explain the impact of business & social networks, inter-organisational collaboration, competence & goodwill trust, tacit & explicit knowledge, prior learning & absorptive capacity on the innovative capability development process of the firms under investigation. This is very crucial for the purpose of this study in the sense that it was able to provide some explanations to the main research issue which is about:

"*The process of developing innovative capabilities in biotechnology: The case of UK firms*

3.4.1 Stages of data collection

To ensure that useful data was received in order to satisfy the objectives of this study it was necessary that appropriate settings were identified. As such, to find suitable cases the researcher chose to focus on the East Midlands region. The region is one the areas, in England, which has a large concentration of biotechnology companies (Smith and Ehret, 2013). This concentration of a group of firms in a single location facilitated data collection by providing continuous access to the founders and managers within the biotechnology sector.

Before undertaking the main research project a pilot study was carried out with a view to sharpen the data collection procedures and to test the feasibility of conducting the proposed research. At this initial stage of the research a firm had to be operating in the life science sector for it to qualify. Its size, age or sales revenue did not matter. The preliminary literature review and the pilot study results performed an important role in formulating research questions for the main research project. This prior study facilitated the development of theoretical propositions though tentative at this stage (Huberman and Miles, 1994). The propositions were intend for use at the data collection stage for the main study. This is consistent with the views of Baxter and Jack (2008).

Baxter and Jack agree that when a case study proposal includes specific propositions the likelihood that the researcher will be able to place limits on the scope of the study is significantly increased as well as the feasibility of completing it. A similar data collection strategy was employed by Baxter (2000/06). In her study on the development of nursing students decision-making in a clinical setting Baxter used propositions that include: knowledge, experience, feelings of fear and degree of confidence.

In light of this, the researcher was confident that the strategy adopted for this study was robust and rigorous. Thus, the propositions developed after conducting a pilot study helped the researcher to focus the data collection and to determine the direction and scope of the study.

3.4.2 The born global nature of the selected firms

The criteria for selecting cases were purposeful and it was based on theoretical sampling (Patton, 1990). The cases were chosen on the basis that similar results were predicted to be produced within each case – a process termed *literal replication* in Yin (2009). After establishing a sample selection strategy, BioCity Nottingham (BCN), Enterprise Europe Network (EEN), Pera Innovation Network (PIN), Loughborough Innovation Centre (LIC) and Medilink databases were used to identify suitable born global biotechnology firms. Appropriate cases were classified using the following criteria: (1) a biotechnology firm had to conform to a commonly used definition of born globals which accentuates that at least 25 percent of its sales had to come from outside their home market in the first three years of their inception (see for example Gabrielsson and Kirpalani, 2012; Oviatt, and McDougall, 2005b; Knight and Cavusgil, 1996), (2) The born global firms were also expected to use the East Midlands region as their home market.

As already mentioned the logic underpinning this classification was that the region has a high concentration of technology-based biotechnology companies. The study considered research activities at BCN, LIC, Pera Innovation Network and AstraZeneca's re-organisation as the key factors contributing to the formation of small biotechnology companies in significantly large numbers, (3) The firms had to use scientific knowledge for new drug discovery services and technical know-how to assist their clients to develop new clinical processes, (4) The companies had to be involved in collaborative networks domestically and internationally. (5) Well-established biotechnology companies were excluded from the sample because of their tendency to develop less flexible structures.

The criteria set above for selecting companies led the study to five born global biotech firms. Table 7 below shows that all the firms fit into the commonly used operationalisation model which views born globals "as firms less than 20 years old that internationalised on average within three years of founding and generate at least 25 percent of total sales from abroad" (Knight *et al.,* 2004, p.649).

Table 7: An overview of sampled born global biotech firms

	Critical Pharmaceuticals	***XenoGesis***	***BAST***	***Sygnature Discovery***	***Haemostatix***
Location	BCN East Midlands	BCN East Midlands	BCN East Midlands	LIC East Midlands	BCN East Midlands
Company Age	12	3	4	10	11
Company size (2013)	Micro/small	Micro/small	Small	Micro/small	Micro/small
No of Employees	13	9	69	6	6
Total turnover	£618,315	£124,962	£6,951,533	£300,681	£163,616
Overseas sales in year 3 (2013)	£381,348	£86,642	£2,244,018	£165,884	£61,742
% Overseas sales	61%	69%	32%	55%	37%
Overseas partnerships	4 in the USA and Europe	6 in the USA, Canada, India and China	3 in North America and Europe	2 in America and Europe	2 in China and the USA

3.5 Data collection procedures

The data collection steps for this study included setting the precincts (as discussed in section 3.4.2 above), collecting data through qualitative interviews and observations, secondary documents and visual materials as well as establishing the protocol for recording information. Twenty four face-to-face interviews were carried out lasting between 105 to 150 minutes with an average duration of 115 minutes. In each case, 4-6 interviews were carried out to increase the reliability of the data to be collected for analysis (Eisenhardt, 1989; Huberman and Miles, 1994). The interviews were conducted with the CEOs, BDOs and senior scientists at the premises of the five firms. Nine additional interviews were carried out with experts in the main knowledge centres within the East Midlands with a view to verify the accounts given by the main informants. In the following section the study discusses in detail four types of data collection procedures which were utilised at the data collection stage for each firm.

3.5.1 Qualitative interviews

Semi-structured qualitative interviews were of particular interest to the wishes of the researcher as they presented him with a number of benefits including: opportunities to collect factual information about how the selected born global bio-tech firms developed scientific knowledge and how that knowledge was channelled towards improving their operations while at the same time enhancing creativity. The semi-structured research technique was chosen as opposed to the structured or unstructured research techniques because of its flexibility and adaptability (Easterby-Smith *et al.,* 2012). The semi-structured interviews were customised to suite the context of the selected born global firms. Cameroon & Price (2009) explained that in a practical business research method semi-structured interviews are more appropriate. The research technique allowed the researcher to have some control over the line of questioning (Creswell, 2014; Mills and Birks, 2014).

Whereas, with the unstructured interview approach the interviewer introduces a broad topic and the danger is that the interviewee determines what to say about it (Bryman & Bell, 2011; Cameroon & Price 2009; Burns & Burns 2008). Additionally, the semi-flexibility of the semi-structured interview technique allowed the researcher to ask additional questions about the collaborative actions of small born-global bio-tech firms in the East Midlands assisting the study to fully explore the research question and the research objectives located in *chapter 1* of this study. A set of guiding questions were utilised in order to ensure that the interviews remained focused on the main area of discussion. Cameroon & Price (2009, p.373) commented that "it makes sense to develop an interview guide for semi-structured interviews". This acts as a prompt ensuring that the all areas that the researcher intends to cover are fully examined.

Furthermore, this research technique enabled the researcher to gather data about how the small born-global bio-tech firms developed their innovative capabilities and to understand the linkages of various elements within their knowledge supply-chain. The research technique helped the researcher to satisfy the second objective of this study stated as:

"To explain the connectivity of the main elements of the knowledge supply-chain of small born-global firms and the extent to which they assist their innovative capability development process".

3.5.2 Qualitative observations

The researcher took field notes on the activities of CEOs, Business development officers and senior scientists at each firm. During arranged visits to all the five firms the researcher recorded, in note form, their science-related activities e.g. lab-based collaborative programmes outlined on secure interactive whiteboards. The use of whiteboards was replicated in all the firms because they used lab equipment and facilities provided by BCN.

The researcher assumed what was described by Creswell (2014) as a *complete observer* role. The observations at the premises of the firms followed what Flick (2014) describes as an open-ended approach which permitted the researcher to ask general questions of the participants and it allowed them to freely provide their views. This data collection procedure provided the researcher with two main advantages: (1) the researcher had first-hand experience with the identified key participants in each firm and (2) the researcher was able to record information as it occurred.

3.5.3 Documentation

During the process of interviewing the key participants the researcher was able to gather documentation about their planned partnering activities e.g. newsletters and official reports published at BCN – an 'incubator' providing support and science facilities to the sampled firms. These documents enabled the researcher to obtain the language and words of participants. The researcher benefited by saving time and expenses associated with transcribing field data. More importantly, the documents represented data to which the participants had given attention. Additionally, secondary data materials were accessed using the websites of the chosen firms, Companies House and publicly available literature. This technique for accessing achieved material was used for all the cases.

3.5.4 Audio-recording

All the interviews with the key participants were audio-recorded and transcribed. Recorded information gave the researcher more time to reflect on the meanings and interpretations that the participants attached to networking, inter-organisational collaboration and knowledge creation. The researcher faced challenges associated with the interpretation of their statements. However, to ensure the accuracy of the presented accounts the participants were provided with the transcribed data to validate whether it represented their accounts of events.

3.5.5 The benefits of qualitative techniques

As explained above the use of this qualitative technique ensured that rich data was collected. Mason (2002) expressed that using the interactive, situational and generative approach to acquire data with the more structured composition and uniform style of a survey interview gives the author the privilege to access the accounts of social actors, agents, individuals, or subjects as data sources. Indeed, investigating instances or cases of collaborative actions of small born-global bio-tech firms in their natural setting gave the researcher the opportunity to delve into their actions in more detail. This also allowed him to discover things that might not have become apparent through superficial research. As Burgess (1982, p.107) notes, conducting an in-depth interview gives the researcher the "opportunity to probe deeply to uncover new clues, open up new dimensions of a problem and to secure vivid, accurate and inclusive accounts that are based on personal experience".

It is also instructive to mention that in instances where clarification or additional information was required follow-up emails and telephone calls were made. The credibility of the information collected from the key informants was enhanced when the study reached a point of saturation i.e. a point where the participants were giving previously presented events. At that stage no further interviews were deemed necessary (Riley, 1996) and the interviewing process was stopped. This lead to the commencement of data analysis.

3.6 Inductive analysis

The study follows an inductive analysis style with elements of deduction. The cases chosen for analysis consisted of CEOs/founders and their top management teams who are former employees of AstraZeneca or had vast experience of the bio-tech industry accumulated over years of operating in the sector and an in-depth knowledge of the pharmaceutical industry.

The next step in the analytical process was to investigate the sampled cases in order to identify differences, patterns and trends in relation to how they create knowledge in each case (Bellamy & Perri, 2009; Miles & Huberman, 1994). Yin (2009) suggests that using pattern matching logic in case-oriented studies is the most appropriate technique for case analysis. As such, cross case synthesis was used (Yin, 2003; Huberman & Miles, 1994) and a table (see table 9 on p.143) populated with qualitative data from individual cases showing a wide range of features on a case by case basis was developed (Lindstrand *et al.,* 2011).

Similar cases with identical features recognised as a typical small born-global firm were closely scrutinised. Taking the literature review into perspective and the emerging themes about the processes involved in generating scientific knowledge for small born-global firms a causal link between various elements including networking, collaborating, trust, knowledge sharing, prior learning and absorptive capacity was formed. This is in line with Muller (1982) and Miller (1983) who suggest that the process of analytic induction starts with a tentative hypothesis to explain something. The researcher's intentions are to contribute to the concepts of dynamic capabilities and network theory by modifying the theoretical propositions on Freeman's *et al.* (2010) *Rapid Knowledge Development Model for Born-global Firms*.

This is achieved by tracing/analysing emerging theoretical concepts, trends, patterns and insights about the collaborative activities of small born-global bio-tech firms using within and across case analysis. As a result, the extent of influence of the main elements, as outlined in the previous paragraph, on the process of innovative capability development was established. Farquhar (2012) suggests that sifting through data helps a researcher to identify common ideas and themes that are supported across the interviews.

As such, common themes were identified in the data prompting the researcher to modify Freeman's and others propositions accordingly using new empirical evidence from qualitative conversations and emerging concepts from secondary data. Cohen *et al.* (2007, p.462) discusses the idea of "progressive focussing" understood by Parlett & Hamilton (1976) as a process which starts with the researcher using a wide lens to collect data and then through reviewing, sifting and sorting it the salient features, of small born-global bio-tech firms, for example, can bubble to the surface. In the same vein, Gerring (2005) argues that changes in the social world imply the dynamic nature of concepts.

In other words, concepts are not static they have to be manipulated to take into account the world's changing terrain and how people make sense of things happening around them (Weber, 1905/1949). As such, this study recognises the changing nature of the biotechnology sector i.e. the constant quest for new products to better the life of human beings and other species (Horsley, 2012). The debate on which strategy to use for analysing qualitative data has brought different perspectives from a number of scholars. For example, Yin (1994) claims that, where a researcher uses existing theory to formulate the research question and objectives the researcher may also use the theoretical propositions to help him/her to devise a framework that is needed to direct the data analysis process.

On the contrary, Bryman (1989) sees this from a different perspective. Bryman argues that devising theoretical propositions before actually collecting the data as a way to direct and to help to analyse qualitative data should be disfavoured. He suggests that there is a danger that the researcher may make premature conclusions on the subject under investigation. He also maintains that the theoretical concepts developed in this way may predominantly be based on the views of the participants in the social setting.

Other researchers (e.g. Creswell, 2005; Huberman & Miles, 1994; Glaser & Strauss, 1967; Schatzman & Strauss, 1973; Saunders *et al.,* 2003) highlight the benefits of an inductive approach expressing its "grounded" nature. In particular, Saunders *et al.* (2003) make three points highlighting that, exploring data without a descriptive framework: (1) allows theory to emerge for the process of data collection and analysis; (2) it is not necessary to commence one's study with a defined theoretical framework and (3) one identifies relationships between collected data and then develops propositions. The scholars further express that when following an inductive approach it is important to have a clear research process.

As is abundantly clear from the debate about data analysis above, it was confusing for the researcher to adopt one extreme of analysing data. Nonetheless, within this web of confusion the study borrows elements of both inductive and deductive data analysis to examine the activities of small born-global bio-tech firms. Inductive analysis is more prominent. The main reason for using a mixture of the two scientific paradigms was to enable the research to benefit from existing theory so as to develop a new and useful theory which satisfies his intentions in conducting the study. The variables modified from Freeman's *et al.* (2010) original model of rapid knowledge development are used to analyse data from five small born-global bio-tech firms.

The modifications to Freeman's and others model were informed by the results from the "pilot" study, secondary data analysis and within case analysis which Cohen *et al.* (2007) suggest should commence earlier in the research. Yin (2009) accepts this way of analysing data by stating that a data analysis strategy based on theoretical propositions is the most preferred strategy in case-oriented research studies. Data collected from each firm were sorted and transformed into chronological order and each case history using thematic analysis.

Thematic analysis is multi-discipline; it is used in education research (Cohen *et al.,* 2007), it is also used by research clinicians (see Newfield *et al.,* 1991; William, 1992), and in political science (Easterby-Smith *et al.,* 2012). The method for analysing data was chosen because of its ability to focus on identifiable themes and patterns of behaviour (Aronson, 1994). Identifiable themes for this study are related to business & social networks, inter-organisational collaborations, competence & goodwill trust, tacit & explicit knowledge, prior learning & absorptive capacity.

The study takes the stance that these concepts are the building blocks to the process of developing the innovative capabilities of small born-global bio-tech firms operating in a hyper-competitive environment driven among other things by the wealth of information a firm can have access to (Shilling, 2008). This is in line with Taylor & Bogdan (1984, p.131) who defined themes/concepts as units derived from patterns such as "conversation topics, vocabulary, recurring activities, meanings or feelings". The emerging themes from qualitative conversations helped the researcher to piece together and form a comprehensive picture of small born-global bio-tech firm's collective experience of business & social networks, inter-organisational collaborations, trust building, knowledge sharing, prior learning & absorptive capacity in networks. The cross case analysis was used to analyse the collaborative activities of each small born-global bio-tech firm (Bellamy & Perri, 2009). The first step in this process was to analyse each case (within case analysis).

The technique for analysing focussed on business & social networks and other variables (outlined above) as conduits for the process of innovative capability development of small born-global bio-tech firms. For each firm investigated the key variables including: business & social networks, competence & goodwill trust, inter-organisational collaborations, tacit & codified knowledge, learning & absorptive capacity contained in the amended conceptual framework were used to assess their impact on the capacity, of small born-global bio-tech firms, to generate fluid scientific knowledge and technical know-how. The analysis showed that the connection between business, social networks and trust was crucial because it provided the foundation to the process of knowledge-creation and new drug discoveries for born globals bio-tech firms. From analysing the cases there was strong evidence indicating that competence and goodwill trust are essential to the process of sharing, exchanging scientific knowledge and technical know-how in the form of tacit and codified knowledge.

Thus, competence and goodwill trust in business and social networks can be combined into the theoretical concept of dynamic capabilities and network theory. Based on within case and secondary data analyses competence and goodwill trust are a pre-requisite for knowledge sharing which is essential for small born-global bio-tech firms in terms of making innovations. The next step was to conduct a detailed analysis of the investigated firms so as to identify any differences or similarities in the collaborative behaviours across different firms to help to explain in great depth the research phenomenon. Huberman & Miles (1994, p.173) suggest that cross case analysis helps to deepen “understanding and explanation”. Cross case synthesis was used (see Yin, 2003/9; Huberman & Miles, 1994) and it allowed the researcher to map the steps involved in the process of developing innovative capabilities undertaken by firms under investigation and their impact on generating fluid scientific knowledge and technical know-how which underpin innovation.

Yin (2009) maintains that cross-case synthesis involving at least two cases is likely to be easier and findings are likely to be more robust than using a single case. As such, the researcher was able to develop sophisticated descriptions and more powerful explanations (Gerring, 2005). The cases were further probed to understand the connectivity of the building blocks of networks, inter-organisational collaborations, trust, and knowledge, prior learning and absorptive capacity as conduits for the innovations of small born-global firms in the East Midlands. In light of the preliminary literature review and cross case analysis the researcher was inclined to conclude that there is a strong association between these building blocks. For example, a CEO of a small born-global bio-tech firm who is a former employee of a well-established pharmaceutical company is likely to have business and social connections that he regularly interacts with to discuss, share experiences and exchange ideas about drug discoveries.

The cross case synthesis revealed that the CEOs or science directors from the analysed cases have some form of links with their personal connections and business networks e.g. all of the participants had established business connections at BNC where their businesses were resident. Given the overwhelming evidence of similarities between the participants the researcher felt that there was no need to further sub-divide the firms. Evidence from within case analysis indicates that all the participants have connections regionally (in the East Midlands), nationally (in the UK) and overseas (e.g. in America, Asia etc.). Crucially, the participants confirmed that their business, social relationships, competence and goodwill trust significantly influenced how they share scientific knowledge and technical know-how with their partners.

Empirical evidence was compared with themes emerging from recent literature on born globals which is fairly scant. Consequently, the researcher modified construct definitions to include various dimensions of the capabilities view (structural, relational, and cognitive) and their influence on a firm's access to fluid scientific knowledge and technical know-how. The researcher follows Yin's (1984) replication strategy. The "*Knowledge and Innovative Capability Development Model*" was used to study each case in detail. Successive cases were examined to compare and verify their collaborative activities (Huberman & Miles, 1994). In cases where information was not readily available subsequent phone calls and emails were made to the CEOs/founders/science directors, and the top management teams of the firms under the microscope. In order to provide a detailed account of the impact of business & social networks, goodwill & competence trust, inter-organisational collaboration, tacit & explicit knowledge, prior learning & absorptive capacity on the process of developing innovative capabilities for small born-global bio-tech firms the researcher chose to use an in-depth description of each firm. This is consistent with Yin (2003) who argues that single or representative cases can be used as examples of a larger population of cases.

In line with other scholars (Mele´n & Nordman, 2009; Haslam *et al.,* 2011; Zheng *et al.,* 2010) the researcher chose the firms to represent a larger population based on their ability to illuminate the points that his analysis of knowledge and the capacity of small born-global bio-tech firms sought to make (Lindstrand *et al.,* 2010). He selected the firms because they provided a good representation of typical born-global bio-tech firms and they were not considered extreme cases. Because the researcher had conducted interviews during the "pilot" phase this, consequently gave him rich data to use as a platform on which to base case descriptions for the main study.

Analytic generalisation was used to examine and validate data from five firms and science parks (Yin, 2009; Huberman & Miles 1994/2002). Following that data from these firms was checked to identify any competing or falsifying explanations in relation to theoretical propositions (Kvale, 1989b). In instances where competing or falsifying explanations were identified propositions were reformulated to reflect the data. To enhance our understanding of the proposed concepts, the data were studied again to determine whether they relate to the reformulated propositions e.g. propositions such as competence, goodwill trust, prior learning & absorptive capacity etc.

Secondary data related to these propositions are located in chapter 2 and transcribed data collected from qualitative interviews was kept secure. Engaging in the process of validation, the researcher was able to construct plausible explanations of the cases by developing the propositions and theory to such a point that all fit into the data (Yin, 2003/2009). Thus, the final propositions consisted of business & social networks, competence & goodwill trust, inter-organisational collaborations, tacit & explicit knowledge, prior learning & absorptive capacity as the building blocks towards developing the innovative capabilities of small born-global bio-tech firms. Therefore, based on analytical generalisation the researcher was able to construct and develop new theory with regards to the innovative capabilities of small born-global bio-tech firms – The "*Knowledge and Innovative Capability Development" model* (see p.206).

3.6.1 Internal validity

Validity is the extent to which the research findings accurately represent what is really happening in the situation (Collis & Hussey, 2003). In that sense, the researcher is confident that using within case analysis the findings of the study will accurately represent the world of small bio-tech firms in particular, the impact of business and social networks as conduits for acquiring scientific knowledge and developing technical know-how. This is consistent with Farquhar (2012); Gibbert & Ruigrok (2010) who collectively acknowledge that internal validity is related to the casual relationships between variables and results. They both claim that internal validity applies at both the data collection and data analysis stages. Furthermore, Yin (2009) suggests that internal validity is a concern for explanatory case studies where the researcher intends to explain why event *X* led to event *Y*. Indeed, this study aims to explain the connectivity of various elements in the knowledge supply-chain of born global biotech firms and their impact on how they develop innovative capabilities.

Therefore, the analysis of instances of occurrences within cases and cross case ensures that the research findings are based on the data collected from small born-global bio-tech firms in the East Midlands and a detailed evaluation of the literature. As such, the researcher is confident with the findings of the study in terms of their accuracy in explaining the capacity of small born-global bio-tech firms to generate fluid scientific knowledge. Eisenhardt (1989, p.544) argues that case-study researchers can claim internal validity of their findings through “enfolding the literature”. In other words, she is expressing the notion that emerging theoretical concepts and developed theories from within and across case analysis need to be closely examined with the existing literature. Indeed, this suggestion is particularly important to the achievement of the research aims and objectives of this study, in particular, the author’s intention to contribute to the theoretical concepts of dynamic capabilities and network theory.

As such, it is safe to claim that the proposed *"Knowledge and Innovative Capability Development Model"* accurately represents what is happening in the world small born-global bio-tech firms. Collis & Hussey (2003) advise that research errors including: faulty research procedures and poor sampling can potentially undermine the validity of the research findings. Collis' & Husseys' advice was taken into consideration during the case selection stages and, as a result, a criterion for the representative sample was set to avoid these research errors. Farquhar (2012) adds that to increase the internal validity of the research findings great care should be taken in the way data about the research sample is presented; she argues that it should be presented in such a manner that the reader can readily access it.

3.6.2 Reliability

In addition to informing the reader about the actions of small born-global bio-tech firms the study makes a contribution to the theoretical concepts of dynamic capability theory and network theory. As such, reliability of the modified conceptual framework the "*Knowledge and Innovation Capability Development Model"* will be tested when the research is repeated (Farquhar, 2012; Collis & Hussey, 2003). Yin (2009) emphasise the need for the researcher to document the procedures that the initial researcher followed in their study. In light of this, the procedures for this study are clearly documented in this thesis. To dispel any suspicions about the transparency of the research the supervisory team were informed of the progress of the field work in every step during the data collection process. This is consistent with Yin's advice that the general way of approaching the reliability problem is to operationalise as many steps as much as possible and to do the research as if someone is looking over your shoulder.

3.6.3 Generalisability

The limits to the extent one can generalise the findings of case-oriented research design has been extensively debated in social science research (see Skate, 1995; Creswell, 2007; Gomm *et al.,* 2000; Huberman & Miles, 2002). Yin (2009) makes a strong case regarding the generalisability of case-based research arguing that the generalisability is achieved through the findings being generalised to theoretical propositions. He called this *analytical generalisation* denoting a process where generalisation takes place from data to theory rather than to population. Farquhar (2012) stresses that the positivist-view of statistical generalisation does not apply to case-study research where the primary goal is to study the research phenomenon in its real life context. Yin advocates for what he terms *logic replication* as opposed to *logic sampling*. From this perspective, it can be argued that the findings of this study in particular, the modified conceptual framework can be applied to other biotechnology networks/clusters e.g. to The Golden Triangle of Cambridge, London and Oxford reproducing similar findings to those achieved through analysing small born-global bio-tech firms in the East Midlands region.

3.7 Operationalisation of the main concepts

According to Bryman (2007) operationalisation entails devising measures of the concepts in which the researcher is interested. Knight (1997) claim that while measures of imprecise concepts are never completely valid or reliable, researchers strive to maximise these qualities. Research literature deals, only to a modest degree, with measurement problems when it comes to exploratory/qualitative research (Ghauri & Grønhaug, 2005). However, Berg (2007) goes so far as to say that failure to define and operationalise concepts will spell disaster in many cases.

The problem is usually approached by using semi-structured questions, based on an interview guide – a technique which was adopted in this study. As the study has already explained the interview guide questions were developed based on the literature and the preliminary study. This type of study may be seen as data-driven however, without utilising the concepts related to born-global firms the knowledge and innovative capability development model will be difficult to construct. Berg (2007) adds that if researchers do not make clear their concepts the results they produce may be meaningless in terms of explanatory power or applicability. The scholars suggests that, "if you have not worked with the literature in developing relevant meanings and measureable attributes, it will be impossible for you to see how eventual results fit into this extant body of knowledge" (p.37). From that perspective, it is essential that a mapping between empirical observations and concepts is undertaken.

3.7.1 Business & social networks

According to Solberg (1997), the more global the industry structure is the more important is the presence of an active and widespread network. The motives for forging global networks for born-global firms were investigated and their influence on how they develop innovative capabilities was sought. The business and social networks studied in this thesis were both business and personal contacts that the key informants define as crucial to how the firm acquired/acquires knowledge and technical know-how. These contacts were either established from their previous research programmes domestically or internationally. To evaluate the impact of these contacts on how they generate their scientific knowledge and technical know-how the interviewees we asked questions that were related to the types of linkages that existed between them and the network of people they identify as being important? Follow-up questions such as how close were these relationships we also utilised?

3.7.2 Alliance-building

Born-globals are entrepreneurial firms which are able to achieve economies of scale soon after their establishment. They reduce the impact of financial challenges and the liability of newness by forging alliances and other special types of partnerships, thus shielding the firms from the full impact of rapid growth (Altshuler, 2012). Small biotechnology firms that form partnerships with large pharmaceutical firms do so for their mutual benefit (Schilling, 2010). Segers (2013, p.24) adds that, "to varying degrees, new biotechnology firms depend on strategic (technology) partnerships with other organisations or large firms".

The interviewees were asked to explain the importance of forming alliances with other pharmaceutical firms, academic and research institutions both domestically and internationally. They were further probed to ascertain the basis of their success in the knowledge-intensive science sector. Mattsson (2011) suggest that, collaborations give rise to knowledge sharing and exchange in the form of analytical skills, technical know-how and observational learning.

3.7.3 Trust-building

Successful business alliances are often considered to be based on trust, close co-ordination of activities and constant communication (Altshuler, 2012, Kale *et al.,* 2000; Kanter, 1994). The process of developing trust is fraught with challenges and it often occurs over a long period of time based upon interactions between different boundary spanners and facilitated by organisational similarity (Gulati & Sytch, 2008). A similar view was presented by Parkhe (1998) who insisted that the process of trust development occurs over time and it takes the form of multiple interactions as well as reinforcing positive experiences.

To construct a clearer picture regarding how born-global bio-tech firms develop trust in their collaborative projects, the interviewees were asked to narrate the steps they took before commencing the process of exchanging scientific knowledge and technical know-how with their partners. The reasoning behind asking such types of questions was to ascertain the impact of trust, as a component of their knowledge supply-chain, in terms of succouring the development of innovative capabilities. Freeman *et al.* (2013) maintain that for born-globals their knowledge development process is anchored on business relations and more so, on relational trust.

3.7.4 Knowledge-creation

Scholarship on networking universally acknowledge that firms which are embedded in evolving networks of inter-firm and inter-organisational knowledge relationships have the opportunity to 'soak-up' a wide range of specialised knowledge resulting in better performance (Powell, *et al.,* 1996; Malebra & Breschi, 2005, Grant, 1996). According to Chesbrough *et al.* (2006) 'open innovation' provides multiple learning occasions for young firms and it also reduces R&D costs due to the fact that a firm can share part of the required knowledge with other firms or research-oriented institutions. Similarly, Kogut & Zander (1992); Malebra & Orsenigo (2000) acknowledge that young high-tech firms benefit from external knowledge networks because they enable them to bridge their knowledge gaps. The key discussions with the interviewees were based around identifying the processes involved in knowledge-creating whether it was explicit or tacit knowledge. Specifically, the researcher sought to gather data about how small firms created science-related knowledge. The participants were also probed about the role of trust in facilitating knowledge sharing outside their business. The conversations went to as far as to discuss conditions that the firms deemed necessary for them to exchange/share science knowledge. The topic on how the knowledge is stored and managed in the firms was also explored.

3.7.5 Prior-learning & absorptive capacity

Absorptive capacity is concerned with a firm's ability to recognise assimilate and to apply new knowledge productively within the firm (Cohen & Levinthal, 1990). Taheri & Geenhuizen (2011) maintains that the absorption of diversified knowledge through global networks improves creative activity and enhances practical adjustment of innovations by utilising complementary knowledge in business relationships. Concerning born-global bio-tech firms it is imperative that their top management use their local and global connections as a source of new scientific knowledge and technical know-how. Freeman *et al.* (2010) maintain that, the interpersonal relationships (of the born global managers through their earlier networks), inter-firm partnership and co-operating inter-dependence, which lead to trust, "may be viewed as the fastest and most expedient conduit of tacit knowledge" (p.79). Altshuler (2012) suggests that tacit knowledge increases the firms' absorptive capacity. Discussions with key informants were targeted at understanding the importance of prior-learning and the accumulated science experience of the owners and the top management in terms of facilitating the acquisition of useful information in networks.

3.8 Measurement

The formulated parameters in the form of concepts were designed to measure how small born global bio-tech firms develop their innovative capabilities and these are presented in table 8 on p.132. The table displays collected data concerning the activities of small born global firms that assisted their capability development processes. The data shows what the firms were able to achieve e.g. they were able to develop new drug testing combinations or new clinical products as a result of jointly working with other firms, research institutions, hospitals etc.

Table 8: Outcomes of the science activities of small born-global firms

		Formulated concepts designed to measure the innovative capabilities of small born global biotech firms					
		Business & Social Networks	**Competence & Goodwill trust**	**Inter-organisational Collaborations**	**Tacit & Explicit Knowledge**	**Prior learning & Absorptive Capacity**	**Innovative Capabilities**
Small Born-global firms	**Critical Pharmaceuticals**	Strong academic, personal & institutional networks. VC are also part of the network	Trust is build based on the reputation of the partner	Engages in collaborative projects with other firms in the East Midlands and overseas. Work with Universities & scientists on specific projects.	The firm sponsors biochemistry students to work on projects and to study at University. Data from projects is stored on a database. Students are also bonded	Experience is seen as essential in order to understand what knowledge should be acquired	Nano-enabled intranasal formulation of teriparatide for the treatment of osteoporosis as a result of result of working with an academic institution
	XenoGesis Ltd.	Same as BAST Inc.	Trust is built in escalating series but in cases of a partner whose cognitive distance is big that is seen as the basis for trust	The firm work with scientist from their clients to bridge the knowledge gap.	Same as Critical Pharmaceuticals	Same as Critical Pharmaceuticals	Data interpretation techniques necessary for new drug testing as a result of working with other firm
	Haemostatix Ltd	Same as Critical Pharmaceuticals & XenoGesis	Trust is portrayed as key to knowledge exchange	Same as XenoGesis	Most of the board members have experience in product development and commercialisation	Board members have vast experience in drug discoveries which helps to understand the needs of the firm	Haemostats technology used by surgeons to manage problematic bleeding. Funding was key to the development of the technology
	Sygnature Discovery	Same as XenoGesis & Critical Pharmaceuticals	Trust is built in escalating series with partners	Same as all the other participants	Same as	Same as above	Gold standard' techniques in pain, metabolic and CNS disorders, inflammatory disease and in vivo pharmacokinetics
	BAST Inc.	The firm has a strong network of 24 other firms. The CEO has personal connections with expert scientists & connections developed from his previous employment	Same as Critical Pharmaceuticals	Collaborations are seen as the route to new drug discoveries	Same as XenoGesis	Same as with all the other firms	New statistical tools in parameter estimation and optimal design e.g. Risk and Utility Assessment through Mechanistic Modelling

Bellamy & Perri (2009, p.59) suggest that a case-study strategy “enable researchers to study and measure the interaction between factors, or variables, in producing outcomes of interest”. Indeed, by understanding the influence of elements that include: networks, trust, knowledge sharing, prior learning & absorptive capacity the researcher was able to analyse how the firms generate fluid scientific knowledge and acquire new technology. More importantly, the researcher was also able to understand the degree of importance small born-global bio-tech firms place on each factor and the strategies they adopt to ensure that they enhance their capacity to make crucial innovations.

This provides the reader with a detailed analysis of how the formulated measures perform a key role in the knowledge supply-chain of the firms under investigation. This is consistent with Miles & Huberman (1994) who suggest that doing an aggregated case analysis with a core list of variables identified as having a strong impact cross several cases is a very powerful way to move from very case-specific explanations to findings that bridge to the discovery or re-enforcement of constructs. Maxwell (1984) makes a strong case for analysing data this way arguing that “casual explanation is a legitimate goal of qualitative research, and one for which qualitative methods have some unique advantages”.

The strength of the ties and relationships within networks were used to measure social capital broadly defined as the sum of the actual and potential resources embedded within, available through and derived from the network of relationships possessed by an individual or social unit. Therefore, the types of connections that the CEOs/founders or science directors had developed from previous employment and through networking acted as a channel for novel information inflows (Powell & Grodal, 2005).

The end result of a process for developing innovative capabilities is the formation of new scientific mathematical combinations or the development of new clinical product. In making this assumption the researcher is aware that the measurement may be limited; the use of SPSS computer software would have generated some quantitative data to indicate the exact strength of the relationship between the dependent factor - scientific knowledge/technical know-how for example with independent elements within the knowledge supply-chain such as business & social networks, competence & goodwill trust etc. However, the questionnaire survey did not generate sufficient data to test the strength of the relationships between these elements.

The structural dimension was measured by the types of actors that were included in a network of a born-global bio-tech firm (e.g. scientists, academia and research institutions) and how they were reached through the network given that some were located overseas (Lindstrand *et al.,* 2011). To measure the relational dimension of social capital the researcher used acceptable measures including: trust, trustworthiness, norms and obligations in a global network (Fukuyama, 1995; Coleman, 1990; Putnam, 1993). The cognitive dimension was measured through resources that provided “shared representations, interpretations, and systems of meaning among parties’’ (Nahapiet & Ghoshal, 1998, p.244).

3.9 Ethics in social science

The issue of ethics in social science research has far-reaching consequences for the subject under study. Surprisingly Easter-Smith *et al.* (2012) highlight that in management research both the British Academy of Management and the American Academy of Management have been very relatively relaxed about the provision of ethical codes.

Pressure to have a code of ethics which every social science researcher should adhere to has been mounting especially from other academic disciplines including: medicine and psychology (see Easterby *et al.*, 2012). A number of scholars have attempted to define ethics. Saunders *et al.* (2003) define ethics in the context of research. The scholars agree that "ethics refer to the appropriateness of the behaviour in relation to the rights of those who become subject of your work or are affected by it" (p.95).

In that sense, the researcher ensured that his actions did not have an adverse impact on small bio-tech firms he is investigating. Wells (1994, p.284) define ethics in terms of a "code of behaviour appropriate to academics and the conduct of research". The behaviour of the researcher was hugely influenced by the broader social norms within the bio-tech industry. Zikmund (2000) contend that a social norm indicates the type of behaviour that a researcher has to adopt during the process of collecting data in the bio-tech industry e.g. respect and privacy of the research participants. Henn *et al.* (2009) point out that when we talk about ethics in social research the main goal is to address those issues concerned with the behaviour of social researchers and the negative consequences that their research may bring to the people they study. Well (1994) affirms that in reality the prevailing norms of behaviour inform a wide range of ethical positions for the researcher.

3.9.1 Ethical considerations

In Barnes (1979) ethical factors are portrayed as factors that "arise when we try to decide between one course of action and another not in terms of expediency but by reference to standards of what is morally right or wrong" (p.16). Saunders *et al.* (2003) agree that ethical concerns will emerge as the researcher plans to collect data i.e. planning to gain access to small born-global bio-tech firms, collect analyse and report about their collaborative activities.

Henn *et al.* (2009) suggest that ethical considerations do not focus on the researcher but they place the spotlight on the participants of that study and when designing research scholars need to ensure their protection. Indeed, when conducting research it is important that the research participants are treated in a dignified manner which Collis & Hussey (2003, p.39) described as common *"courtesy*". Fisher (2007) stresses that researchers should avoid using the information they discover about people or organisations to harm them. Furthermore, Fisher's suggestions are particularly relevant and important for this study. Necessary steps and measures ensured fair treatment of the participants were put in place in accordance with the requirements of Nottingham Trent University (NTU) policies concerning conducting research. In the same vein, Collis & Hussey (2003) affirm that in any research project it is ethical to inform potential participants of the purpose of the research and to obtain their agreement to their participation. As such appropriate documentation outlining data confidentiality and the participant's consent to the interview was arranged and it can be found in appendices 2, 3 & 4.

3.9.2 Confidentiality

Information collected about the collaborative actions of small born-global bio-tech firms is held with the strictest confidence to safeguard the originators and a confidentiality form was signed. This is consistent with a number of scholars (see Saunders *et al.,* 2003/2007; Bellamy & Perri, 2009; Henn *et al.,* 2009). It is an important step in the data collection process in the sense that this thesis will be published for public consumption. Therefore, it is crucial that firm specific information or product commercialisation data is not made public unless the firm or a bio-entrepreneur agrees to data being made available to the general public (Fisher, 2007).

3.9.3 Informed consent

Social scientists (see Fisher, 2007; Gerring, 2005; Burns & Burns 2008; Henn, *et al.,* 2009) acknowledge that regarding research ethics the issue of informed consent is perhaps the most important one. For any small born-global bio-tech firm or bio-entrepreneur wishing to participate in the interviewing process a consent form was designed outlining what their participation entails. This ensured that the participants were fully aware of the purpose of their participation and how the data they generate will be used and stored.

The consent form explicitly details information about how generated data will be stored, presented and who will have access to it. Barrett (1995) makes an important statement regarding ethical considerations in organisational research by expressing that regardless of how robust and sound the chosen research approaches, methodologies, and methods are for any research, ethical considerations are very important and it is essential that the researcher investigates these implications before commencing the project. Saunders *et al.* (2003) emphasise the need to ensure that the promise to maintain the confidentiality and anonymity of the participant is kept throughout the research project. Easterby-Smith (2002) discusses how snowball sampling can cause serious ethical problems. The scholars emphasise that great care should be taken to maintain each participants anonymity. Indeed, the University's guidelines i.e. Nottingham Trent University Code of Ethics makes it clear and compulsory that a research project must meet the following criteria:

a) *Integrity* – the research has been carried out in a rigorous and professional manner
b) *Plagiarism* – proper acknowledgement has been made regarding the origins of the data and ideas used by the researcher for the purpose of the research

c) *Data Handling* – the researcher has ensured that there is effective data record-keeping, proper storage with regard to confidentiality and data protection
d) *Ethical Procedures* – the researcher has ensured that, in line with the university procedures, ethical approval is granted by the Research Ethics Committee. This procedure ensured that the research project conforms to the required codes of conduct

Appropriate documentation is attached in appendices (*see appendices 2, 3 & 4, p.265-282)* showing a completed ethical approval form and a sample of a consent form outlining steps that have been taken to protect the participants.

3.9.4 Research limits

As much as the chosen research approaches are deemed appropriate for this study the researcher is aware of the inherent limits of the methodologies. The researcher undertook a "pilot" study to inform the design of the actual study and that process required significant resources which meant that more time was devoted to data collection and transcribing it consequently generating huge amounts of data and some of it was not needed.

The critics of case-oriented research (COR) design point out that the proponents of COR find it difficult to cope with huge volumes of data (see Bellamy & Perri, 2009; Henn *et al.,* 2009). This makes the research strategy susceptible to the problem of producing particularistic insights and the relevance of its findings maybe unclear in a different setting (Bellamy & Perri, 2009). Henn *et al.* (2009) contend that this situation leads to a lack external validity or generalisability of the research findings. Similarly, Remenyi *et al.* (1998) argue that case-oriented research studies lack objectivity and rigour.

Bryman (2008) highlights that the main question that has been subjected to much debate regarding the use of case-oriented research approaches concern its validity and its generalisability. Henn *et al.* (2009) agree that the issue of the extent to which inferences maybe drawn from case-based research approaches is a contentious one and can be decisive for researchers of such a research design. Maybe in defence of these criticisms levelled against COR, by design the research approach seeks to understand contemporary phenomenon and in that regard the idea of objectivity is not something that this research is aiming to achieve although *critical realism* suggests both elements of subjectivity and objectivity (Farquhar, 2012).

In a further attempt to counter the arguments against the COR Henn *et al.* (2009); Bellamy & Perri (2009); Bryman (2008) discuss the idea of trade-offs in social science research. Indeed, a shortfall in identifying the general law of small born-global bio-tech firms is a small price to pay in favour of the richness and depth of theoretical insights of these types of firms which can be gained through a well-designed and well-executed case-study. Nonetheless, the research could have benefited from the use of a quantitative research technique such as SPSS computer software.

As the study aims to explain the relationship between innovative capability development and variables that include business and social networks, trust, inter-organisational collaborations, tacit and explicit knowledge, prior learning and absorptive capacity the researcher is aware that the use of SPSS to generate chi-square tests and frequency tables would have enhanced the research findings as well the accuracy and validity. More importantly, the researcher would have identified the level of impact each variable had on the process of developing innovative capabilities for small born-global bio-tech firms.

An attempt was made to generate data by distributing a questionnaire using survey monkey but not enough responses were collected (see *appendix 6* for a sample of a questionnaire). Over a period of about four months only two responses were returned. As time was of the essence for this study the questionnaire technique was subsequently abandoned. Another reason for dispensing with the use of a questionnaire was that the nature of the study required the researcher to develop a deeper understanding of the research phenomenon and in that regard the use of questionnaires would not have sufficed.

Chapter 4

4. Research findings

This chapter of the thesis provides the reader with the research findings based on within and across case analysis. The chapter culminates with the proposal of a new model of knowledge and innovative capability development. The new model uses seven propositions to explain the connectivity of building blocks of networks, competence & goodwill trust, inter-organisational collaborations, tacit & explicit knowledge, prior learning & absorptive capacity in the knowledge supply-chain of small born-global bio-tech firms. The also explains their impact on the process developing innovative capabilities for these bio-tech firms.

Baxter & Jack (2008) suggest a number of ways for reporting the findings of case-study research. The scholars suggest that findings can be reported by telling the reader a story, by providing a chronological report and by addressing each proposition. Benefits associated with remaining focussed and avoiding collecting large amounts of data attracted the researcher to tell a story about what is happening in the firms on which the case-study is based as well as the use of propositions as a means for reporting the research findings. Yin (2009) affirms that “theoretical propositions stemming from “how” and “why” questions can be extremely useful in guiding case-study analysis”. The researcher also utilises the principles of an analytical strategy by developing case descriptions for each case. The main aim is provide the reader with rich data about the research subjects.

4.1 Case findings

This part presents detailed findings within each case. It describes the actions of small born-global bio-tech firms regarding how they develop their innovative capabilities. This is consistent with Eisenhardt (1989, p.540) who suggests that "within case analysis typically involve detailed case-study write-ups for each site".

Indeed, this part of the study narrates the actions of individual firms which informs the reader about what is happening in the complicated world of small born-global bio-tech firms (Huberman & Miles, 1994). In other words, the researcher is making the complicated situation of the research phenomenon understandable by reciting the collaborative actions of each bio-tech firm and by explaining how they fit in together according to the concepts of dynamic capabilities and the network theory. Scholars Gersick (1988) and Pettigrew (1988) acknowledge that although within case analysis is purely descriptive the research technique is crucial in terms of enabling the reader to gain an insight into the research phenomenon. More importantly, within case analysis assisted the researcher to cope with a large volume of data collected from the research sample (Eisenhardt, 1989).

Further, Voss *et al.* (2002) suggest that following a detailed account of the case-study companies the next thing would be to analyse patterns of data within each case. In light of this section 4.3 provides a cross case synthesis of collected data (Yin, 2009; Huberman & Miles, 1984). In Voss *et al.* (2002) constructing an array or display of data is seen as a very useful way of presenting it. As such, table 9 on p.143 provides an array of data describing small born-global firms and science institutions. The data on science institutions is provided to give the reader more information regarding their assumed position in the process of capability development in terms of facilitating a platform on which small born-global bio-tech firms develop their innovative capabilities.

The main aim for doing within case analysis following a general outline of the activities of the sampled firms was to become intimately familiar with each bio-tech firm particularly all the elements that influence their capacity to generate fluid scientific knowledge (Stake, 2005). This assisted the researcher to uniquely map out the pattern of each case prior to generalising across the cases (Eisenhardt, 1989).

Table 9: Description of Small Born-global Firms comprising the sample

Firms	Origins	Bio-tech Activity	Year Founded	No. of Interviews
Critical Pharmaceuticals	UK-based biotechnology spinout company from the University of Nottingham	Involved in drug delivery technologies for the sustained release and nasal delivery of proteins and peptides and labile or insoluble small molecules. Delivers Advanced Therapeutics	2002	6
XenoGesis Ltd	UK based founded after the closure of AstraZeneca	Specialises in pre-clinical drug metabolism and pharmacokinetics (DMPK), quantitative bio-analysis and expert interpretation	2011	6
Haemostatix Ltd	Spin-out firm from the University of Leicester – UK based	Develops a pipeline of haemostats based on its new class of active ingredients that replace thrombin. The firm also commercialises its new technology platform based upon a specific peptide sequence that binds to fibrinogen – a protein essential to the formation of clots.	2003	3
Sygnature Discoveries	Founded in BioCity Nottingham	Provides integrated drug discovery services. The company is also involved in a wide spectrum of drug discovery programmes and the outsourcing of discovery projects to contract research organisations (CROs)	2004	3
BAST Incl.	Spin-off business launched after the announcement of the closure of the AstraZeneca	The pharmaceutical company is involved in a new drug development process known as Model-based Drug Development (MBDD) where investment decisions are supported by a simulation of the probability of success. The company is part of a collaborative network of twenty four other organisations with the East Midlands and internationally.	2010	6
Science Institutions		**Networking Activity**		
BioCity Nottingham (BCN)	A result of collaboration activities between Nottingham Trent University, The University of Nottingham and EMDA	UK's largest bio science innovation centre. Operates as an incubator for small firms within and outside the region. Currently houses advanced equipment and technology in over 12,000m2 of bespoke laboratory and office space and it is also the site of a new nano-technology and micro-technology fabrication facility for the East Midlands region (BioCity, 2012).	2003	1
Medilink East Midlands	Part of Medilink UK which was established in 1999 operating in other parts of UK	It is a life science industry association, whose aim is to help companies establish, develop and grow and connects them with other global players. Its network consists of more than 4,000 contacts in over 600 organisations represents all aspects of the sector, including private and public institutions; from multinationals to high potential start-ups, as well as the NHS and universities.	2004	2

Pera Innovation Park	Part of a Europe network established 65 years ago to help UK & Europe businesses	Pera Technology helps hundreds of companies across Europe and beyond to harness the potential of science and technology to create new and valuable products and processes to create sustainable, valuable businesses. The innovation centre also provides integrated R&D services for firms of all sizes	2008	3
Midlands Enterprise Europe Network	Part of Enterprise Europe Network (EEN)	The Midlands Enterprise Europe Network is a local node within a network of 600 regionally based contact points covering the entire European Union and beyond. The Enterprise Europe Network is the official EC business support network for business cooperation and technology transfer, providing organisations with access to technology transfer for technological cooperation, research, licensing, manufacture and joint venture agreements.	2008	3

Case 1 – Critical Pharmaceuticals Ltd (CP)

Year *Important events*

2002 Critical Pharmaceuticals was established

2004 Since CP started trading 2004 was the first year the firm secured Seed funding in the region of £1.5m

2005 CP received funding (£1.4) from Quester Capital

2007 Lisbeth Illum was appointed as the CEO

-Working in collaboration with scientists at the University of Nottingham CP announced the completion of a series of pre-clinical studies investigating the effect of supercritical CO2 on a therapeutically relevant protein – human growth hormone ('*hGH*').

-CP also announced the successful completion of proof of concept of two single shot vaccines developed using their NanoMix™ technology.

2008 CP was awarded two CASE awards by the Biotechnology and Biological Sciences Research Council (BBSRC)

-CP was further awarded a £33000 grant by the Bioknex Industrial Partnership Scheme to help the firm to assess the potential of drug discoveries

-CP presented their discoveries at the Controlled Release Society's Annual Conference in New York

-Potential investors endorsed CriticalMix drug delivery technology and CP's own pipeline potential

2009 CP secured the sale of their anti-obesity nasal drug with Global Health Ventures Inc. (OTCBB: GHLV), a HealthCare Technology merchant bank

2011 CP entered into collaboration on the development of a novel injectable sustained release drug delivery system with PolyTherics Limited which is expected to run until 2014

2012 Critical Pharmaceuticals and the University of Nottingham jointly developed Nano-Enabled Nasal Spray for Osteoporosis

-The Technology Strategy Board and the Engineering and Physical Sciences Research Council (EPSRC) provide grant funding to support the £545,000 project.

A narrative of CP

Critical Pharmaceuticals Ltd was formed as a spin-out company from Nottingham University (NU) in 2002. The bio-tech firm was established by two researchers in chemistry and pharmacy (BioCity, 2012). The co-founder of the firm, who is a world-renowned scientist in the field of super-critical fluid processing, discovered that super-critical carbon dioxide (scC02) could be used to mix sensitive substances into the polymers. According to its CEO this was the groundwork that the firm needed to take-off. The firm produces polymers that are used in medical devices and for drug delivery on a research contract basis. The CEO explains that CP is now independent and it no longer receives any support from University of Nottingham. In 2004 the firm received seed funding from Mobius – a regional funding institution and it moved into new premises following the formation of BioCity Nottingham (BCN).

As the company further developed its technology and products it attracted more funding from leading UK investors including: Catapult Venture Mangers, The Lachesis Fund, e-Synergy, East Midlands Business Angels and The Wellcome Trust as well as other business angel investors (Critical Pharmaceuticals, 2012). The company further received funding from the Wellcome Trust which enabled the firm to transform the delivery of '*hGH*' by enabling non-invasive delivery. '*hGH'* is a drug which treats human growth disorders in adults and children. For Critical Pharmaceutical funding performed a key part in terms of unlocking its innovations.

Business & social networks

The firm's established business and social networks considerably improved its capabilities to make new innovations. For CP, BCN is seen as important platform which enables connections with complementary businesses to actually happen. According to the CP's business development officer (BDO) his personal connections have also been valuable to its (CP's) economic development.

He particularly refers to other scientists who he met at university, and those who he worked with in his previous employment, as sources of science knowledge. He explained that they are often in touch and they frequently exchange ideas and problem solving techniques in science. Moreover, the top management team (the CEO, BDO & Science Director) who are the key informants for this study collectively agree that CP access financial support, expertise, marketing, PR, and scientific knowledge from tenants at BCN and from their global personal and business networks to back-up their business operations. The BDO continued to explain that science knowledge and financial support are essential resources that are necessary to improve operational efficiency if one is to achieve the firm's corporate goals.

In addition to this, its head of process development confirmed that networks are important for CP in the sense that they enable the firm to access scientific capabilities that are not available internally. He stated that they facilitate both domestic and international links with other firms, academic institutions, investors and research centres. He said this enables CP to acquire important science-related information, knowledge and to secure the much-needed funding.

Alliance-development

According to Harryson *et al.* (2007) innovation is a learning process which occurs by participating in open collaboration involving a wide range of actors as opposed to operating as a lone ranger in a laboratory. It is widely accepted in the literature (see Chesbrough, 2003a, Freeman *et al.* 2013, Polanyi, 1948) that innovation is based more upon personal interaction, emulation and joint learning among a variety of actors than upon the pure upstream and quite isolated technology development process. A look into the itineraries of the top management team validates that they engage in international conferences deliberately convened for the purpose of encouraging collaborative partnerships and learning.

For example, in April 2013 the CEO of CP said that he attended BIO International Convention in Chicago in the US, the head of process development disclosed that he presented case studies on the delivery of biological drugs at an American Association of Pharmaceutical Scientists National Biotechnology Conference in May 2013 and the head of Pre-clinical and Clinical Development at CP revealed that he attended the *Biosimilars to Biobetters* conference in Stevenage, UK in May 2013. Based on the top management team's participation in a wide range of networking activities in science-themed conferences, it is clear to see that CP aims to hone/sharpen its drug delivery processes by receiving feedback from world renowned scientists, well-established biotechnology firms and research institutions. This is consistent with Roudini *et al.* (2012, p.129) who insists that in global networks, "knowledge flow and exchange become possible through business connections and they foster communication between included groups, and establish a crucial channel for resource acquisition".

Similarly Yi *et al*. (2008) suggest that, integrating knowledge from diverse context is necessary to a firm's ability to generate new information which is essential for innovation. To underscore CP's intentions of developing strategic alliances the pharmaceutical company is involved in a joint collaborative project with PolyTherics Limited ("PolyTherics") estimated to be worth £700 000. The main purpose of the alliance is to allow the sharing of resources, assets and competences that are needed to enhance drug discovery activities. The science programme commenced in 2011 and it is expected to run until 2014. PolyTherics Limited is a London based company which uses biomedical polymers to optimise pharmaceuticals, in particular biopharmaceuticals, for the treatment and cure of the world's most debilitating diseases. Their expertise and knowledge capabilities complement Critical Pharmaceuticals' technology of human injectable drugs.

According to Jordan the Head of Preclinical and Clinical Project Management at CP the pharmaceutical company engages in collaborative activities that are aimed at driving processes in drug delivery. In addition to the pharmaceutical company's collaboration with PolyTherics Limited it works in partnership with some of the leading institutions within the East Midlands. These include: the University of Nottingham (UN) and Nottingham University Hospitals NHS Trust to develop its innovative formulation known as '*teriparatide'*. The CEO of CP expressed that the company was excited with the idea to work with internationally recognised clinicians and scientists at The University of Nottingham and Nottingham University Hospitals NHS Trust to rapidly develop a highly innovative formulation of '*teriparatide*'.

Trust-building

According to Granovetter (2005) close knit ties enable a strong element of trust which makes it possible for the exchange of vital resources to take place. Both the CEO and the BDO at CP emphasise that they exchange scientific knowledge with those partners who they trust. They both claim that without trust, project-based collaborations may not be productive. The head of process development explained that most of the companies they work with have people who they have met in transitional encounters (seminars, conferences and workshops). In transitional encounters where usually there is a loose agenda the BDO suggests that tacit knowledge can be exchanged on a small scale and he said in most cases this marks the beginning of the trust-building process. This endorses Granovetter's (1973) dated but influential study concerning weak and strong ties. Granovetter argues weak network ties can be productive in the sense that they allow very detailed and useful information to flow between individuals. Furthermore, the BDO maintained that CP develops trust with partners based on their competences, reputation and he explained that the more you work with them the more you get to know them.

He elaborated on this saying that CP uses small projects as a way of testing the trustworthiness of its potential partners. The company's CEO concurred with this expressing that CP conducts due diligence on its potential business partners with a view to predict or construct a picture of their likely behaviour based on their previous dealings. He related the process of trust-building with potential partners to experiments in a science lab where one tries different science mathematical combinations until he/she comes up with the right solution which provides acceptable results.

Knowledge creation

CP generates its knowledge by engaging in science-related research programmes with its trusted partners particularly, the clients who contract them carry out drug testing functions. Data generated in research programmes, that involve CP and its clients/partners, is shared via a central data pool which can only be accessed by authorised individuals. The Head of Preclinical and Clinical Project Management explained that, they openly share and exchange ideas, business processes and scientific knowledge with all the companies taking part in a specific science project/programme. These he said are either their clients or collaborating partners. He said that openly sharing science data is anchored on trust built over a number of years with their partners/clients. In their efforts to continuously generate knowledge CP's CEO said that the company sponsors PhD students. This is consistent with the literature Lawton-Smith (2006) argues that universities perform a leading role; they foster a steady supply of scientific labour, which invaluable to the knowledge economy. Students work as understudies to experienced scientist at CP. To harness all the knowledge generated in such joint collaborations CP enters into a binding contract with the students. The CEO explains that the science knowledge generated by students is protected and it becomes part of CP's intellectual property.

The intellectual property agreement they enter into with the student allows CP to have access and to retain the ownership of all lab-based experiments, outcomes, and research findings.

Prior-learning & Absorptive Capacity

The founder of CP is an academia and a world-renowned scientist in the field of super-critical fluid processing with 15 years of experience in the life science sector. According to a University website profile where the co-founder also works as a professor, it is publicised that he is the Chair of Chemistry at the University. He has published over 300 papers in high-level scientific journals. Structurally, the top management team at CP consists of well-experienced scientists who have international connections and they all share the same view about the world of science. Table 10 below illustrates the cumulative experience of the top management team.

Table 10: The top management team and the board of directors of CP

Name	Title	Background/Experience
David Gouch	Chairman	Founded or co-founded 6 companies one of which, Vectura, has been successfully floated on AIM and moved to the main exchange in 2007. He also has over 30 years of experience as a senior manager, consultant, entrepreneur and investor and has raised, or helped to raise, close to £100m in equity capital and VC funds
Gareth King PhD	CEO	Experienced in the development and implementation of commercial strategy through deal making, business development and building strong collaborations
Terence Chadwick PhD	Non-Executive Medical Director	Experienced in internal medicine, endocrinology developing medicines for respiratory, metabolic and CNS diseases.
Professor Steve Howdle PhD	Founder and Chief Scientific Officer	He is a world-renowned scientist in the field of supercritical fluid processing with over 15 years' experience in the field.
Alan Baines	Financial Director	He was senior partner in an internationally renowned business development firm
Graham Ward	Non-Executive Director	Has 16 years' experience in consulting and from 1988 to 2004. Graham was a Director Pricewaterhouse Coopers and Deloitte. He served as a Non-Executive Director with Nottingham City Hospital
Andrew Naylor PhD	Head of Process Development	Andrew has over 9 years' experience of polymer synthesis and processing in supercritical fluids. He manages a range of internal and external collaborative R&D projects
Faron Jordan PhD	Head of Preclinical and Clinical Project Management	has several years' experience working in contract research as well as experience in quality assurance for a biotechnology company where he was responsible for GLP compliance
Professor Lisbeth Illum PhD	Scientific Advisor	Lisbeth is a world-renowned scientist and entrepreneur in the field of novel drug delivery systems for difficult drugs, such as peptides and proteins
Professor Stephen Shalet	Consultant Endocrinologist	Stephen is a world-leading expert in the treatment of children and adults with endocrine disorders
Professor Martin Savage	Consultant Endocrinologist	Professor Savage is a world-leading expert in the treatment of children with endocrine disorders.
Derek Riley	Qualified Person (QP)	Derek is a senior pharmaceutical executive with extensive global experience in pharmaceutical research and development, regulatory compliance, quality assurance, quality control and facilities qualification / validation
Andrew Burgess	Process Engineer	Andrew is a Chemical and Bio-Process engineer who has been working in the field of supercritical fluids for over 10 years.

The CEO of CP claims that the idea to have a top management team that has experienced, multi-skilled scientific, clinical and commercial leadership team directed by a board of international standing with a broad base of expertise and deep knowledge in science is to enable CP to have a good understanding and an awareness of the capabilities that are required to enhance innovation and improve firm productivity. He insists that the firm's top management team performs a decisive role in unlocking its innovation conundrum. He further elaborates that their (top management) years of experience in the biotechnology sector considerably enhanced their capacity to make important drug discoveries.

Thus, a good understanding of science by key people in the business increased the CP's chances of making rapid progress in developing nasal administered drugs. Oviatt & McDougall (1994) express similar views arguing that the previous experience of the management team has affirmative influence in enhancing a firm's formation of capabilities. Admittedly, one of the advantages of a well-networked top management team to CP is that the bio-tech firm can potentially tap into their networks and make points of entry into elements of the global innovation systems. CP has a strong advisory board and the role of the board is mainly to get connected to international competency. Other possibilities for getting contacts include personal networks, through academia and through being exposed internationally at conferences. CP gets exposed a lot through EU projects and conference.

Case 2 – XenoGesis Ltd

Year	*Important events*
2011	XenoGesis was founded following the closure of AstraZeneca - its founder was made redundant by AstraZeneca in 2011
2012	XenoGesis top management attend Bio-Spain 2012 – an international meeting on Biotechnology -The firm announced a positive first quarter in its first year of trading

-XenoGesis Won the Best Start-up award at the 2012 Medilink Innovation Day

-XenoGesis enters into a strategic alliance with XenoTech a US-based company

2013 XenoGesis was awarded a grant for research from the government-backed Biomedical Catalyst Feasibility grant

-XenoGesis attended Bio-Europe Spring's 7th Annual International Partnering Conference in Barcelona

-Dr Richard Weaver the founder of XenoGesis attends the International Society for the Study of Xenobiotics (ISSX) Workshop on The Role of Drug Metabolism in Immune-Mediated Drug Toxicity in Boston, USA

-With its US strategic partner XenoGesis co-sponsored a booth at the exhibition in Boston, USA

-XenoGesis introduces two new key physicochemical assays: kinetic solubility and logD7.4

-Dr Iain Beattie an experienced mass spectroscopist joins XenoGesis team in August 2013

A narrative of XenoGesis

XenoGesis Limited is the brain child of Dr R Weaver who is an ex-AstraZeneca employee. AstraZeneca the world's fifth largest drug company, which develops treatments for lung and breathing problems, closed its research facilities in Loughborough as part of a global restructuring strategy. This move resulted in the loss of 1,200 jobs. The restructuring exercise by the giant drug company forced Dr Weaver to set up his own business. The scientist said that this gave him the opening to start-up his own business something that he has always wanted to do as such, the termination of his employed acted as a catalyst. He expressed that, "where there is a threat, there is also an opportunity". He started his contract research organisation (CRO) with limited resources. He rented a laboratory facility at BioCity Nottingham Ltd (BCN). Despite Dr Weaver's association with AstraZeneca there is no connection between his company and his former employer. Based at BCN – the region's science incubator, XenoGesis specialises in pre-clinical drug metabolism and pharmacokinetics (DMPK), quantitative bio-analysis and expert interpretation.

The company's laboratory tests have shown how the human body might affect the way a drug behaves. XenoGesis received rewards as recognition for its achievements. In July 2012 the bio-tech firm was awarded the Best Start-up Award at the East Midlands innovation awards ceremony hosted by Medilink. The pharmaceutical company operates as a CRO advising its clients on how to modify the chemical structure of a compound so as to make it more 'drug-like'. Its founder and CEO claims that the company's ability to utilise sophisticated science combinations makes its services attractive to global drug companies. The company signed-up several international clients including pharmaceutical companies from the USA and Europe in its first year of trading. XenoGesis has three revenue streams at the core of its business: (1) Pre-Clinical Drug Metabolism & Pharmacokinetics (DMPK / ADME) lab services, interpretation and recommendation, (2) Quantitative Bio analysis, (3) Expert Drug Discovery DMPK Consultancy.

Business & social networks

The operations manager of XenoGesis states that they have close relations with their strategic business partners and in most cases they are long-term. He maintains that close business ties are crucial to the firms' continued development and growth. The founder of XenoGesis considers his connections which he established during his time at AstraZeneca as vital to the success that his company has enjoyed since its inception. At BCN the firm has developed a strong network consisting of former work colleagues who have started their bio-tech ventures, investors and innovation science experts. XenoGesis' operations manager suggests that the firm has grown from strength to strength. In November of 2011 it moved to a bigger office space at BCN. Its founder and CEO explained that:

> *I read about the support being offered following the AstraZeneca R&D Charnwood closure announcement and over the past year I've received fantastic advice and encouragement from the BioCity team.*

The highly reputable address, the support infrastructure, the access to shared facilities such as the Biotel laboratory and being close to so many other innovative companies in the sector means that XenoGesis will have the best start and I'm really excited about its future.

Thus, the founder's structural social capital performs a decisive role in enabling XenoGesis to acquire financial resources, crucial scientific knowledge, and technical know-how. Furthermore, the CEO maintained that, "it is quite unusual for a new company working in this field to get off to such a flying start but we have the support of a strong Board of Directors and staff team, and several international partners". In March of 2012 Mobius Life Sciences Fund which is part of XenoGesis network at BCN announced an investment in the firm citing its fast growth as the main reason for investing.

More importantly, Mobius funding came with help and support from experts at BCN which was targeted at ensuring XenoGesis' continued growth and improved drug discovery activities. Support and funding are part of XenoGesis's structural dimension and this is similar with the other 4 firms sampled for this study which benefit from the support offered at BioCity. The Director of the Mobius Life Sciences Fund Dr Glenn Crocker explained more about why his organisation invested in XenoGesis:

XenoGesis has already shown its growth capability by winning significant contracts and exceeding its early targets. The highly experienced and committed management team are focussed and passionate about what they do. They are ambitious but also realistic in their plans. I believe XenoGesis is just the kind of venture Mobius Life Sciences is looking to invest in.

The achievement of funding was noted as an important breakthrough for XenoGesis which enabled the young firm to advance its drug development processes.

Alliance-building

The BDO at XenoGesis believes that building strategic alliances is a very important strategy which enables the firm to bridge its knowledge gaps. The drug company works with a number of partners which include: XenoTech LLC, JD International Consulting, PRECOS, and Cypex. To this end the founder and CEO said that:

> *Working in partnerships and collaborative projects increases our level of innovation by bridging the gap between our internal knowledge base and the threshold level required to discover new drugs. We also benefit in terms of low operational costs from our strategic partners and from those partners who have a good reputation we get access to their markets and their expertise.*

As a strategy for building strong alliances the firm incorporated directors from other firms to work in an advisory capacity directing drug discovery processes. XenoGesis does not only work with scientists within its locality; the entrepreneurial bio-tech firm aspires to develop links with reputable international bio-tech firm, research institutions and science labs. In the recent past its CEO together with the chief science officer were involved in conferences on biotechnology and science in London and Barcelona that took place in June of 2012. The conferences provided the firm with an opportunity to network with potential partners in the region of 80 international experts in the field of drug metabolism. According to its science director this partnering exercise considerably increased the firm's possibility to develop productive alliances. The widening of the XenoGesis' business and social connections (structural and relational dimension) has enabled the firm to grow at a fast pace and to achieve scientific excellence and innovation.

Trust-building

XenoGesis builds trust with its business partners by conducting due diligence. The company gathers intelligence about the level of technical abilities and reputation of their potential partners. In the majority of cases XenoGesis obtains this type of information from people who may have worked with their potential partners before or from their landlord - BCN. XenoGesis's CEO said that, "you form a partnership with someone you know very well and trust based on your previous interactions with them or they may have been recommended to you by the people who have already trust". The company's operations manager further adds that they look for partners who have higher skills and are well-established or well-respected in the bio-pharmaceutical industry. Similar to CP XenoGesis tests the trustworthiness of a partner by engaging in smaller projects and according to its operations manager they look for signs and signals which help to predict their likely behaviour. She explains that it is very important to try different combinations to ensure that you end up working with people who have the same scope and direction with the company.

Knowledge creation

When it comes to knowledge-sharing between XenoGesis and its various partners trust is seen as the main catalyst. A significant proportion of XenoGesis business partners consist of scientists who are known to the top management team. The CEO of XenoGesis said that he feels comfortable to share ideas and science-related data with his personal connections that he established during his time at AstraZeneca. The science director of XenoGesis expressed that the majority of the tests that they carry out are in the public domain (information is available to everyone). Together with the CEO they contribute to national and international scientific conferences by publishing science-related research papers that are accessible to other scientists. XenoGesis is also trying to develop its own science combinations which are specific to its business.

The science director said that data about their own science combinations remains confidential and can only be accessed by the people who have the right to view it.

Prior-learning & absorptive capacity

Cumulatively, XenoGesis has more than 70 years of combined experience in the pharmaceutical industry. The top management team consist of people who are educated to a PhD level and have considerable science experience obtained from their previous engagement with large pharmaceutical companies. Table 11 below illustrates their experiences in biotechnology.

Table: 11 The XenoGesis core team

Name	Title	Background/Experience
Richard Weaver PhD	Founder and Managing Director	Richard has held Project leader posts with a track record of delivery at early and late stages of the Drug Discovery process within AstraZeneca. He has also held multiple prestigious global roles
Dr. rer. nat. Manfred G. Ismair	Chief Scientist	Manfred Ismair is an experienced scientist in the fields of DMPK, molecular/cell biology and drug transport
Dawn Parkins	Operations Manager	Dawn Parkins is a Regulatory Affairs Professional and Research Scientist with over 20 years' experience working in commercial, academic and local government research institutions
Glenn Crocker PhD	Non-executive Director	Glenn Crocker is also Chief Executive of BioCity Nottingham Ltd, which he has grown over 9 years to be the largest bioscience incubator in the UK. BioCity creates, develops and provides investment, facilities and support to early stage life science companies
John Dixon PhD	Non-Executive Director	John Dixon has 36 years' experience in Pharmaceutical R&D in several therapeutic areas. He was Head of Medicinal Chemistry for 20 years at Fisons, Vice President of Preclinical R&D in Astra Charnwood for 4 years and Vice President of Drug Discovery at AstraZeneca Charnwood for 9 years
Nigel Boughton-Smith PhD	Scientific Advisor	Nigel Boughton-Smith has worked in the pharmaceutical industry for over 35 years and has a comprehensive knowledge and expertise in both drug discovery and early development. As the Discovery Leader in multidisciplinary Global Emerging Product Teams in AstraZeneca he managed the progression of a portfolio of discovery projects from lead identification to candidate selection and contributed to the successful delivery of a number of candidate drugs to Phase 1, Proof of Principle and Proof of Concept. Nigel has led a number of teams in the in vitro and in vivo evaluation of chemical entities from a variety of projects and also in establishing robust translational biomarkers for pharmacodynamics and efficacy measurement in clinical trials.
Dr. Iain Beattie	Spectroscopist	Iain has many years of experience of supporting DMPK mainly in drug discovery by using LC-MS/MS to detect and identify drug metabolites in a time frame that allows the information to influence drug design

The CEO of XenoGesis said that:

> *One has to understand the relevance of externally acquired knowledge to science and experience in previous science-related assignments play an important part of that. Given the experience our team of experts have in biotechnology we are in a better position to acquire the science that is necessary for our service.*

The explanation of the role of prior-learning above also imply that in his company the science experiences of the top management team abetted the process of 'soaking-up' useful scientific knowledge. In the literature Cohen & Levinthal (1990) maintains that AC is a by-product of prior-innovation and problem solving which is dependent upon individual ACs of members of an organisation. Clearly, the previous history and experience in life science of the top management team was crucial in terms of adding value to XenoGesis by assisting in assimilating useful information that was fundamental to its sustainable growth since its inception in 2012. In their study concerning the role of human capital in successful entrepreneurial ventures Gurău *et al.* (2010) observed that human capital available within an organisation can help the organisation to obtain positive business results.

Case 3 – BAST Inc. Ltd

Year	*Important events*
1991	BAST Inc. first operated in Houston and Austin, Texas, USA As a consulting business offering population PK and PKPD analyses on a contract basis to pharmaceutical companies. -BAST was dedicated to training scientists of its clients in the population approach -Joachim Grevel the founder offered workshops on the premises of BAST in Austin, TX, at GlaxoWellcome in RTC, NC and in London, UK, at Bayer Pharma in Delaware, USA and in Wuppertal, Germany, and at the FDA in Maryland, USA, and at the Canadian FDA in Ottawa. -During these early years Joachim Grevel defended numerous applications for market authorisation at the FDA
1997	The firm stopped trading in the US because Joachim intended to join AstraZeneca in the UK

2010 Following the closure of AstraZeneca's Loughborough research site in 2011 Joachim Grevel re-established BAST Inc. using BCN and Loughborough Innovation centre as its bases

2011 BAST took part in a research project on malaria vaccination involving international scientists

2012 Moved from BCN to Loughborough Innovation Centre on permanent basis
-Entered a joint partnership with an accounting firm MJ Reeves

2013 Entered into a collaboration to work with Loughborough University to develop new statistical tools in parameter estimation and optimal design, funded by grants of the European Union under the FP7 and IMI calls
-Recruited a Senior Clinical Pharmacologist
-Recruited a senior scientist in PKPD modelling, Clinical trial simulation.
-BAST is developing a state-of-the-art clinical trial simulator and it is inviting other companies to participate in their Advisory Board
-Entered into a knowledge transfer partnership (KTP) with Loughborough University

A narrative of BAST Inc. Ltd

BAST provides strategic consulting services to pharmaceutical companies to assess the potential for success of projects. The probabilities of success and failure are derived from simulations that use mechanistic models. The design of experiments and clinical studies are optimised, and the investment risk throughout a development portfolio is quantified. The founder of BAST first managed a similar business under the identical name in Houston, Texas, from 1991 to 1998 and the company stopped trading in 2000. Between 2007 and 2009 the founder of BAST worked for Merck Serono in Geneva. His tasks and responsibilities included: providing technical input to project based work, coaching of junior scientists, modelling and simulation. This demonstrates the founders' desire to work in a collaborative manner facilitating the free flow of scientific knowledge and technical know-how. In 2009 Dr Joachim Grevel moved to the UK where he briefly worked as a science consultant for a number of companies offering population-style data analysis.

Following the announced closure of AstraZeneca in 2010 he revived BAST in the town of Melton Mowbray in the East Midland in England. He assumed the role of a science director. BAST Inc. Ltd predicts the likely success of studies of new drugs by analysing existing knowledge and data. The company also conducts silico research, either publicly or privately funded, in areas of oncology, autoimmunity (e.g. asthma) and drug delivery (nano technology). BAST Inc. Ltd offers its drug discovery services to a global audience on a contract basis.

Business & social networks

When BAST started operating in the East Midlands in England it occupied two sites namely: BCN and the science labs at Loughborough Innovation Centre (LIC). The Loughborough Science Park is regarded as one of the largest innovation centres in the UK. According to BAST's clinical pharmacologist the innovation centre provides small businesses like BAST Incl. with access to world-leading research expertise, undergraduate and research students for projects and placements as well as graduates and postgraduates for employment.

In addition to this, BCN also provides BAST with the possibility to link up with other pharmaceutical companies and to benefit from financial and expert support including research facilities it offers. BAST's current structure can be described as globally dispersed. The pharmaceutical company works on a rhythm, which is focussed on establishing research collaborations with other bio-tech oriented ventures/organisations. The founder and science director of BAST explained that he has a number of personal networks that he feels have been instrumental to the development of his pharmaceutical company. He pointed out that his personal networks are wide spread.

In Europe he said that he established business connections in Switzerland, Italy, France and the UK where he was involved in a number of research programmes as well as in the US where BAST initially traded in the 90s. In Italy the pharmaceutical company is part of the Gaslini Network. Gaslini International is an extensive program of co-operation promoted by the Gerolamo Gaslini Foundation. The foundation intends to establish a network between the Gaslini, research organisations and hospitals in the Mediterranean area. Europe and America are seen as destinations where the firm can engage with other actors in the biotechnology sector to complement its drug discovery services. As part of BAST's aspirations to establish international links, the pharmaceutical company has developed clients in multiple countries. Concerning its activities in terms of networking, the company is part of a collaborative network of twenty four other organisations operating locally (East Midlands) and internationally. According to its founder business networks have been an important part of BAST's drug discovery process.

Alliance-building

BAST is actively seeking to develop strategic alliances with other research institutions (both government and private), organisations and hospitals. In Europe BAST engages in research programmes that are initiated by the Community Research and Development Information Services (CORDIS) a gate way to opportunities for European research and development. According to its founder such links are vital for scientific knowledge which underpins the process of drug discoveries. To underscore its founder's business model, BAST established a research partnership with a Medicine for Malaria Venture (MMV), a not-for-profit public-private partnership which was established as a foundation in Switzerland. The firm was aware that huge amounts of resources will be required to develop modelling and simulation tools to assess the risk and improve decision making.

As such, BAST committed to contribute model-based design and decision support to the partnership on innovative strategies for preventing or treating poverty-related diseases. This demonstrates the firms' commitment to engage in international activities with a view to perform a leading role in knowledge sharing as well as to take advantage of the opportunities global markets offer. This can be directly attributed to the founder's experience with foreign markets given his time in Houston, Texas. Madsen & Servais (1997, p.569) suggest that "commitment decisions depend very much on experience since they are a response to perceived uncertainty and opportunities in the market". According to Helen BAST's senior pharmacologist the MMV's scope of partnering was to involve: NGOs, Universities and other SMEs to jointly submit a project proposal with a view to apply for research funding from the EU Commission's FP7 programme to treat malaria. Although dated but still relevant Wiedersheim-Paul *et al.* (1978) conceptualises that contract patterns are an important vehicle that allows for an efficient exchange of information and they create opportunities for knowledge transfer from partner firms. In the same vein, Burt (1982) and Gulati (1995) suggest that network research highlights the essential role inter-organisational ties play in terms of facilitating knowledge acquisition and its utilisation. To this end the Scientific Director at BAST Inc. commented:

> *We share knowledge with a number of actors in the biotechnology sector including knowledge centres in the East Midlands such as BioCity, science experts from Universities, other parts of UK and Europe. The idea is to share best practice as well as learn from other firms how they make innovations*

Trust-building

At BAST trust is developed in escalating series. The top management team at the pharmaceutical company tests the trustworthiness of their potential business partners by engaging them in smaller drug discovery projects.

As a contract research organisation its founder Joachim and senior scientists Rupert advocate for 'open science' where new information and ideas about drug discovery is honed, developed and exchanged without any caveats amongst the collaborating parties. Helen who is the senior clinical pharmacologist at BAST sums the company's trust-building processes with their business partners stating that:

> *In my view developing trust is a long process with a lot of little steps. Sometimes you chase a dead end and at times you find genuine people who are prepared to contribute to a lasting relationship in a meaningful way which eventually leads to a vital clinical outcome*

The process of developing trust with other firms, scientists and research-oriented institutions in multiples countries is fraught with a wide range of cultural-related challenges (Lasserre, 2012). BAST's founder is multilingual. He has a good command of several European languages which he said he uses as an effective tool in the process of establishing/predicting the likely behaviours of their potential collaborating partners. Thus, a good understanding of the values, assumptions and beliefs of the people one is dealing with is crucial in building trust and in facilitating close ties.

Knowledge creation

BAST Inc. Ltd creates knowledge in their R&D collaborations that the pharmaceutical company participates in. Helen explained that BAST Inc. Limited is in a Knowledge Transfer Partnership (KTP) with Loughborough University. The KTP between BAST and Loughborough University is jointly funded by BAST and the Technology Strategy Board. This alliance allows bench level collaboration using Zucker *et al.* (2002) description of project based collaborations. The structure facilitates mutual sharing of tacit knowledge and the collation of shared science knowledge into explicit knowledge.

This transfer and codification of knowledge at BAST was evident through the research publications emanating from shared work between the pharmaceutical company and its partners. The science director also explained that he presents lectures on Mechanism-based Risk Assessment in drug development. The lecture material includes some input (in the form of knowledge and ideas) from his top management team. In 2011 the science director was part of a European consortium which was approved by the Drug and Disease Model Resources (DDMoRe) as one of the Innovative Medicines Initiative projects of the European Union. The science director of BAST explained that the consortium's primary objective was to develop a drug–disease model library and an open-source inter-operability framework where other scientists can have access to information about the use of optimal design in Pharmacometrics. The project comprised of 9 academic groups, 6 small and medium sized enterprises, and 10 pharmaceutical companies (including BAST) who are also members of the European Federation of Pharmaceutical Industries and Associations.

One of the work packages for BAST and its collaborating partners was to develop and integrate new tools and adaptive optimal designs in pharmacokinetics/pharmacodynamics that employed non-linear mixed effect models (NLMEM). BAST's senior pharmacologist who works within a project team, offering strategic advice in all aspects of Pharmacometrics including supporting regulatory submissions emphasised that as Pharmacometrics continue to increase its scope beyond population pharmacokinetics, design tools for more complex models and for other types of data, especially discrete data, will evermore be needed. She further stressed that joint collaborations with academics, research institutions and investors are very much needed in order to constantly generate sufficient knowledge for developing complex models for discrete data. Thus, knowledge creation at BAST is situational and it is contingent upon the structural dimension of the pharmaceutical company.

In that sense, BAST's collaborative partners can influence or limit the pharmaceutical company's ability to engage in productive R&D programmes which impact on knowledge creation, its transfer and its dissemination.

Prior-learning and absorptive capacity

Similar to the other four cases BAST's top management team consist of well-experienced scientists and the majority of them are former employees of large pharmaceutical companies including AstraZeneca. These scientists have vast knowledge in life science. This strategy of forming a new venture which appears to be adopted by small global-oriented firms was noted by Sharma & Blomstermo (2003). The scholars observed that because born global firms are knowledge intensive-firms with a very high degree of knowledge content they employ individuals who possess high scientific knowledge. To this end the senior pharmacologist explained that BAST is continuously looking to add to its experienced workforce.

She revealed that they are expecting (as of June 2013) to be joined by a scientist who has diverse background and extended experience in applying a wide range of mathematical and computational tools to support decision making. The amalgamation of knowledgeable scientists was an important step towards developing innovative capabilities for BAST. Table 12 on p.166 illustrates the cumulative experiences of the top management team that the firm assembled with a view to broaden the firm's capabilities and the capacity to generate scientific knowledge from its project partners by 'soaking-up' useful data.

Table 12: Top management team of BAST

Name	Title	Background & Experience
Joachim Grevel, Ph.D.	Founder and Scientific Director at BAST Inc.	Former AstraZeneca employee. Consulting in Model-Based Drug Development (MBDD), Supervision of design and analysis work, Business development
Rupert Austin, PhD	Senior Scientist	Ex-AstraZeneca. PK, PK/PD, PBPK modelling and simulation. Population data analysis
Sheila Mburu MScs	Junior Modeller	Focusses on bioinformatics, biochemistry and genetics
Helen Walker PhD	Senior Clinical Pharmacologist	Experience of creating and managing a Global Team of senior Project Leaders during organisational change. 15 years' experience in Clinical Pharmacology and Drug Metabolism and Pharmacokinetics (DMPK) and a proven track record delivering within projects.
Aaron Hayman	Modelling Apprentice	Good programming skills, mathematical modelling ability, statistics and analysing skills and interest in scientific research
Garrit Jentsch PhD	Senior Scientist	Ex-AstraZeneca. PKPD modelling, Clinical trial simulation. Modeller in the Computational Biology Group, Discovery Sciences.

According to the senior pharmacologist at BAST; bringing in experienced people into the top management team is crucial for the company when it comes to acquiring new knowledge and in enhancing the profile (competency) of the organisation. She further explains that experienced team members in their top management team have been valuable in the sense that they brought their contacts to the organisations that include investors, academics and other important government stakeholders. This has added to BAST's capacity to develop essential tools for mechanistic models and optimal design of in vivo experiments.

Case 4 – Sygnature Discovery Ltd

Sygnature Discovery Limited was formed in 2004 through an MBO of the Synthesis department of CombiPure Ltd. Its founder/CEO has experience in research gained from major pharmaceutical companies including: AstraZeneca and OSI Pharmaceuticals; as well as in a commercial environment at CombiPure, where he was Managing Director and Director of Chemistry. The company offers integrated drug discovery solutions to pharmaceutical and biotechnology companies located in the USA and Europe. It operates within a network of expert Contract Research Organisations (CRO's) each specialising in their own area.

The company grew from five chemists to one that employs 56 medical chemists, vitro biologists and the majority of them have PhDs with considerable pharmaceutical industry drug discovery experience. This demonstrates that the top management team and all the employees share the same goals highlighting its cognitive dimension. Similar to the other four firms Sygnature benefited from the closure of AstraZeneca in 2011. The firm employed experienced ex-AstraZeneca medical chemists to cope with the demand of services from clients in the USA and Europe.

Taking the literature review into perspective, Dokko & Rosenkopf (2010) maintain that in addition to the knowledge and skills experienced individuals may have they may also bring pre-existing relationships that facilitates the transfer of knowledge and technical know-how. Specifically, the science knowledge of the company's employees and the experience of the top management team made the company trustworthy to investors. In 2006 the firm posted a turnover of £1 million and in the same year it received FP6 European project funding. Three years later the firm was awarded a £390,000 Grant for Business Investment (GBI) award by the East Midlands Development Agency (EMDA) and the European Regional Development Fund (ERDF). The firm entered into a strategic alliance with Cyprotex in 2009 which was later extended in 2011 for a further 2 years. Cyprotex Discovery Ltd is the world's largest specialist ADME-Tox/PK pre-clinical discovery and it performs a leading role in developing Contract Research Organisations (CRO). Similar to the other four firms sampled for this study Sygnature Discovery's structural dimension consists of a network of companies with some cognitive distance but with complementary foci. In the literature Nooteboom (2005) suggests that when absorptive capacity is aligned with organisational goals and aims it enhances organisational cognition. Indeed, interacting with other firms that may have different complementary foci at some cognitive distance solves what Nooteboom (2009) described as "organisational myopia".

Put differently, the firm was able to bridge its knowledge gap. The main reason for the alliance was to expand its collaborative sales and marketing initiatives in order to provide a fully-integrated discovery chemistry/ADME-Tox/DMPK service as well as accelerate its clients' drug discovery projects into development. Anthony Baxter the CEO at Cyprotex commented that:

> *We are delighted to have extended our strategic alliance with Sygnature. The quality of their work and their desire to help customers achieve scientific success has enabled both of us to form a formidable combined offering in medicinal chemistry-driven integrated drug discovery and ADME-Tox services.*

By using its structural and relational dimensions of social capital Sygnature was able to deliver innovative products and services to its clients as well as save significant amounts of resources in the form of time and financial capital. Crucially, the collaborating partners shared the risks associated with drug discovery. More recently, the firm entered into another strategic alliance with Pneumolabs (UK) Limited with a view to leverage its knowledge base by widening its structural dimension. The CEO at Pneumolabs made the following comment regarding the formation of a partnership between the two firms:

> *Our strategic alliance combines the complementary skills of Pneumolabs, a "centre of excellence" for respiratory disease-focused pre-clinical research services, and Sygnature, a "centre of excellence" for medicinal chemistry-driven integrated drug discovery*

This strategic alliance enabled both firms to share their social capital. In the literature social capital is defined as "the sum of the actual and potential resources embedded within, available through and derived from the network of relationships possessed by an individual or social unit" (Wever *et al.,* 2005, p.1525). These types of inter-organisational collaborations are also evident in cases 1, 2, 3 and 5.

Following the partnership the company committed more resources by opening new purpose designed research laboratories to show its commitment to new drug discoveries. By committing that amount of resources there is sufficient evidence indicating that the firm has trust in its partner. This is in line with Lasserre (2012) who suggests that in global networks trust facilitates the exchange of vital knowledge and technical know-how.

Case 5 – Haemostatix Ltd

In 2003 a research group at Leicester University became interested in developing a new class of active clotting agent, or “haemostat” for the control of bleeding to mitigate the shortage of fresh donated platelets. Sarah Middleton (CEO) and Professor Alison Goodall (CSO) formed Haemostatix in conjunction with the University of Leicester. The University played a crucial supporting role in the company's early stages. For its relational dimension, in 2004, the company established a collaboration with the Scottish National Blood Transfusion Service to secure specialist production capability for its products. In order to enhance its capacity to further develop a new class of active clotting agent Haemostatix received start-up funding of £250,000 from The Lachesis University Challenge Fund and initial investment from NESTA. In 2008 the company received further funding in the region of £1.24 million from a network of investors (structural dimension) that included: Spark Ventures, Catapult and NESTA. The CEO at NESTA, Jonathan Kestenbaum explained that:

> *Haemostatix is a dynamic young company driving forward an innovative product that promises to change lives. We are excited to follow our original funding and look forward to working with them as the business continues to develop.*

Further investments occurred in 2010 when the company received a Translation Award worth £409,000 from the Wellcome Trust to support the development of its innovative haemostat technology. The funding coincided with an investment of £459,000 from Spark Ventures, Catapult Venture Managers, NESTA, the Lachesis Fund and the University of Leicester as well as another new investor, Nottingham's Mobius Technology Ventures. Mobius offer financial support and expert support to companies at BioCity that have shown potential. To further support the development of its innovative haemostat technology in 2011 the company announced that it has received an investment of £250,000 from Esperante. This also highlights that the firm's structural dimension consists of investor companies which appear to be vital for its continued product development and process development.

The top management's structural and relational social capital perform a leading role in terms of how the company acquires financial resources and technical know-how necessary for the development of innovative haemostat technology, for example, the firm's link with University of Leicester. Funding from Mobius and Nottingham City Council is meant to help promising start-up firms resident at BCN and it is the place where Haemostatix uses as its base presenting the firm with every opportunity to access that support and help. In the literature Kang & Park (2012) suggest that governments can encourage innovation and economic prosperity by supporting R&D projects that have the potential to generate social capital. When commenting about the financial support Haemostatix received from Mobius in 2010 Glenn Crocker, CEO of BioCity explained that:

> *We have provided Haemostatix with a supportive business development environment for several years and recognise the enormous progress the company has made with its new product. Mobius Life Sciences Fund is designed to contribute to this kind of investment opportunity alongside major investors.*

In addition to large investments that the company received in the last 8 years it has a management board which consists of experienced members in commercialisation, science and financial investment. Its scientific advisory board is composed of high profile personnel from the UK and the EU. In that regard, the amalgamation of experienced, multi-skilled scientific, clinical and commercial leadership (cognitive dimension) has been crucial to the company's efforts to design a cost effective alternative to platelet transfusion, which represents a new type of treatment that is safer and easier to use than the current therapy, with significant saving in ancillary treatments costs.

To add to its already diverse management team the company is currently recruiting a R&D director (As of August 2012). Similarly, in the other four firms sampled for this study the top management comprises of experienced personnel demonstrating that there is sufficient evidence pointing to the presence of knowledge diversity (cognitive dimension) in all the firms under investigation. In other words, all the firms are benefiting from the experience and knowledge that its members they have accumulated from their previous roles in science related businesses or research programmes.

4.2 Summary of case findings

The findings from each case reveal some insightful data concerning the connectivity of various elements within the knowledge supply-chain of small born global bio-tech firms and how they influenced their capability development process. Evidently, the firms engage in multiple business relationships on a global scale. This business model allowed them to move quickly in identifying new projects and funnelling them inside the firm for accelerated innovation. Networks were important for all the firms at foundation. An extensive range of network types including interpersonal/ social, academic, hospital-based, industry-based, local, and international were mentioned across the sample.

Noticeably, during the first three years of life, the firms heavily relied on research grants, development grants and other, often personal sources of income. Strikingly, the owners of the firms did not see their ventures as spin-offs. They argued on the basis that they independently carry out their operational activities without much support from their previous employers. Take for instance BAST and XenoGesis they were recently established by scientists who were forced to start their ventures after they were made redundant by AstraZeneca. The history of BAST was particularly unique in the sense that the company first operated in the USA in the early 1990s and it ceased to operate in 1997. The owner moved to the East Midlands in England to work as a consultant for AstraZeneca and other pharmaceutical firms. Following the closure of AstraZeneca's R&D facilities in Loughborough Charnwood area he was made redundant and he was left with no option and BAST re-surfaced in 2010.

Three of the companies Haemostatix Ltd, Critical Pharmaceutical and Sygnature Discovery were founded by University professors with international links. What was also interesting to note is that BAST whose formation was different from the three firms mentioned above engages in knowledge transfer partnerships (KTP) with universities. Both XenoGesis and BAST have incorporated their former work colleagues at AstraZeneca into their top management teams while Haemostatix Ltd, Critical Pharmaceutical and Sygnature Discovery seems to be accessing human capital from academic institutions. This did not reveal any significant variations in the way all the firms designed their operational strategies. Specifically, their structural, relational and cognitive dimensions of social capital mirrored each other (see table 13 on p.174). Their innovation 'ecosystems' were similar they consisted of experienced scientists, funding institutions, other pharmaceutical firms, academic & government institutions and science parks. The firms used their business and social contacts as sources of science knowledge.

Trust was the backbone to personal & inter-organisational linkages, knowledge-creation and its dissemination. All the firms strived to develop alliances with a view to collaboratively work on science-based programmes irrespective of the geographical location of the partner. The primary goal for doing this was to acquire essential resources so that they were not left behind given the innovation speed in biotechnology which according to Fontes and Videira (2012) is international in nature and is characterised by the presence of some global players that have a co-ordinating function thus, being able to bring small specialised firms into the value chain. In a short space of time following its inception XenoGesis was able to enjoy a relatively high growth rate because of its global activities in comparison with the firms that emerged from the Universities measured over the same period of establishing. Irrespective of the firm foundings their regional innovation systems (BCN, Medilink, EEN and Pera Innovation) provided them with critical assets such as a strong scientific knowledge base and a pool of highly skilled human resources to support their technological entrepreneurship and to promote connections between the various actors (public and private).

The firms displayed entrepreneurial behaviours synonymous with born global firms. This is observation is reflected in Freeman *et al.* (2013) who maintain that the behavioural patterns of born-globals are unique and highly learning-oriented. As such, the uniqueness of these entrepreneurial types of firms was clear to see throughout the sample. For example, the top management team of all the firms consisted of experienced scientists who had developed a web of connections worldwide. These connections were used as conduits to enable them to bridge their internal knowledge gaps and to link up the firms with other firms who have complementary assets. Consistent with this Ho & Wilson (2006) maintain that the experience of biotechnology firm founders provides for existing social relationships which make it easy for them to obtain the much-needed resources.

4.3 Cross-case findings

While more specific results can be found through within each case this part largely focusses on extracting patterns and trends derived from case findings. The principal reasons for adopting this approach were to develop the main propositions for this study. The main discourse is centred on the connectivity of various elements that include; business & social networks, competence & goodwill trust, inter-organisational collaborations, tacit & explicit knowledge, prior learning & absorptive capacity of small born-global bio-tech firms. In discussing the connectivity of these variables the study traces the structural, relational & cognitive dimensions of all the firms as illustrated on table 13 below. With reference to the literature structural dimension is aligned with global network ties and their overall configuration (Burt, 2002; Ahuja, 2000). Relational dimension focuses on trust, trustworthiness, norms and obligations in a global network (Fukuyama, 1995; Putnam, 1993). Cognitive dimension refers to those resources providing 'shared representations, interpretations, and systems of meaning among parties' (Nahapiet & Ghoshal, 1998, p.244).

Table 13 Structural, Relational & Cognitive dimensions

	Critical Pharmaceuticals	**XenoGesis Ltd.**	**Haemostatix Ltd**	**BAST Inc.**	**Sygnature Discovery**
Structural Dimension	The acquisition of scientific knowledge is based on the firm's relationship with academic network and it's connections with other firms & research institutions	Similar to Critical Pharmaceuticals but the CEO interacts with his former work colleagues from AstraZeneca (global reach)	The firm's discovery activities are enhanced by venture capitalists (VC) and Technology Ventures such as Microbus	Similar to XenoGesis & CP the firm collaborates with other small to medium size enterprises (SME) and universities	Same as the other four firms and that the firm has strategic alliances with bioscience group
Relational Dimension	It is based on competence and goodwill trust and a long-term interaction with the firm's academic network & business network	Similar to CP and that trust is built in escalating series by trying different combinations particularly, using a try and error method	Similar to XenoGesis and CP	Same with the other four firms and that obligations in a global network of 24 other firms	Based on competence & goodwill trust e.g. partnership with Cyprotex Discovery in 2007
Cognitive Dimension	The firm consists of experienced, multi-skilled scientific, clinical and commercial leadership team directed by a board of international standing with a broad base of expertise	Similar to CP and the top management consists of experienced scientists in bioanalysis	Similar to CP & BAST Incl.	Same as the other four firms	All the scientists have PhDs, post-doctoral experience gained from USA & Europe

4.4 Development of propositions

This part of the thesis explains to the reader the connectivity of the formulated measures, including: business & social networks, competence & goodwill trust, inter-organisational collaborations, tacit & explicit knowledge, prior learning & absorptive capacity within the knowledge supply-chain of small born-global bio-tech firms. It also outlines how these variables influence their abilities to develop their innovative capabilities. The section draws upon results from cross case analysis using various elements within the knowledge supply-chain of born-global firms as the main themes. Crucially, it develops propositions which are based on the data obtained from each case. Secondary data is also used to provide some insight and to support empirical evidence. This leads to the construction of a new model of *"Knowledge and Innovative Capability Development"* for small born-global bio-tech firms.

4.4.1 Business & social networks

Business and social networks are requisite to how small born-global bio-tech firms operate in a knowledge-intensive industry. The interaction between individuals, firms or organisations with varied skills, experience and knowledge provides synergy for small firms with limited resources by giving them access to a wide range of economic effects (Ho & Wilson, 2006). Engaging in innovation 'ecosystems' enabled all the firms in the sample to access specialised input and labour, new information inflows and knowledge as well as access to research institutions and government R&D support services (Martin *et al.,* 2011). Breschi & Malebra (2005) suggest that, "resource pooling, risk sharing and the formation of critical masses provide incentive to create a group of interlinked agents" (p.47). Powell *et al.* (1996) insists that, "when the sources of expertise are disparate, collaborative R&D opens an organisation's eyes to the need for accessing ideas and information from a variety of sources" (p.46). This was evident through a case by case analysis.

Small born-global firms link up with other firms, scientists, and research and academic institutions within and outside their domestic market to jointly develop new drugs and share technical know-how. This was reflected in the response given by the *President* at Sygnature Discovery when asked about why his company forge networks.

He said that:

> *Our scientists work with other scientists from other businesses, research institutions and strategic alliances to jointly test and develop drugs. We work in a highly collaborative way e.g. in our molecule synthesising process. We have secure data bases that we use to share data with our partners and clients from wherever they might be either in San Francisco or Santiago. We have realised that we do not have all the capabilities and we feel that it is important to collaborate with other companies for example, we collaborate with Cyprotex Discovery. They have better knowledge about how the drug dissolves in the body. What is important is we share capabilities. We feel that we have modelled our business in a "hub and spoke" model i.e. we are in the middle and we are networking with other companies.*

Discussing on the same topic the CEO of CP mentioned that:

> *In the biotechnology sector you need various skills and knowledge, in addition to our in-house knowledge we collaborate internationally with other institutions such as universities and other companies. We have different levels of collaboration. We collaborate with small and large companies in USA and the EU. We also have intense collaborations with companies near to us which have expertise in areas of interest to us we therefore work with them to access the expertise that we do not have.*

His company's head of clinical processes made similar remarks. He stressed that:

> *Networks are very important. So personally for me it is something that I do a lot through conferences where I get the opportunity to meet people in the same field and those that I have worked with in my previous employment.*

Networks are also important for us in terms of facilitating access to capabilities that we do not have here at Critical Pharmaceuticals. We link with other firms academic institutions and research centres. Networks are developed through knowing people in conferences seminars where you have a chance to meet people face-to-face.

The science director of BAST expressed similar views saying that:

Once a year we have an important collaboration with one company at BCN and there are also a lot of other collaborations with Universities e.g. with Loughborough University (LU). We recently received funding to collaborate with LU to develop a powerful science simulator. From the University we receive research students who will be primarily developing a new system. I personally have social relationships with people who I have known for a long time. I also engage with a number of scientists at our annual meeting code named PAGE. I attend seminars to brush up the ideas I have. There is still a network with people who have lost their jobs at AstraZeneca. Helen is directly involved in communicating with those people as a way of sharing ideas and best practice.

In light of these commentaries there is sufficient data indicating that born global bio-tech firms develop and maintain networks with a view to update their knowledge bases. It is therefore, plausible to claim that business networks in the knowledge supply-chain of small born-global bio-tech firms extensively influence how they acquire expertise in scientific. This is consistent with Nahapiet & Ghoshal (1998) and Tsai & Ghoshal (1998) who suggest that social capital embedded in a firm saves as a conduit that facilitates positive conditions for the exchange of knowledge and the combination of resources to occur. When discussing with an expert working for a knowledge 'hub' the researcher got a sense that the business networks of small born-global bio-tech firms are an important source of new ideas, knowledge and business opportunities.

To put all this into context an innovation advisor, Rosamund Graves explained the role Medilink an organisation she works for saying that:

> *We help firms and industry sectors access information, opportunities and partners on a global scale through specialist networks and business intelligence. On behalf of national government agencies, we deliver programmes to stimulate international inward investment, technology transfer, partnering and access to high growth global markets for UK companies. We provide business intelligence and contacts to help UK firms identify and realise international opportunities.*

Her statement means that her organisation provides opportunities for firms in the UK to forge networks/links with other companies that are located outside their locality. This is an important facility for bio-tech firms in their process of acquiring knowledge and technical know-how. As such, it is not misplaced judgement to infer that business and social networks are part of a 'jigsaw' puzzle that act as a foundation for small born-global bio-tech firms in their process of generating new information.

Proposition 1: *business and social networks are a catalyst for small born-global bio-tech firms in their process of developing innovative capabilities*

An interesting perspective concerning the role of networks was also given by Dr Thorsten of Pera Innovation Network. He outlined how they facilitate collaborations in the bio-tech industry in the East Midlands region. He explained that:

> *We are in contact with a pool of science experts, research institutions, Universities, and various bio-tech firms within and outside the East Midlands. If a small firm comes to us asking for help to develop and grow its operations, we try to match their needs with the portfolio of companies that we have "we call it problem matching". We then facilitate a network which is made up of three or four actors/firms and one of them has to be an established firm or experienced scientist or a University expert.*

So at one given point in time we may have a number of projects that are on-going and these usually last for a period of three years. The bulk of financial support that we get comes from the EC and start-up firms usually receive financial support that ranges from €100 000 to €1m.

The secondary data which is presented in Chapter 2 accentuates that social capital and network ties have a positive impact on international start-ups, new ventures and SMEs' performance (Dlugoborskyte and Petraite, 2013; Feurest, 2010; Oviatt & McDougall, 1994; Oviatt & McDougall, 2005). Consistent with the remarks made by Dr Thorsten of Pera Innovation Network, Hughes *et al.* (2009) suggest that for a firm to gain access to knowledge and technical know-how it is essential to collaborate in networks and engage with a range of advisors that include: scientists, academia and agencies. Furthermore, this was reflected in the conversations with the CEO of XenoGesis Ltd, and the Science Director of BAST Inc. when discussing about how wide-spread their networks were. This is what they had to say:

I have a good network of ex-colleagues that I used to work with at AstraZeneca and such connections are vital for sharing scientific knowledge and technical know-how. I think collaborating with other businesses and academia is essential in the bio-tech industry and it is important that businesses join to work on new discoveries. That is the way things are heading towards nowadays given the nature of the markets. Apart from using my business or social connections as conduits of scientific knowledge I also publish papers (CEO at XenoGesis Ltd);

And

I engage in networking activities both locally and internationally with firms and organisations in the USA, and Asia for example. I personally have some contacts in America where my business started way back in 1998 as a model based on a drug development firm (Science director at BAST Inc. Ltd).

Sally Barker an innovation expert at Medilink East Midlands expounded more on this by outlining how the knowledge centre creates networking opportunities for bio-tech firms that are located in the East Midlands saying:

> *One of the things that we encourage small and established firms in the East Midlands to do is to develop links with international organisations. The Animal corridor from the USA will be visiting the East Midlands in March this year to attend one of our networking conferences. We also had an alliance with bio-masters who specialise in cats and dogs. Some people came over from USA. We also promote international trade and I think international links are also important as they give organisations/firms a chance to acquire new knowledge. People exchange knowledge, ideas and best practice (Innovation Expert at Medilink).*

The conversations with Sally Barker, the CEO of XenoGesis and the science director at BAST substantially underscore the essence of business and social networks. What is vividly projected here is a sense that in the globalised markets of the biotechnology sector going it alone is no longer the best option. This is true for small firms due to fact that it is so difficult for them to possess all of the necessary capabilities. Discussing on the same topic concerning business and social networks Gareth King PhD the CEO of XenoGesis explained that:

> *The way business is conducted in the biotechnology industry has significantly changed when we started most of the knowledge was generated mainly in-house. Cross-function in biology seems to the way forward even for the world class companies such as AstraZeneca they are outsourcing R&D services so as to get the expertise from outside for continuous development and innovation. They have more links with academia and I think that has been very productive. Therefore, I see collaborations as essential for growth and innovation especially in biology and chemistry*

The business and social networks of small born-global firms are a conduit through which they can access scientific knowledge and technical know-how for growth, innovation and development. Lasserre (2012) maintains that firms can benefit in globalised networks by accessing and taking advantage of geographical clusters of knowledge creation and development. Consistent with this the head of process development at XenoGesis said that:

> *We use companies worldwide; we have worked with a number of companies in Demark and USA. I would say we have a global dimension to our operations. We travel worldwide e.g. attending seminars in the USA, in Europe. We engage with global networks to access knowledge sets that we feel are important for our business.*

Considering how Critical pharmaceuticals, XenoGesis, BAST Inc. Ltd, Haemostatix and Sygnature Discovery conduct their business operations it suffices to infer that small born-global bio-tech firms use networks to generate knowledge in order to leverage their internal science capabilities with a view to make new drug discoveries. Thus, giving them greater flexibility needed to survive in a hypercompetitive business environment (Su, 2013; Andersson, 2011; Lasserre, 2012; Hisrich 2012). Furthermore, Schilling (2010) maintains that, “as firms forge collective relationships they weave a network path between them that act as a conduit for information and other resources” (p.158).

Funding institutions were a noteworthy feature that was identified by small born-global bio-tech firm as one of the most important links within the supply-chain which enables a project/programme to take off. Mobius Life Sciences - an investment arm of BioCity Nottingham (BCN) work alongside Nottingham City Council (NCC) to provide financial support “seed investments” in high potential life science businesses. Crocker (2012) explains this more fully stating that the investment arm has a team of investors who are highly experienced and well-networked.

Based on Crocker's remarks one gets a sense that financial support for bio-tech firms considerably boosts their ability make new drugs and it adds value to their businesses which ultimately enhances their capacity to innovate. The CEO at Haemostatix said this:

> *While business networks facilitate the flow of novel information, financial investments are a "shot in the arm" in that they also provide a company with the opportunity to develop innovative technology. In our case we were presented with the opportunity to develop an innovative haemostat technology through a funding from Wellcome Trust CEO at Haemostatix*

The CEO of Haemostatix meant that business links that include funding institutions are the bedrock for small firms seeking to make crucial innovations. The funding structures seen at the Golden Triangle, Silicon Valley, and Boston metropolitan area are being replicated in the East Midlands. This is consistent with the concept underpinning the Cambridge phenomenon. The Cambridge Cluster Report of 2004 reports that between 1993 and 2003 the cluster acted as a magnet attracting supportive infrastructure comprising of a number of key players such as venture capitalists firms, banks, marketing experts and patent agents.

4.4.2 Competence & goodwill trust

A causal link was established between trust inter-organisational collaborations and knowledge-sharing in bio-tech firms. Across the research sample there is sufficient evidence pointing to the fact that exchanging ideas about science was anchored on trust. The study identified trust as the main backbone of the knowledge supply-chain of small born-global bio-tech firms connecting business & social networks with inter-organisational collaborations and knowledge-sharing. This ultimately led to the development of innovative capabilities in the form of scientific knowledge and technical know-how.

Discussions with key informants across the research sample yielded that small bio-tech firms build trust with their collaborating partners based on their partner's technical prowess (competence trust) and good intentions (goodwill trust) within the life science sector. The study uses Blomqvist's (1997) definition of trust expressed as an "actor's expectation of the other party's competence, goodwill and behaviour" (p.3). Consistent with Blomqvist's conceptualisation of trust Gubbins & MacCurtain (2008) insist that to trust an individual's ability is to trust in his or her skills and competences to do the job. Discussing within this context there was strong emphasis, from the informants, on the fact that they will trust a collaborating partner when they know that they are very capable and skilled in a specific area of science more so, if their capabilities complement internal knowledge gaps. Richard Weaver the CEO of XenoGesis said this concerning trust-building in a network:

> *We build trust by first conducting due diligence (i.e. we do a search on their level of technical capabilities, their reputation which we get from people who have worked with them before). In other words we look for partners who have higher skills and are well established/known in the industry. This is all done in a trial and error method.*

Paul Clewlow of Sygnature Discovery explains trust-building from a slightly different angle:

> *Our clients and business partners build trust basing it on our competence and reputation. Getting acknowledged by colleagues at BioCity and overseas because of the quality of the work that we do is very important in this business and that's all part of establishing credibility.*

The interpretations from these remarks are supported in the literature (see Blomqvist, 1997; Şengün, 2009) and they validate the relevance of competence (technical capabilities, skills and know-how) in the biotechnology sector.

More importantly, their meanings (Paul's and Richard's remarks on p.90) imply that trust is a necessary antecedent and a base in professional relationships within a business context. Networking with organisations that have better skills levels was an important factor in building trust in the biotechnology sector. Business partners were expected to have technological knowledge and competences. The reputation of a partner (moral responsibility and positive intentions towards the other) was also a vital factor that influenced the decision to accept a potentially vulnerable position - risk inherent by partnering. In the literature Welter (2012, p.194) claims that "trust is seen to assist in lowering the transaction costs of commercial actions and the risks inherent in entrepreneurship". In the majority of the firms trust was built in escalating series using a "trial and error" method. To this end Helen Walker a senior pharmacologist at BAST stated that,

> *In establishing strong business connections, we start with smaller drug delivery projects and if those are delivered we then escalate the collaboration to another level where we engage in more joint projects.*

The President of Sygnature Discovery Paul Clewlow maintained that:

> *It takes time. Trust with a client is very important and it is done in little steps at a time. We ensure that we deliver to our clients promises that we have made from the day we entered into a collaborative project. We also ensure that information is made available to the client when the client needs it. We also build rapport with them. The science is really important to what we do but we also have to develop personal relationships especially with our clients in Santiago or San Francisco for example.*

Clearly, in the biotechnology sector trust is built in escalating series; different combinations involving collaborations that start with smaller projects with a view to establish the commitment of a potential partner were used.

Once trust was established the collaboration was validated and the channel through which scientific knowledge and technical know-how are exchanged was established. In a discussion with a senior scientist at XenoGesis on the same topic he clearly stressed that:

> *There has to be utmost trust in a relationship and there has to be a benefit for both partners and that will lead to knowledge-sharing. If that is non-existent that relationship will not last.*

And Paul Clewlow said this:

> *Social networks are important as they lead to trust and strong business relationships. I think it is important that those relationships become the backbone to business relationship as well as using our scientists to talk with scientists from other firms through encouraging them to attend collaboration seminars that way they get to know what is happening in terms of scientific developments. And I guess at the end of the day the pharmaceutical industry is changing and the business model seems to indicate that collaboration is essential.*

As the study has already referred to the fact that trust is a major pillar in the knowledge supply-chain of small born-global bio-tech firms; the remarks above and on p.186 capture this. They denote that productive business relationships are directly anchored on trust. This is consistent with the *social exchange theory.* The theory hypothesises that information, advice; social support and recognition are important means of building trust created through repeated interactions and reciprocity (Pretty & Ward, 2001; Inkpen & Tsang, 2005; Blau 1964, Whitener *et al.*, 1998). In addition to the meaning of the social exchange theory, when asked about how Sygnature Discoveries Ltd develops trust with its partners the company's president specified that:

> *I guess our partners also do a due diligence to assess whether we fit into what they are looking for.*

With our alliances we are well connected actually, before establishing this connection we first test the partners trustworthiness through engaging in small projects and we take it step by step until we are fully convinced that a stronger partnership can be established. Competence and reputation play a key role in building new networks.

In light of this, it cannot be misplaced judgement to suggest that building trust requires small born-global bio-tech firms to have access to a wide scope of information because different types of information including relational-emotional, socio-economic and tacit-explicit extensively impact on the trust they experience. Trust between firms in the same locality was naturally developed. However, with organisations and institutions outside their locality there was more of "trial and error" requiring a lot of information search. Notably, due diligence was done mainly to test the trustworthiness of a potential business partner in particular, their intentions. This is related to the goodwill dimension of trust.

The process of testing a partners' trustworthiness through small projects was targeted at identifying positive or negative signs and signals which Blomqvist (1997) claims are visible and easier to evaluate when the relationship is developing. Testing a partner's intentions earlier on in a collaborative relationship was a vital step for small born-global firms. More importantly, the stage was critical to how they forged productive working relationships in newly established networks. Responding to the question on trust-building in newly developed networks usually established in a global context the CEO of XenoGesis stressed that:

It is very important to try different combinations to ensure that you end up working with people who share the same values with you, approach business in a similar way you do and their views mirror yours.

In this case it was the CEO's envisaged strategy that his organisation should develop trust with their partners based on the soundness of their strategy and vision.

In the relevant literature (see Mishra 1996; Sydow 1998) the competences of an organisation are seen as a basic and profound source of trust in asymmetric technology partnerships. Blomqvist, (1999) suggests that competence trust may be born out of a firm's technical capabilities, financial resource base and partnering competences.
Thus, the study proposes that:

Proposition 2: *For small born-global firms competence and goodwill trust are major pillars that reduce friction and perceived risks allowing the free flow of fluid scientific knowledge and technical know-how through established or newly developed business partners.*

The most common form of trust that was evident in the research sample was the sense of benevolence meaning that the scientific knowledge and technical know-how developed together with partners will be protected within the trusted group/network (Hoy & Tschannen, 1999). The firms relied on the goodwill of their partners to act in the best interest of both parties. In on-going relationships future behaviour was not specified but there was a mutual attitude of goodwill. As illustrated on the *Knowledge and Innovative Capability Development Model* figure 8 under section 4.5 on p.206 trust was the basis on which inter-organisational collaborations stemmed from in the capability development process of small born-global bio-tech firms. More importantly, trust was a pre-requisite to knowledge sharing and the exchange of technical know-how.

4.4.3 Inter-organisational collaborations

Data collected from sampled firms confirms that there is a connection between inter-organisational collaboration, trust & new drug discoveries. A detailed case by case analysis specifies that the main reason why small born-global bio-tech firms collaborate with other firms/research institutions is to acquire new information and science-related ideas in order to enhance their innovative capabilities (drug discovery).

Basile (2010) explains that innovation "is a complex and interactive process that involves a variety of actors" (p.3). In a conversation with the head of process development at Critical Pharmaceuticals on the subject of working with other organisations to improve firm-based capabilities he said that:

> *We work with research institutions such as Sheffield University and companies worldwide. We have worked with companies in Demark and USA. I would say we have a global dimension. We travel worldwide e.g. attending seminars in the USA, and in Europe seeking for partners with complementary capabilities.*

The biotechnology sector is a science-driven industry in which scientific knowledge is both complex and ever-expanding in search of new discoveries. The industry is characterised by widely dispersed sources of expertise. In such business environments, Powell *et al.* (1996) suggest that the locus of innovation is usually found in networks of learning as opposed to going it alone. Consistent with the statement made by his head of process development the CEO of Critical Pharmaceuticals said that:

> *In the bio-tech industry you need various skills and knowledge, in addition to your in-house knowledge. We collaborate with other institutions that include universities, other companies - large or small both locally and internationally and along with that we have different levels of collaboration. We collaborate with companies in the USA, EU. We also have intense collaborations with companies near to us who have expertise in areas of interest we therefore work with them to access the expertise that we do not have.*

Paul Clewlow of Sygnature Discovery expressed similar views saying:

> *We work with people who have better knowledge than ours in areas that complement what we do. We have realised that we do not have all the expertise. We work with companies that have the part of the 'jigsaw' that we do not have and that benefits all of us in terms of reciprocity*

Scholarship on inter-organisational collaborations universally acknowledges that firms should look further than their own boundaries to acquire strategic resources (see Subramanian & Soh 2010; De Weaver, 2005; Feldman, *et al.,* 2002). In the East Midlands where not much is reported about inter-organisational collaborations as compared to well-established networks such as the Golden Triangle of Cambridge, London and Oxford, Silicon Valley and Boston Metropolitan Area there are "hot spots" where science-related activities are happening in significant proportions. For example, in the 'Science City of Nottingham' joint research projects between scientists, academics and life science firms irrespective of their location are actively encouraged by knowledge centres that include BCN, Pera Innovation Network and Medilink. From that point of view, one gets a sense that the traditional model of large pharmaceutical companies where all research activities were carried-out under one roof by large pharmaceutical companies is slowly fading into the horizon. This is giving rise to the emergence of well-networked organisations that work in collaborative programmes. The managing director of BCN Toby Reid observed that:

> *The large Pharma used to employ a large number of scientists under one roof; that structure is fragmenting which means that small organisations are being formed.*

Helen Walker of BAST echoed similar sentiments and she explains that:

> *The pharmaceutical industry is changing in a way that has never been seen for a long while. The 'Big Pharma' model is transforming and this restructuring is leaving a huge number of scientists with no work which is causing them to start their own businesses and collaborating with other organisations has become very much part of that of their operational strategy.*

The remarks by Toby Reid and Helen Walker demonstrate that the traditionally auspicious 'Big Pharma' model in the pharmaceutical industry is evolving.

Large pharmaceutical companies are re-configuring their business models to achieve operational efficiency. The preferred option appears to be out-sourcing science-related R&D as opposed to conducting the research in-house. In the East Midlands the majority of these firms are based in network centres that include BCN and LIC. This marks the genesis of a significant move towards project-based programmes. The outcome of this is that there will be more and more collaborations between small and large organisations. As such, smaller firms whose structural designs are known to be adaptive and flexible will perform a more active role. The head of process development at Critical Pharmaceuticals Andrew Naylor explained that:

> *If you avoid science-based collaborations in the biotechnology industry which is nowadays littered with small but extensively innovative firms you will not get anywhere. In a business such ours you need to share expertise in order to innovate and develop the business. I personally keep contact with people who I previously worked with in projects with a view to keep on sharing knowledge because technology is ever-changing therefore, we need to be upfront. I also see academic collaborations as very important because they produce new ideas and knowledge.*

Richard Weaver of XenoGesis expressed similar views when he commented that:

> *To be creative in science one has to collaborate on a number of levels with multiple actors. Talking from my personal experience acquired in science I believe that to be innovate you have to work with people who have some expertise in other science-related fields so that you can learn from them and that can only be good for your business growth and development*

Other studies (see Gabrielsson & Kirpalani, 2012; Cannone *et al.,* 2012; Stuart *et al.,* 2007; Zucker *et al.,* 1998) have report a growing trend in the biotechnology sector where small firms are being contracted to do the research for other pharmaceutical companies.

Kang & Park (2012, p.70) report that “while the new biotechnology firm specialises in specific types of knowledge, products and applications large established firms have expertise in the commercialisation of new inventions that involve large scale production, marketing and distribution, and regulatory processes”. In the same context Gareth King - the CEO of Critical Pharmaceuticals emphasised that:

> *We acquire financial support to back up our products, expertise, marketing, PR, scientific knowledge and these are things that we do not have in-house and they are needed to enable us to achieve our goals. The only way to achieve this is through linking up with people who have been there and done it and are well established in the market.*

There is a strong hint in the remarks above informing the study of the significance of inter-organisational collaborations in terms of: (1) bridging the knowledge gap of small born-global bio-tech firms; (2) enabling them access to markets; (3) providing them with financial back-up and (4) getting help from science experts who have vast experience. Consistent with this, Schilling (2010) stresses that, small pharmaceutical firms form partnerships with other pharmaceutical firms for their mutual benefit. For example, large pharmaceutical companies gain access to the drug discoveries of the small pharmaceutical firms and likewise the small pharmaceuticals firms gain access to the capital resources, manufacturing & distribution capabilities of large pharmaceutical companies. BAST Inc. Ltd seeks to establish working relationships with firms that can enable them to develop useful science tools. Its science director stated that:

> *We are interested in collaborating with a computer firm to jointly develop simulation mathematical combinations. This cross fertilisation is important in the sense that it enables us to develop what we intended to produce*

Discussing on the same subject regarding alliance-building the CEO of XenoGesis explained that:

> *We have developed a good working relationship with XenoTech a company which is located America. They are our distributor in the US. We know that they have credibility through their peer reviewed journals and we also visited their premises as part of developing trust. We discovered that XenoTech have life science expertise and they are mature than us and they have been going since 1984 and they have developed a strong base in science which we are now using for distribution purposes.*

The remarks made by the science director of BAST and the CEOs of XenoGesis and CP above indicate that small bio-tech firms seek to collaborate with companies that complement firm-based capabilities. In the East Midlands this trend is on the rise. For example, Nottingham Trent University, Nottingham University and University of Leicester (UoL) are jointly working with small bio-tech firms to share expertise, resources and human capital with a view to develop life-saving drugs and clinical equipment. Critical Pharmaceuticals work closely with academia to develop a highly innovative formulation of *teriparatide*. The UoL performed a crucial role in supporting Haemostatix Ltd during its early stages of development. The firm received support in the form of clinical laboratories as well as opening up links with other institutions and organisations. As a result of Haemostatix Ltd's links with the UoL it received start-up funding of £250,000 from The Lachesis University Challenge Fund and an initial investment from NESTA. The founder of Haemostatix expressed her profound gratitude in 2006 when her organisation received support from Quester, "Quester has worked with the company (Haemostatix Ltd) since 2002 and we are pleased to have their financial support and strategic input to take the business forward".

Proposition 3: *Inter-organisational collaborations are an important developmental step within the knowledge supply-chain of small born-global firms and they influence their process of developing innovative capabilities*

It is however important to reiterate that inter-organisational collaborations have the potential to produce desirable outcomes for all the parties only when trust has been established first. The majority of the firms participating in the study are contract research organisations (CROs) implying that they work with other firms or for other firms to develop drugs. Their collaborating partners are not only located within their vicinity but they are global dispersed which means that trust (in the form of competence and goodwill) becomes important. In that sense, one can envisage a strong association between trust and inter-organisational collaborations. Small born-global bio-tech firms collaborated with organisations they believed to have expertise and experience. The idea was to limit the chances of failure given their lack of resources. Carrying on with the discussion concerning inter-organisational collaborations and trust the president of Sygnature Discovery Paul Clewlow was asked to explain the importance of a potential partner's expertise in science and benevolence in trust-building and this is what he had to say:

> *We develop trust with potential partners based on their science and technical capabilities. We also receive advice from BioCity, Medilink and UKTI about potential partners and I guess it is part of due diligence. You need to confident that they will respond in a positive way and their attitude is congruent with your expectations.*

Paul's version of a potential business partner's capability also hints that a firm intending to enter into partnerships with another firm that is not known to them they use BCN, Medilink a knowledge network centre and a government advisory body on trade and investment (UKTI) as intermediaries.

These network facilitators provided small born-global bio-tech firms with information about potential partners' scientific capabilities and technical know-how more so, for those which are geographically distant. In addition to this, the network centres also supported other firms from oversees intending to relocate their operations to the East Midlands. Rosamund Graves an innovations manager at Medilink East Midlands explained this situation more fully when asked about the role her organisation performs in facilitating inter-organisational collaborations, she said that:

> *We would facilitate for companies that intend to relocate to the East Midlands by providing them with the necessary information. We support both domestic and international organisations and recently we had a company that came from India intending to establish in the East Midlands. In that case we supported them by providing them with information to enable them to achieve their goal.*

In the literature Bachmann & Inkpen (2011) accept that in cases where face-to-face interaction with a potential partner is not possible or desirable a third party may operate as a guarantor. Tony Reid the managing director of BCN elaborated on this by explaining that for their tenants they:

> *Guarantee a certain level of competence and quality of a potential partner but after that they take a step back and let people work and learn on their own*.

Over a period of time a strong bond was gradually developed by engaging in smaller research projects between collaborating firms regardless of their geographical location. When the relationship got stronger the level of trust was increased accordingly thereby, facilitating the free flow and exchange of scientific capabilities as well as technical know-how. In the literature high levels of trust are associated with a decrease in perceived risk and they are cast as being fundamental to the formation of strong relationships.

Thus, strong relationships are a precursor to trusting that a business partner will act in the interest of both parties. Evidently, some form of connection existed between firms which used a pre-existing business network such as BCN as their base but for partners outside their locality the "trial and error" method taking the form of smaller projects was used as the main method of assessing the trustworthiness of prospective partners. As such the study's 4th proposition is that:

Proposition 4: *Small born-global bio-tech firms build trust with their prospective partners in escalating series basing it on their partner observations through inter-organisational collaborative projects*

4.4.4 Tacit & explicit knowledge

The process of acquiring knowledge is a very complex exercise which involves participating in generating, storing and disseminating it in a way that benefits all the players involved (Powell & Grodal, 2005). There were sufficient clues indicating that small born-global bio-tech firms work in collaborative projects with a view to ensure that they continue to receive crucial scientific knowledge. The science director of BAST Ltd Inc. Joachim Grevel commented that:

> *The idea of working in joint projects is essential in science as it gives small less established firms access to vital knowledge. I think the idea of intellectual capital is important for both established organisations and small start-up firms like ours. It is basically an understanding that we share ideas and collaborate in projects and generate IP in joint programmes.*

Consistent with this, Andrew Naylor the head of process development at Critical Pharmaceuticals explained that:

> *We create knowledge by engaging in science-related research programmes with our partners. We are currently working with a Danish company on a drug discovery programme. All the data from experiments becomes our joint intellectual property.*

We also sponsor PhD students who we enter into contractual agreements which enables us access to their research output and any experiments (results) they may produce as part of their research. So that is roughly how we generate knowledge.

Andrew Naylor's remarks are supported by his CEO Gareth King who explains how they generate knowledge at length saying:

We have some structure take for instance when we work with a business partner who has expertise in a certain area we come to some form of agreement in order to protect IP. We all sit down and we choose leaders from each side and these people work together and they have to work out what is needed. They come up with a plan for the project; they update us with what is required for that project to progress. Once a project is underway it is monitored all the way to final delivery. We usually encourage the leaders to produce a document explaining how the project is progressing so that we have an idea of what capabilities are needed for it to fulfil its purpose. We ask them to produce a report to evaluate the project i.e. what has been achieved etc. All the data that is generated from this is kept securely in a database which we both have access to.

Helen Walker the senior pharmacologist made similar remarks explaining that:

We participate in a Knowledge Transfer Partnership (KTP) programme. The programme helps us to create and share knowledge. In our case we jointly create knowledge with students who undertake projects which BAST mentors. This is how it works a student who is identified as having potential is recruited to work with a mentor. Now one of the key requirements of that partnership is to produce a report of their work and we also expected them to keep a lab log book. That way we are confident that all the data they generate from that partnership is retained in the business. Basically, we keep a trail of their work. Actually, it is good practice in science to keep a trail of your work.

Commenting on the same subject regarding knowledge creation Richard Weaver of XenoGesis said that:

> *We receive knowledge through published data and from people who we have had some dealings with them.*

Paul Clewlow of Sygnature Discovery remarked that:

> *We send our scientists for training in Universities with a view that they will be able to acquire knowledge which would be useful for our drug discovery service. Crucially, we keep all the data from tests stored in our secure databases which are only accessed by authorised parties.*

The remarks made by the key informants, above and on p.202-204, signify that small bio-tech firms create science knowledge by participating in science-related projects and programmes, and through working with academic institutions. Taking a closer look at these commentaries one gets a genuine feeling that small born-global bio-tech firms create knowledge using a wide range of sources. These encompass joint research projects with other firms which are known to them, through knowledge transfer partnership programmes and by sponsoring undergraduate students.

This is consistent with the literature for example; De Weaver *et al.* (2005, p.1525) broadly define social capital "as the sum of actual and potential resources embedded within, available through and derived from the network of relationships possessed by an individual or social unit". Bourdieu's (1986), Coleman's (1990), and Putman's (1995) conceptualisation of social capital assumes various dimensions which are reflected in the statements made by the interviewees. Bourdieu (1986, p.248) defines social capital as "the aggregate of the actual or potential resources which are linked to possessing of a durable network of more or less institutionalised relationships of mutual acquaintance or recognition". Coleman (1990) defines social capital by its function.

Coleman argues that social capital consist of some form of social structure that facilitates certain actions by actors within it. Putnam (1995) appears to treat social capital as a single dimension. Putnam defines it as “the networks, norms, and trust that enable participants to act together to effectively pursue shared objectives” (1995, p21). Taking into account the literature and the remarks from the key informants the study proposes that:

Proposition 5: *Tacit and explicit knowledge created in collaborative projects performs a leading role in facilitating a small born-global bio-tech firm’s ability to improve its capacity to innovate.*

Furthermore, across the entire sample there was sufficient data indicating that ideas and knowledge created in science-related projects/programmes are codified and retained in the firm for future developments. This was realistically explained in a discussion with the CEO of Critical Pharmaceuticals concerning how his firm managed data accrued from collaborative projects. This is what he said:

> *From a scientific perspective for a lot of the key projects we trap the knowledge that people have used in a project and we have project management systems to make sure that we capture all the knowledge e.g. by monitoring projects, gantt charts and project reports.*

Managing scientific information this way was not only unique to Critical Pharmaceuticals. All the firms echoed the same sentiments. They also revealed that knowledge management was a crucial part of their drug discovery process. For example, the science director of BAST Ltd Inc. stressed that:

> *We are part of a collaborative network and I agree that knowledge exists in people’s minds but I also think that it should be codified and stored in databases for all the members in the network to access it and hopefully make essential innovations.*

As a matter of fact, we are part of consortia of 24 other firms and we are developing a common sharing repository where everyone with interest will have access to this data and we hope to have the system up and running in about 5 years.

The findings are consistent with a number of scholars (see Daud & Yusoff, 2010; Hughes *et al*., 2009; Nonaka *et al.* 2000) who discuss the concept of knowledge externalisation. Knowledge externalisation allows knowledge that exists in the head of the knower to be codified into rules, specifications and formulas that can be used and become the basis of new knowledge. All the firms that participated in the discussions regarding developing innovative capabilities in the biotechnology sector placed great value on both tacit and explicit knowledge acquired from their trusted partners.

The findings from across cases also show that knowledge created in collaborative projects was regarded as essential to the development of new scientific combinations and formulas needed for testing new drug discoveries and compounds. Conversations with the key informants also yielded that their firms go beyond their immediate environment in search of a new context and a new world-view. This is consistent with Todtling *et al.* (2009) who suggest that sector based innovations are not bound by geographical location. They often have international or even global reach. Global networking in search of new insights was a dominant characteristic in the majority of the firms that took part in the survey. In the literature Nonaka *et al.* (2000) point out that the process of creating knowledge is a continuous one and it transcends beyond one's immediate environment. The interaction between individuals or a group of firms is vital in terms of facilitating knowledge transfer.

Small born-global bio-tech firms work in collaborative projects with other scientists, research institutions and other firms with an objective to stimulate its transfer. Porter *et al.* (2005) point to the amalgamation of intellectual capital of clinical researchers and research academics as key to the success of the commercial world of biotechnology in the Boston metropolitan area. Similarly, Todtling *et al.* (2009, p.67) claim that, "universities are regarded as key knowledge sources of firms for more advanced innovations". This bears striking resemblance to the methods used by firms in the East Midlands region to create science knowledge. There is evidence of the existence of strong ties and relational-like trust in the sampled firms that are located at BCN, the region's science centre. Based on their shared values and common beliefs vested in BCN the firms naturally formed business connections and the intentions of all the firms were predictable. Boschma (2005); Asheim & Gartler (2005) make similar observations and they highlight the fact that interactions that occur in an institutional context facilitate the transfer of tacit and explicit knowledge. Through strong ties and relational-like trust, knowledge was freely exchanged. Discussions with the participants yielded two main forms of knowledge sharing in the biotechnology sector.

The idea to complement each other's innovative capabilities was one form of knowledge-sharing that was clear. The strategy was evident across all the sampled cases. The collaboration between Critical Pharmaceuticals and PolyTherics is an example of complementary knowledge assets. Critical Pharmaceuticals specialises in injectable products and PolyTherics Limited are innovators in precision improvement of proteins and peptides. In that sense, their expertise and knowledge capabilities complement Critical Pharmaceuticals' technology of human injectable drugs. The second form of knowledge sharing was in the mould of process re-configuration. It is however important to mention that the process of transferring knowledge occurred after the establishment of the intentions of the partnering firm(s) or institution(s).

BAST Ltd as a contract research organisation (CRO) exchanged knowledge with its collaborating partners by re-arranging science apparatus in such a way that enhanced new drug discoveries. When responding to the question about how his firm's collaborative partners utilise the knowledge acquired in collaborative drug discovery projects the science director explained that:

> *We use the information that we share with them to enhance their innovations and to accelerate their business processes. Basically, our ideas would change the next developments that they have which helps them to reduce costs and even sharpen their innovations and the way they put their resources together e.g. their operations and product development strategies*

In the first form of knowledge transfer where both parties provide valuable input to the project, there was high commitment to create tacit and explicit knowledge. The firms developed relational capacities pooling together the skills of specialised participants who ultimately played a leading role in the overall flow of information and resources in the network. The exchange and transfer of specialised scientific knowledge and skills between the firms engaged in collaborative projects or in the wider network at BCN had a significant impact on how they increased their capacity to innovate. This highlights the fact that tacit and explicit knowledge are important elements that have an impact in the knowledge supply-chain of small born-global bio-tech firms. Nonaka & Takeuchi (1995) suggest that the creation of new knowledge is predominantly characterised by the interaction between two main forms of knowledge i.e. tacit and explicit knowledge.

4.4.5 Prior learning & absorptive capacity

Small born-global bio-tech firms operate in a constantly changing business environment which has become global as a result of the liberal trade structures governing trade today. This requires constant resource re-configurations to sustain their economic development.

In that sense, prior-learning and the cumulative science experiences of bio-entrepreneurs is a catalyst that facilitates the economic development of their bio-tech ventures by assisting in the process of acquiring useful scientific knowledge from multiple knowledge sources. The head of process development at XenoGesis explained this more fully when asked about the importance of prior learning in terms of understanding the specific knowledge that is useful for their science in business and social networks that span beyond their proximity. This is how he puts it:

> *Understanding what is required is important in terms of acquiring useful knowledge/principles that are necessary in science experiments.*

The same sentiments were echoed by Ben Nichols the CEO of Haemostatix who explained that:

> *Experience in science plays an important role when it comes to selecting the right type of knowledge that is needed to develop new technology.*

The Richard Weaver the CEO of XenoGesis contributed to this by stating that:

> *It is important to have some understanding of science in order to acquire useful information. More importantly, it is crucial that one adopts a methodical or rational way with a view to acquire essential data. In other words, you will be separating wheat from chuff. Here at XenoGesis we are constantly looking for relevant data and in that regard science experience comes into play. It would be difficult to know our knowledge gaps if we did not have the necessary science experience.*

The science director of BAST Joachim Grevel commented that:

> *We work in projects on a global basis. In that sense, personal experience becomes very important in locating what is essential for our business. Take for instance I attend various conferences throughout the year where more than 5000 pieces of information are generated therefore understanding what is necessary you have a better chance of acquiring. In that sense when you attend such conferences you will be able to realise useful data.*

The commentaries on p.202 demonstrate that BAST's and XenoGesis's ability to exploit and assimilate external knowledge was crucial to their process of developing innovative capabilities. In the literature Cohen & Levinthal (1990) argue that a firm's ability to evaluate and utilise information is heavily influenced by prior-related knowledge. Within case analysis indicated that for all the sampled firms their management structure was composed of individuals who had vast experience in science and have worked for large bio-pharmaceutical firms. As such, their wealth of experience was vital in terms of understanding the knowledge gap in their firms. To get a different perspective on this the topic about prior-learning and absorptive capacity was presented to an innovation expert at Sally Barker Medilink as a point of discussion and she commented that:

> *Working with other organisations to share knowledge and ideas is great, but what is important is that one has to have some knowledge about the knowledge that will help his/her business to take that one step forward.*

Helen Walker of BAST commented that:

> *Absorbing information is one thing what is important is that when you go back to your company you have a good understanding about how you are going to use the information. Therefore, to productively apply the knowledge to your science there is no doubt that you have to have vast experience in science.*

All of the comments above and on p.202 reveal to greater extent that the personal experience and prior-learning of key individuals in a firm have considerable influence on how bio-tech firms select useful knowledge that complement their specific knowledge gap. Clearly, working with other firms or science institutions whose complementary foci is at some cognitive distance results in the accumulation of vast amounts of information but recognising what a firm needs increases its innovative capacity. Indeed, working in collaboration accelerates the firm's process improvement.

Taking the literature review in Chapter 2 into perspective, Schilling (2010) suggests that a firm's prior-related experience shapes its ability to recognise the value of new information and its ability to utilise that information effectively. Thus the study proposes that:

Proposition 6: *The experiences of small born-global bio-tech firms are essential to their ability to recognise, assimilate and apply knowledge from their business and social relationships in a way that enhances their capacity to innovate*

It is instructive to inform the reader that the concept of learning has not been fully explored here because it is beyond the remit of this study. Although the concept has been discussed in a limited fashion it has been an important part of the process of understanding its role in the development process of innovative capabilities. Following an in-depth account of various elements within the knowledge supply-chain of small born-global bio-tech firms the study proposes a refined conceptual framework of knowledge and innovative capability development.

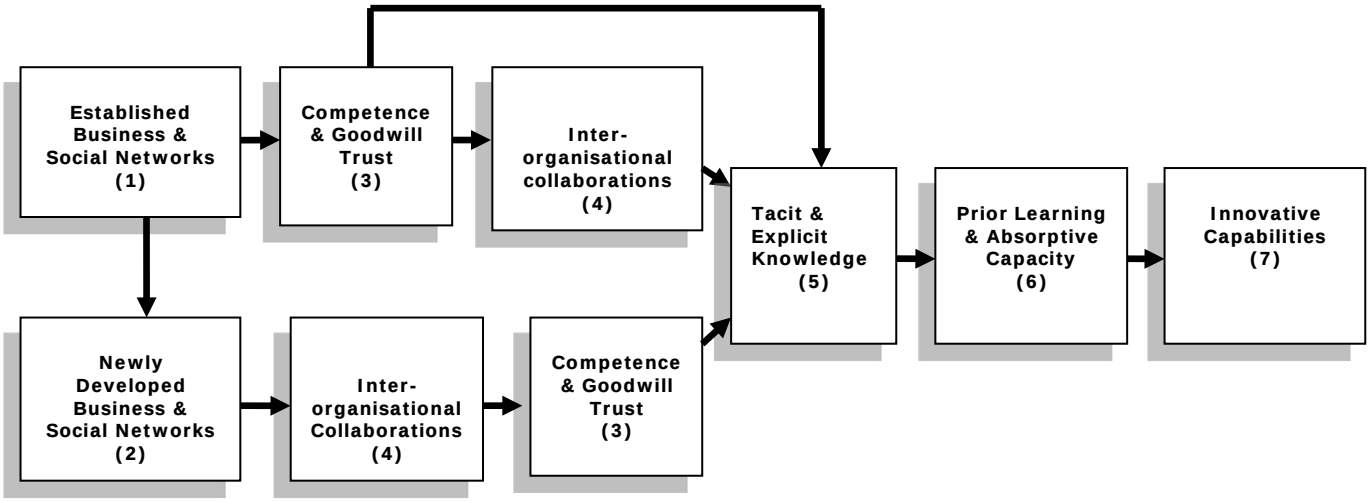
4.5 A model of knowledge and innovative capability development

This section of the thesis provides the reader with a diagrammatic representation of the variables/factors, along with a detailed explanation of the improved *"Knowledge and Innovative Capability Development Model"* following an in-depth explanation of the key concepts contained in the model. Before the study clarifies the connectivity of various elements within the knowledge supply-chain of the small born global biotech firms; it is deemed necessary that the reader is informed about the role theories occupy and perform in social science. The formation of theories in social science is fundamental to how researchers explain what they are trying to talk about (Gerring, 2005). Precisely, theories are instrumental in social science as they help researchers to make connections between the world people live in and how they interpret it (Gerring, 2001).

Concepts can be seen as occupying a central role in social science. In that sense, the concepts contained in the improved model on figure 8 p.206 are essential to what this study intends to convey to the reader. Bellamy & Perri (2009, p.90) point out that regardless of one's research philosophy developing an adequate conceptual framework provides a roadmap that guides how the study explores the social world and for those working with variables and correlations they are able to "establish valid measures and apply them reliably". Building on the instrumental work by Freeman *et al.* (2010) regarding how smaller firms rapidly develop new knowledge by forging business networks, this study uses their ideas as a foundation on which it develops a new improved framework. The modified concepts on the new framework are based on empirical evidence and existing literature. Developing a frame of reference in this manner makes the theories developed in this study credible and acceptable (Bellamy & Perri, 2009).

Furthermore, Saunders *et al.* (2007) concur with this view and they insist that developing a strong theory involves a process that delves into underlying processes with a view to understanding the systematic reasons for an occurrence or non-occurrence. Taking a cue from Saunders and others the study proposes the "*Knowledge and Innovative Capability Development Model"* – an improved version of Freeman's *et al.* (2010) model. Figure 8 on p.206 neatly illustrates the proposed conceptual framework for this study.

Figure 8: Knowledge and Innovative Capability Development Model



Source: Modified from Freeman *et al.* 2010 "A Process Model of Rapid Knowledge Development: The Smaller Born-global firm" and author's ideas

The *"Knowledge and Innovative Capability Development Model"* builds on earlier theories concerned with knowledge development (*see* Lane *et al.,* 2006; Elfring & Hulsink, 2003; Freeman *et al.,* 2010). The model shows that elements/variables that include: business & social networks, competence & goodwill trust, inter-organisational collaborations, tacit & explicit knowledge, prior learning & absorptive capacity have a strong connection. The connectivity of these variables has a positive or negative influence on how small born-global firms develop their capacity to innovate. Small born-global bio-tech firms operate in a very complex and sophisticated business environment which is ever changing. Therefore, it is imperative that firms formulate strategies that enable them to continue to produce innovative life-saving products.

The primary aim should be to enhance their innovative capabilities to enable them to make crucial innovations (Powell & Grodal, 2005). The firms used in this sample are all resident at BioCity implying that they exist in a network which is established where they have developed strong business and social ties. They also demonstrated an entrepreneurial flair by venturing into the global markets in search of global partners.

As denoted on figure 8 p.206, the establishment of business and social networks described as innovation networks by Powell & Grodal (2005) both locally and globally, is the key building block within the knowledge supply-chain of small born-global bio-tech firms. Elfring & Hulsink (2003) make an important observation about entrepreneurial firms. Elfring and Hulsink claim that networks (business & social) meaningfully contribute to the venturing process of small but entrepreneurial firms. They present them with access to knowledge and unique capabilities that underpin innovation.

At their local network (BCN) and the wider East Midlands region the firms were aware of the competences and the intentions of their potential collaborative partners thus, trust was built at a very early stage. This allowed rapid knowledge transfer and the exchange of technical know-how. As trust-like relationships existed in established it led to intensified inter-organisational collaborations. Established networks made it possible for small born global bio-tech firms to develop new networks – networks of networks (see Cooke, 2003; Davis, 1970; Wall, 2009). In newly developed networks, trust was very loose or in the majority of cases it did not exist at all. Therefore, for R&D institutions, firms or scientists located in foreign markets inter-organisational collaborations in the form of smaller projects were used in a “trial and error” method to test the trustworthiness of the prospective partner in newly established networks. In the process of developing innovative capabilities small born-global bio-tech firms embarked on a number of different, often unsuccessful, configurations and techniques before finding the right combination that worked well for the firm (Lichtenthaler & Lichtenthaler, 2009).

Schilling (2010) explains this process of experimentation and learning more clearly asserting that this stage in the knowledge supply-chain is vital in the sense that it allows the firm to build a base of knowledge about how key components behave, what alternatives are more likely to be successful than others, what types of projects the firm is most successful at, and so on. The can disclose that small bio-tech firms were forced to adopt the experimentation approach because of the dynamic nature of the biotechnology sector i.e. its heavy reliance on highly fluid scientific knowledge and technology to make new drug discoveries and the speed at which these types of firms form and disintegrate required high levels of trust (Maxwell & Lévesque, 2011; Welter 2012). This, therefore, strongly suggests that trust is ever-more critical for the transient and the high speed environment of the small born-global bio-tech firms as the basis for knowledge sharing (Freeman *et al.,* 2010). As such, trust was built in escalating series because of the risks associated with developing new partnerships. Sitkin & Pablo (1992) discuss about risk perception referring to the assessment of the risk inherent to a situation.

In all of the five small born-global firms the assessment of the risks associated with knowledge-sharing with new partners was done in a carefully orchestrated logical step-by-step approach as described above. Once trust was built, whether in established or newly developed business and social networks, it paved the way for effective knowledge-sharing. Hill (1990) suggests that it is highly likely that a firm will engage in knowledge transfer with partners that have demonstrated their trustworthiness and co-operative ability in their other relations. Indeed, the process of knowledge-sharing is embedded in pre-existing business and social connections. Hutchings & Michailova (2006) suggest that sharing of knowledge, depends on the pre-existence of insider relationships and a disposition towards co-operative interdependence.

It is widely accepted that small firms with limited resources have a tendency to soak-up as much information as is possible with the hope that something magical will happen (Simba, 2013). The proposed model accentuates that for small born-global firms prior-learning a good understanding of the complementary resources needed for the firm to develop new life-saving drugs or technical products is essential. Otherwise, engaging in collaborative projects will count to nothing in the way of innovations. The underlying assumptions of the model are that by acquiring new scientific knowledge and technical know-how the firm enhances its innovative capabilities that will support the development of new products and services in the life science industry.

4.6 Discussion of findings

This study offers an interesting contribution to the discussion about how small born-global firms develop their innovative capabilities. The study accentuates that, following the re-structuring of the life science industry which has seen large pharmaceuticals such as AstraZeneca and Lund in Sweden closing down their R&D facilities to concentrate on external collaborations, small born-global bio-tech firms appear to taking a leading role in science-related R&D activities. This is well-represented in the extant literature (see for example: Karra *et al.,* 2008; Gurau *et al.,* 2010; Rafols *et al.,* 2012; Taks, 2012)

Small born-global firms are taking advantage of the advancement in information technology and the harmonisation of global markets by engaging in global networks (Eurofound, 2012; Dlugoborskyte & Petraite, 2013). Consequently, networks have become a key part of their knowledge supply-chain. In biotechnology, there is a strong association between the performance of firms and innovative regions. It is generally accepted that small firms do not possess all the resources that are necessary for R&D and sustained economic growth (Freeman *et al.* 2013; Gabrielsson & Kirpalani, 2012; Eurofound, 2012).

As such, they rely on their business and social connections and they locate their businesses in regions where they have an opportunity to explore and exploit pooled resources (Kocak & Abimbola, 2009). Arguably, the development of new products in life science is very much driven by a firm's ability to build strategic alliances mentioned in Harryson *et al.* (2007) as part of a total knowledge creation process. Alliance-building is an integral feature of networking. Therefore, a good insight into processes of alliance-building, knowledge-creation and the network perspective is fundamental to our comprehension of corporate technology and innovation management processes of small born global bio-tech firms.

It is universally agreed that the science-related industries are knowledge intensive (see Travinsky, 2012; Tanev, 2012; Cavusgil & Knight, 2009; Gabrielsson *et al.*, 2008). Small firms in this field have limited options and engaging in collaborative R&D activities seems to the most viable approach to take as opposed to going it alone. The study discusses various interconnected elements that dominate their knowledge supply-chain and how they influence innovation. The study infers that, it is imperative that small born global firms strengthen their internal capabilities by recruiting experienced scientists and participate intensively in globalised R&D programmes. Their innovation 'ecosystems' should include key performers in science such as university scientists, established pharmaceutical firms, science parks and government sponsored trade advisors. This will allow them to move expeditiously and identify research programmes/projects that will help them to accelerate firm-based innovations. Nonetheless, in this euphoria to speed up drug discoveries small born global bio-tech firms should be very cautious of the risks associated with an excessive focus on exploitation. The danger is that, they may end up diverting resources away from exploration which might adversely impact on their ability to innovate.

Accordingly, too much focus on exploration can seriously weaken a firm's ability to appropriate and capitalise on the innovation (March, 1991; 1999; Levinthal & March, 1993). When discussing about innovation it is reasonable for one to think about the concepts of dynamic capabilities and networking because the theories have direct implications on how small born global bio-tech firms develop their innovative capabilities. The dynamic capabilities theory explains how organisational and strategic routines designed by firms enable them to achieve new resource configurations. The theory explicates a firm's ability to integrate, re-configure and to acquire new ideas, information and knowledge. Clearly, the dynamic capabilities theory is anchored on a firm's knowledge-based processes which are instrumental to knowledge-creation, knowledge-integration, and knowledge-configuration.

The network theory draws one's attention to the fact that firms can overcome their resources shortages by accessing external resources such as knowledge and international opportunities. International network relationships mitigate risks associated with newness and inexperience. At the network level firms have a chance to form partnerships, business networks, personal networks, and to participate in clusters. This demonstrates that both dynamic and network theories are interwoven into the innovation management processes of born global firms.

The dissection of small born global bio-tech firms in this study joins together ideas of both international business and entrepreneurship theories. Avoiding being too defensive about the design of this study; it was inevitable to adopt a series of theories in order to comprehend the behaviour and decision rationale of born global firms (Su, 2013; Cavusgil & Knight, 2009) especially in the literature where the study touches upon a variety of concepts.

As such, the main theories which are helpful in building the epistemology of small born global bio-tech firms for this study include: dynamic capabilities theory, organisational learning, knowledge management, innovation, and network theories (Dlugoborskyte & Petraite, 2013).

4.7 Potential hazards

It will be naïve on the part of the researcher to ignore the issues small born-global bio-tech firms have to contend with in the process of acquiring scientific knowledge and technical capabilities. Firms may choose not to collaborate or to engage in research programmes with others for a variety of reasons. A firm may possess all the capabilities needed to develop a clinical product in-house (Schilling, 2010) meaning there will be no need to search for partners. Alternatively, after assessing a number of firms using the "trial and error" method a company may conclude that there is no other firm whose skills or resources complement theirs or there may be no partner willing to collaborate and it could decide to go solo.

The study can reveal that one of the main issues that arose in inter-organisational collaborations was to do with intellectual property risks. During the data collection phase the researcher had an opportunity to discuss with a scientist at a University in Nottingham. The scientist expressed concern about participating in the interview for fear of divulging sensitive information about her business strategy. She was actually a victim of patent violation – her compounds (scientific combinations) for testing new drugs were used without her permission by a supposedly business partner from a country in the Far East. Similarly, Lasserre (2012) reports that, "the protection of intellectual property rights (IPR) is a source of concern and sometimes an impediment to global collaborations" (p.298). Other firms may choose to go solo in order to have full control over the project's development and its returns (Lin & Chen 2002; Schilling, 2010).

New inventions occur as a result of complex linkages between a number of actors in a concentrated area and this brings about the problem of critical mass constraint noted by Lasserre (2012) as existing in situations where, in order to perform one activity efficiently and effectively, a firm has to mobilise resources using its external links. Admittedly, the scientists, bio-entrepreneurs and technologists who participated in this study are not lone inventors, they thrive by networking. They aim to benefit from the complementarities of personal and business networks in their field through horizontal integration and in related domains through vertical integration. They also require state-of-the-art science equipment for their inventions to materialise. Anything below that threshold of resources causes difficulties in the majority of research projects. As such, critical masses for small born global bio-tech firms are unavoidable. What is crucial though is for them to be flexibly, adaptable and learn rapidly in order to avoid the constraints associated with critical mass.

Chapter 5

5. Conclusion

This chapter of the research project provides a summary of the highlights of the study. It provides a set of conclusions that are based on the main findings of the research. The main aim of the project was to explain the connectivity of various elements within the knowledge supply-chain of born global bio-tech firms and how they influence their strategic plan for generating scientific knowledge and technical know-how. The findings establish that the relationship between business and social networks and other elements/variables that include: business & social networks, competence & goodwill trust, inter-organisational collaborations, tacit & explicit knowledge, prior learning & absorptive capacity of small born-global bio-tech firms is decisive to their innovation development process. All the elements mentioned above indicated that they have a considerable impact on the process of how small born-global firms develop their innovative capabilities. This satisfies the second research objective of this study which was aimed at explaining the connectivity of various elements within the knowledge supply-chain of small born-global firms.

The proposed model of *Knowledge and Innovative Capability Development* is constructed from a detailed case-by-case analysis, across case and the existing literature together with evidence from a “pilot” study. The concepts contained in the new model endorse the importance of horizontal networks and the links between firms, research institutions and academics which have complementary technologies and science within the knowledge supply-chain of small born-global bio-tech firms. The most significant contribution of the study is concerned with theory-building. The newly formulated theory of innovative capability development contributes to a better understanding of two theories namely: dynamic capabilities and network theories.

The network approach focuses on specific, well-selected relationships in the innovation process with specific actors within an innovation 'ecosystem' described by Booth (2009, p.705) as a 'brave new world'. It stresses the motives for engaging in co-operations such as technological complementarities or access to resources and specific knowledge, and it emphasises on the connection between trust and social capital (scientific knowledge) as vital to the development of networks. The connectivity and collaboration between various actors within the East Midlands network shows that they performed a leading role in ensuring continued development of knowledge and technical know-how by providing expert advice, financial support and infrastructure to bio-tech firms. The principles of dynamic capabilities theory are borrowed to explain how organisational and strategic routines designed by small born global firms enabled them to achieve new resource configurations. The theory helped to explicate how these entrepreneurial firms integrate, re-configure and to acquire new ideas, information and knowledge.

From that perspective, the construction of a new conceptual framework satisfies the third research objective which was aimed at making a theoretical contribution to dynamic capabilities and network theories. The study also demonstrates that the structural, relational and cognitive dimensions of small born-global bio-tech firms are important in providing the firm with business partners that have complementary capabilities allowing them to jointly develop new innovative products. Entrepreneurial firms such as born-global firms are known for their resource deficiencies especially, financial resources. In that respect, the study safely discloses that within the structural dimension of these firms venture capitalists (VC) execute a crucial role as they provide the much-needed financial support which makes it possible for a proposed research project(s) to progress to the next level.

The study also concludes that in order for small born-global firms to receive and share tacit and explicit knowledge some form of trust between the collaborating parties has to be established. Particularly, competence trust i.e. trust which is based on the scientific and technical capabilities of the prospective partner and goodwill trust referring to the intentions of the prospective partner were identified as critical to inter-organisational collaborations that occur in the biotechnology sector. The collaborations in this sector predominantly involved small born-global bio-tech firms, bio-pharmaceutical companies, research institutions, and academia.

The key criteria for collaborating were based on the extent to which the partner complements the existing knowledge base. More importantly, the research highlights the fact that trust, in the collaborative projects of bio-tech firms, is built in escalating series. Established science networks are an exception. In science parks such as BCN relational-like trust already exists among resident firms. However, in newly developed networks trust exists very loosely or does not exist at all. With newly developed relationships the study can infer that the “trial and error” method was evoked. The process starts with a firm engaging in smaller projects aimed at testing the trustworthiness of a prospective partner and this is likely to lead to more collaborations.

This observation is consistent with Shilling (2008) who argues that experimenting by linking up with different partners during the stage of establishing a partnership is necessary for high tech firms because collaborating is not without risks. The exchange of crucial scientific knowledge and technical know-how was found to occur only when trust has been established between the collaborating parties.

The study also concludes that prior-learning and the absorptive capacity of small born-global bio-tech firms performed a leading role in their knowledge acquisition process. It was insightful to note that within the knowledge supply-chain of small born-global bio-tech firms previous learning and the sector based-experiences of the CEOs, bio-entrepreneurs or science directors were crucial in terms of absorbing specific capabilities or for selecting the 'right' partner with specific skills or knowledge that complements the firm's internal capabilities. Cohen & Levinthal (1990) emphasises on the importance of understanding what is needed for the firm to enhance its innovative capacity. Without prior-learning it is difficult for a firm to acquire knowledge or skills that complements its firm-based capabilities. It was fascinating to find that the once secretive science sector is moving at an alarming pace towards the concept of open science (Owen-Smith & Powell, 2004). The explanations above regarding how various elements interacting within the knowledge supply-chain of small born global firms fit in together satisfies the first research objective of this study. The first objective about understands how various elements that interact within the knowledge supply-chain of born-global bio-tech firms relate to their capability development

Successes in producing innovative products and services documented elsewhere e.g. Silicon Valley, the Golden Triangle of Cambridge, London and Oxford and the Boston Metropolitan Area have initiated this huge wave skewed towards inter-organisational collaborations. Regarding the increase in the number of biotechnology firms the study concludes that the current restructuring phase in the pharmaceutical and biotechnology sector is the main contributing factor. Rafols *et al.,* (2012) made similar observations and they reported that this is a fast-developing trend which has seen the disintegration of the "Big Pharma" model in favour of outsourcing R&D activities to small bio-tech firms in highly concentrated innovative regions usually populated with entrepreneurial firms.

Findings from a case by case analysis revealed that born global bio-tech firms participate in networks. Specifically, they engage in science research programmes that involve international scientists in which existing firm-specific information is recycled and added to new information. Innovations are honed and sharpened resulting in the development of innovative products which have made a marked difference to human and animal life. The study also highlights that although collaborating with other organisations brings a wide range of economic effects there are challenges that small born-global bio-tech have to deal with to achieve their corporate goals. These have been identified as: intellectual property violation, communication problems, cultural related issues, government policies and political influence.

Irrespective of the afore-mentioned challenges associated with collaborating, the reader is informed about the fascinating developments that are taking place in the life science industry particularly in the bio-tech sector where entrepreneurial firms are engaging in science-related collaborative programmes. The study shows that the concept of working in collaboration is on an upward trend in the bio-tech industry following the restructuring that is taking place industry wide. The study can disclose that the East Midlands region is very active in science-related collaborations. Going way back to the 1960s the region was already encouraging innovation networks which resulted in the development of a world known pain killer *ibuprofen* and lately the MRI scan to better the lives of human beings.

These findings are useful to a wide range of stakeholders that include: the government, the EU Commission, other researcher and bio-tech firms. They help them to evaluate whether their networking strategies are enhancing product and process innovations in the biotechnology sector. Finally, this research has shown that the process of developing innovative capabilities for small born-global firms requires them to develop productive relationships with other organisations. Their business and social networks should include both domestic and global partners to increase their propensity to generate new scientific knowledge and technical know-how. The learning experiences of bio-entrepreneurs who are responsible for formulating the strategies for their firms are crucial in terms of choosing the right combination of resources that complement their operations.

Conclusively, the study demonstrates that firms which operate in the bio-tech sector should aim to adjust their resource mix in order to enhance their innovative capabilities as they underpin their ability to make innovations. When doing so, they have to pay particular attention to various elements that include: trust, knowledge management and absorptive capacity within their knowledge supply as they significantly influence their capacity to develop their innovative capabilities.

5.1 Research contribution

The contribution of this study is in three folds. Firstly, the study highlights the experiences of small born-global bio-tech firms in the East Midlands within their knowledge supply-chain. It explains various elements that influence their capacity to generate scientific and technical know-how. Smith *et al.* (2012) suggest that, the East Midlands region possesses an important local concentration of pharmaceutical (R&D) activities. On that account, this study has enlightened the reader about the actions of bio-tech firms which appear to be leading the way in science-related R&D programmes within the region.

Secondly, the study makes a theoretical contribution by modifying Freeman's *et al.* (2010) influential conceptual model of rapid knowledge development for smaller born-global firms. The modified model can be used to explain the innovation management processes of both small and large organisations. Thirdly, the study is valuable to a number of stakeholders. It informs other researchers about the activities of small born-global bio-tech firms and it helps science institutions, policy-makers including: the UK government, the EU Commission to assess whether their strategies are enabling small firms to make new discoveries in the biotechnology industry given the amount of investment in the sector which is in the region of £5.5bn (HM Government, 2010).

The idea to reach a wide range of audiences was rather nicely summed up by Todtling *et al.* (2009) who understood innovation systems model as encompassing the business sector, the science sector, and policy actors. This is consistent with Easterby-Smith *et al.* (2012) who argue in favour of research that contributes to a field of study in different ways. The scholars insist that, "theoretical contribution is most important, and it may be supplemented by each of the others" (p.237).

5.2 Newness

The achievements of this research are new in the way they employ the preliminary research findings, case-by-case, cross case analysis, and secondary data to formulate a new conceptual framework which contributes to the understanding of the concept of dynamic capabilities and network theory. While other instruments exist with capabilities similar to the *Knowledge and Innovative Capabilities Model* very few have been developed to be utilised in the life science sector. This research was particularly new in demonstrating the connectivity and the influence of various elements within the knowledge supply-chain of small born-global bio-tech firms.

5.3 Limitations of the thesis

While this study has provided valuable insights into the social world of small born-global bio-tech firms global markets are much more complex and sophisticated. Science-related projects/programmes that have a global dimension involve more than eight participants, decision-making in that context is fraught with many more variables and challenges that influence the process of developing innovative capabilities, and the focus on bio-tech firms in the East Midlands region mimic the demands of a study of this magnitude at the feasibility stage.

Therefore, it merits investigations that use of research methodologies which involve quantitative measures in order to provide even more accurate insights into the extent to which various elements and elements mitigate in the knowledge supply-chain of born-global firms.

5.4 Barriers to collaboration

The study also highlights some barriers that hinder the process of capability development in complex global networks. The issue of appropriation of intellectual property was a serious factor which affected the process of exchanging technical know-how and scientific knowledge. The global networks of born-global bio-tech firms involve multiple parties from different countries. Therefore, during fieldwork all the participants emphasised that trust and commitment were the most important factors that influenced the productivity of a relationship in the way of resource sharing. To overcome the dilemma of trust firms evoked the “trial and error” method i.e. conducting due diligence on their prospective partners. What was clear in the conversations with the key informants was that; in established networks trust occurred at a very early stage in a relationship but in newly developed relationships it was developed in escalating series. This is consistent with what Schilling (2008) called a process of experimentation when formulating an alliance.

5.5 Recommendations

Political institutions and government policy-makers play a leading role in shaping firm development patterns in market-oriented economies, especially, in uncertain economic times. A flexible, dynamic and innovative bio-tech sector significantly improves the lives of human beings and animals. In the recent past the world has witnessed the private sector taking a leading position in the society in creating wealth and jobs for example (Halkier *et al.,* 2010).

This apparent transformation from government to governance requires extensive and on-going interaction and partnership between public and private actors as opposed to imposing government ideologies by exercising authority. This state of affairs is needed for small born-global bio-tech firms to realise their potential especially in the life science sector where life-saving drugs and clinical products can make a difference to the lives of the general public worldwide. To achieve this desirable state it is necessary to develop a platform on which a wide range of resources can be exchanged in order to influence the direction of socio-economic activities.

The ability to perform this role effectively depends not only on political and financial resources - for example, but it also depends on the decentralisation of policy-making and revenue-generating powers. In that sense, the study recommends that the central government should reconsider its strategy of centralising policy-making and devolve those powers to local authorities. This will enable local institutions that facilitate networking such BCN, Medilink, Business Link etc. to respond quickly to the needs of small but entrepreneurial firms and at the same time encouraging their economic growth and development.

5.6 Future research direction

This study explains the innovative capability development process of small born-global bio-tech firms. The traditionally held view that large Bio-pharmaceuticals are the most dominant force in global markets might well be evolving. As such, the advent of small born-global bio-tech firms on the global stage in substantial numbers (Kermani & Bonacossa, 2003) worldwide reflects an emerging business model with the potential to perhaps become the most dominant in harsh economic times in which large organisations are feeling the strain.

In that regard, the born-global phenomenon requires great attention because it heralds the emergence of a new phase in international exchange systems whereby regardless of the size of a business, any company can perform an important role in global markets. For future research, the study recommends research which focus on how small born-global bio-tech firms learn to cope with the complexity of global markets given their cultural diversity. This will help us to deepen our understanding of how born-global firms organise the exchange of ideas, technologies, people and information in global networks.

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Appendices Section

Appendix 1: Interview guide questions

Nottingham Business School

Division of Management

Discussion about Born-Global Firms – East Midlands, England

Semi-structured questions – Interview guide questions

I would start by saying thank you for agreeing to participate in the discussion about small born-global bio-tech firms. In particular, their collaborative activities with other firms, research institutions, regional incubators and research centres which can be found within the East Midlands and overseas

1. Before we go into great depth about how your firm develops its capabilities in order to improve its drug discovery abilities or technical know-how for the development of new clinical apparatus, would you tell me a bit about your firm's business activities? Do you operate in both the domestic and international markets?

2. The process of developing scientific knowledge in the bio-tech sector requires to a greater extent fluid scientific information inflow into a firm and that has been seen, from an academic perspective, as vital for new drug discovery and new product development. Can you explain to me the extent to which you use your personal or business networks to acquire this type of information and how wide spread are these connections? And how risky is sharing information with your business partners?

3. Are you part of an established business network? In the future do you see your firm developing new partnerships as a way of enhancing your knowledge base i.e. enhancing your ability to develop new scientific knowledge and technical know-how for the development of new clinical products and services?

4. To what extent does trust influence how you share and exchange ideas with your business partners? Could you tell me a bit more about how you develop this trust in both existing and potential i.e. newly developed partnerships?

5. Is your firm engaged in inter-firm collaborations, if so which ones? In other words you are working with other firms within the East Midlands or overseas to jointly discover new drugs or to jointly develop new clinical products.

6. Going back to the question of trust and inter-firm collaborations at which stage would you say trust occurs when collaborating with other firms or research agents in your established networks or newly developed networks? As a follow up question to that what would you say comes first, is it inter-firm collaborations or trusting your business partners? What might be the reasons for developing trust in these two different ways?

7. How do you build trust in your collaborative networks? Do you trust a firm/business because of the competences (i.e. based their skills & knowledge bases and reputation?

8. How important are social networks in your efforts to develop new scientific knowledge and technological know-how?

9. Working in collaborative networks is a very risky strategy how one can minimise the risk involved e.g. minimising the risk of having your ideas represented by your partners as theirs.

10. What risks do you envisage when collaborating with other firms that are in the same line of business or different line of business?

11. How do you learn in networks? Is it through observing others or through coaching?

12. When working in collaborative projects with external parties the issue of who owns the new development becomes very important. How do you ensure that a joint discovery or the joint development of clinical equipment remains jointly owned?

13. Tacit knowledge exists in the head of the knower. In your personal and business networks how do you ensure that this knowledge is exchanged and captured in your firm?

14. That leads us to the question of knowledge acquisition. When working with people who have better skills, better knowledge bases and technological know-how how do you select useful information?, because there is this danger that you end up acquiring vast amounts of knowledge that you may never use. How important is prior learning in the process of assimilating knowledge that your social and business networks make available to you?

15. Do you do a trial and error method to see which combinations of business partners might work for you? And how important is this experimentation stage in building a resource base for your firm?

16. In the last 5 years can you recall any discoveries or clinical services/apparatus that you have developed that you can attribute to your collaborative actions locally and internationally?

17. What is your opinion about working in collaboration in the bio-tech sector?

Appendix 2: Ethical approval form

NOTTINGHAM TRENT UNIVERSITY
COLLEGE OF BUSINESS, LAW AND SOCIAL SCIENCES

BLSS/College REC Form

APPLICATION FORM FOR ETHICAL APPROVAL OF A RESEARCH PROJECT

For use by members of academic staff and doctoral students

Who should use this form?

You should use this form if you are a member of academic staff or a research degree student (including the DBA or ProfD). If you are a student on a taught masters or undergraduate programme, you should use Form BLSS/School REC

Can I begin work before the project is ethically approved?

NO primary data collection can begin until a favourable ethical opinion is received from the College Research Ethics Committee or from an external REC, or, alternatively, you have established that your project does not need ethical approval. Collecting primary data in the absence of ethical approval, or in the face of an adverse ethical opinion, may constitute a disciplinary offence.

If, after receiving ethical approval, you change your project such that the information provided in this form no longer holds, the approval will automatically become void, and you should re-apply for ethical approval.

Is there any help available to complete this form?

Yes. Guidance on filling in this form can be found in Guidance Note BLSS/Ethics 01. This document can be found in the ethics section of the University's Research Intranet.

In this site, you will also find documents dealing with specific issues in research ethics, and also some examples of participant information sheets and consent forms.

Further advice is available through the BLSS Graduate School Office. Please email Sandra. Odell

Please make sure that you complete the Declaration at the end of the form. Doctoral students must ask their Director of Studies to countersign the form before it is submitted.

1. Information about the project

Title of Project: **An Investigation how small born-global bio-tech firms in the East Midlands, UK develop their innovative capabilities: A multi-case approach**
Name of Principal Investigator (PI): **Amon Simba**
Names of co-investigators (CIs) (If any of the CIs are not employed at NTU, please give the name of their organisation) **None**
How many additional research staff will be employed on the project? **None** Please give their names (if known) and their organisational affiliation: **N/A**
Project start date: **1st of April 2010**
Estimated end date of the project: **1st of April 2014**
Who is funding the project? **Myself** Has funding been confirmed? **N/A**
(For research degree students only) Have you applied for and received project approval? **Approval applied for – Approved** If so, please give date of approval: **January 2012**
(For research degree students only) please provide the name of your Director of Studies **Dr. Francis Neshamba**
Which learned society's code of ethical practice is most relevant to your project? (*for example, the Social Research Association, the British Psychological Society, the Socio-legal Studies Association)* **Social Research Association**

2. Does this project need ethical approval?

	Yes	No
Does the project involve collecting and/or analysing primary or unpublished data from, or about, living human beings?		**No**
Does it involve collecting or analysing primary or unpublished data about people who have recently died, other than data that are already in the public domain?		**No**
Does it involve collecting or analysing primary or unpublished data about or from organisations or agencies of any kind, other than data that are already in the public domain	**Yes**	
Does it involve research with non-human vertebrates in their natural settings or behavioural work involving invertebrate species not covered by the Animals Scientific Procedures Act (1986).[1]		**No**

[1] The Animals Scientific Procedures Act (1986) was amended in 1993. As a result the common octopus (*Octopus vulgaris*), as an invertebrate species, is now covered by the act.

If the answer to all the above questions is NO, you do not need to submit your project for ethical approval. You should sign the Declaration at the end of the form, and keep a copy for your own records. Doctoral students must ask their Director of Studies to countersign the declaration, and they should keep a copy, too.

If the answer to any of the above questions is Yes, please proceed to Section 3 below

3. Does the project require Criminal Records Bureau checks?

Please refer to Guidance Note BLSS/Ethics 06.

	Yes	No
Does the project involve direct contact by any member of the research team with children or young people under 18 years of age?		**No**
Does the project involve direct contact by any member of the research team with adults with learning difficulties; adults who are infirm or physically disabled; adults who are resident in social care or medical establishments; or adults in the custody of the criminal justice system?		**No**
Has a CRB check been stipulated as a condition of access to any source of data required for the project		**No**

If you have answered Yes to any of these questions, please explain the nature of the contact required by the project, and the circumstances in which it will be made.

4. Is this project liable to scrutiny by external ethical review arrangements?

	Yes	No
Has a favourable ethical opinion been given for this project by an NHS or social care research ethics committee, or by any other external research ethics committee?		**No**
Will this project be submitted for ethical approval to an NHS or social care committee or any other external research ethics committee?		**No**

If the answer to either of these questions is YES, please sign the declaration at the end of the form, and send a copy to the Research Office. Doctoral students must ask their Director of Studies to countersign the form before submitting it.

Note - if you are applying to an NHS or Social Care REC, you are advised to consult Guidance Note BLSS/ Ethics 03

If the answer to both these questions is NO, please proceed to Section 5.

5. About the project

If the information required below is provided in a succinct form in a previous document, such as your application for external funding or for approval of a PhD project you may submit this document (or preferably the relevant section from it) either in whole or partial answer to the questions below.

What are the aims and objectives of the project?

The main aim of this research study is to investigate how entrepreneurs in the biotechnology sector make innovations through strategic alliances. It explores how the learning and strategic alliance of bio-entrepreneurs influence their capability development by taking advantage of regional knowledge networks. It also examines how they manage knowledge both within the firm and that which is acquired from their external connections in order to ensure continuous innovation and sustainable business development.

To explore the extent to which bio-entrepreneurs/bio-tech firms within the East Midlands region in Britain use knowledge networks to generate knowledge and share ideas.

To examine the learning processes of bio-entrepreneurs and bio-tech firms in a network or a cluster in the UK.

To investigate how external resources such as knowledge, acquired from knowledge networks is vital for business and new product development.

To understand the importance of knowledge management systems and how these systems can ensure continuous product development

Briefly describe the principal methods, the sources of data or evidence to be used and the number and type of research participants who will be recruited to the project

In order to investigate the dynamic impact of knowledge networks and clusters on the innovative capabilities of bio-entrepreneurs, bio-tech firms are drawn from the East Midlands region. A semi-structured questionnaire is used to collect qualitative data from 10 bio-tech firms and a structured questionnaire is employed to collect quantitative data from 150 bio-tech firms to be targeted as part of the survey. Seminars and conferences on networking will be attended to observe activities in the bio-technology sector.

What research instrument(s) will be used to collect data?

A semi-structured questionnaire is used to guide face-to-face interviews and the interviews are recorded using a voice recorder. Additionally, a structured questionnaire is used in a survey to collect data for analysis using SPSS.

If you are using an externally validated scale, please specify

If you are not using an externally validated scale, please attach a copy of the research instrument you will use to collect data (for example, a measurement scale, questionnaire, interview schedule,

observation protocol for ethnographic work, or, in the case, of unstructured data collection, a topic list).

6. Confidentiality, security and retention of research data

	Yes	No
Are there any reasons why you cannot guarantee the full security and confidentiality of any personal or confidential data collected for the project?		**No**
Is there a significant possibility that any of your participants, or people associated with them, could be directly or indirectly identified in the outputs from this project?		**No**
Is there a significant possibility that confidential information could be traced back to a specific organisation or agency as a result of the way you write up the results of the project?		**No**
Will any members of the project team retain any personal or confidential data at the end of the project, other than in fully anonymised form?		**No**

If the answer to all these questions is No, please explain briefly how you will ensure the confidentiality and security of your research data, both during and after the project

The tapes and transcripts of interviews discussions will be handled only by me, in line with data protection principles and the approved research protocol. Hard copies of research notes will be kept in locked filing cabinets, and electronic files are kept on password protected computers which are not accessible to any other university staff. Participants will be assigned pseudonyms and will not be otherwise named or identified in any publication arising from this project. All possible care will be exercised to ensure that participants and the organisation they work for cannot be identified by the way I write up my findings.

At the end of the study, in line with usual practice, all the transcripts will be deposited in the archive of research material maintained by the Business School. The transcripts will be fully anonymised before they are archived. Once the transcripts have been deposited in the Business School archive, the tape of the interviews will be destroyed and the relevant files erased from my computer.

If the answer to any of these questions is YES, please explain:

why it is necessary for the research to be conducted in the way you propose, such that the usual standards of confidentiality and security cannot be respected
what steps will you take to maximise confidentiality and security, within the constraints imposed by the research design
what steps you will take to ensure that participants understand and consent to the implications of these constraints?

7. Informed consent

Please see Guidance Note BLSS/Ethics 02 for examples of model participant information sheets and participant consent forms, together with advice on how to use them

	Yes	No
Will all participants be fully informed why the project is being conducted and what their participation will involve, and will this information be given before the project begins?	**Yes**	
Will every participant be asked to give written consent to participating in the project, before it begins?	**Yes**	
Will all participants be fully informed about what data will be collected, and what will be done with these data during and after the project?	**Yes**	
Will explicit consent be sought for audio, video or photographic recording of participants?	**Yes**	
Will every participant understand what rights they have not to take part, and/or to withdraw themselves and their data from the project if they do take part. Will they also understand that they do not need to give you reasons for exercising these rights and that there will be no repercussions as a result?	**Yes**	
If the project involves deceiving, or covert observation of, participants, will you debrief them at the earliest possible opportunity?		**No**

If the answer to <u>all</u> the above questions is YES, please explain briefly how you will implement your answers. You are advised to attach copies of your participant information sheet and consent form as evidence of your plans.

All participants will be approached prior to commencement of the fieldwork and given a participant information sheet explaining the purpose of the study, what their participation will involve and their rights with respect to non-participation and if they subsequently decide not to participate. They will be asked to sign a written consent form and their permission will be sought to tape record the interviews. No deception or covert observation of the participants is anticipated. Please see Appendices 1, 2 and 3 for copies of the participant information sheet and consent form for this project.

If the answer to <u>any</u> of the above questions is NO, please explain:

why it is academically necessary for the project to be conducted in a way that will not allow all participants the opportunity to exercise fully-informed consent
and how you propose to address the ethical issues arising from the absence of transparency.

You are advised to attach copies of your participant information sheet and consent form as evidence of your plans.

8. Risk of harm

(If there is any possibility that the project involves significant risks to researchers, you are advised to consult Guidance Note BLSS/Ethics 04 on the assessment and management of risk, and to submit a risk assessment form to the relevant authority).

Is there any significant risk that your project may lead to:	Yes	No
Physical harm to participants or researchers?		**No**
Significant psychological or emotional distress to participants		**No**
Harm to the reputation of participants, or their employers, or of any other persons or organisations?		**No**

If the answer to any of these questions is YES, please explain:

the nature of the risks involved, and why it is academically necessary for the project to incur them
how you propose to mitigate them
the arrangements by which you will ensure that participants understand and consent to these risks
any arrangements you will make to refer participants to sources of help, if they are seriously distressed or harmed as a result of taking part in the project
your arrangements for recording and reporting any adverse consequences of the research
N/A

9. Risk of disclosure of harm or potential harm

If the project is likely to involve work with children, or the discovery of physical or mental abuse of children, you should consult the Nottingham Trent University Policy on Child Protection (available in the BLSS Ethics Toolkit) before completing this section of the form.

	Yes	No
Is there a significant risk that the project will lead participants to disclose evidence of previous criminal offences, or their intention to commit criminal offences?		**No**
Is there a significant risk that the project will lead participants to disclose evidence that children or vulnerable adults are being harmed, or are at risk of harm?		**No**
Is there a significant risk that the project will lead participants to disclose evidence of serious risk of other types of harm?		**No**

If the answer to either question is YES, please explain:

why it is academically necessary for these risks to be incurred
what actions you would take, if such disclosures were to occur
whether you will take advice before taking these actions, and from whom
what information you will give participants about the possible consequences of disclosing information about criminal or serious risk of harm

10. Payment of participants

	Yes	No
Do you intend to offer participants cash payments or any other kind of inducements or compensation for taking part in your project?		**No**
Is there any significant possibility that such inducements will cause participants to consent to risks that they might not otherwise find acceptable?		**No**
Is there any significant possibility that the prospect of payment or other rewards will systematically skew the data provided by participants in any way?		**No**
Will you inform participants that accepting compensation or inducements does not negate their right to withdraw from the project?		**No**
If the answer to any of these questions is YES, please explain: the nature of the inducements or the amount of the payments that will be offered the reasons why it is necessary to offer them why you consider that they are ethically and methodologically acceptable		

11. Capacity to give valid consent

Please note that, from October 2007, research involving people who are mentally incapacitated and cannot give valid consent must be cleared through the NHS research ethics procedures, not through a University REC

Do you propose to recruit any participants from the following groups?	Yes	No
Children under 18 years of age		**No**
People with learning difficulties		**No**
People with communication difficulties, including difficulties arising from limited facility with the English language		**No**
Very elderly or infirm people		**No**
People with mental health problems or other medical problems that may impair their cognitive abilities		**No**
Any other people who may not be able fully to understand the nature of the research and the implications for them of participating in it		**No**
If you have answered YES to <u>any</u> of these questions, please explain how you will ensure		

that the interests and wishes of participants (and in the case of children, the wishes of their parents or guardians) are understood and taken into account

12. Is participation genuinely voluntary?

Are you proposing to recruit participants from the following groups?	Yes	No
Employees or students of NTU or of organisation(s) that are formal collaborators in the project		**No**
Employees recruited through other business, voluntary or public sector organisations		**No**
Pupils or students recruited through educational institutions		**No**
Clients recruited through voluntary or public services		**No**
People living in residential communities or institutions		**No**
People who are in-patients in a hospital or other medical establishment		**No**
People recruited by virtue of their employment in the police or armed services		**No**
People being detained or sanctioned in the criminal justice system		**No**
Other people who may not feel empowered to refuse to participate in the research		**No**
If you have answered YES to <u>any</u> of these questions, please explain how your participants will be recruited, and what steps you will take to ensure that their participation in this project is genuinely voluntary		

13. Online and Internet Research

If you intend to conduct any part of your project online, please consult Guidance Note BLSS/Ethics 05 before completing this section

	Yes	No
Will any part of your project involve collecting data by means of electronic media, such as the internet or email?	**Yes**	
Is there a significant possibility that the project will encourage children under 18 to access inappropriate websites, or correspond with people who pose risk of harm?		**No**
Is there a significant possibility that the project will cause participants to become distressed or harmed, in ways that may not be apparent to the researcher(s)		**No**
Will the project incur any other risks that arise specifically from the use of electronic media?		**No**
If the answer to any of these questions is YES, please explain:		

why you propose to use electronic media how you propose to address the risks associated with online/internet research, especially those flagged above (if relevant) Please ensure, too, that your answers to other questions in this form address these questions in ways that are relevant to online research. The questionnaire to be used for collecting quantitative data will be made available via suverymonkey.com an online market research facilitator. The main reason for using this method of collecting data is to ensure that I reach out to a wider range of my research sample at limited costs and it will allow me to collect the key variable that are of interest to this study. Data collected from participants is sent to a secure online storage which can be accessed using a unique password and this is reflected on the company's security statement: Passwords and credit card information are always sent over secure, encrypted SSL connections and when a user accesses secured areas of our site, Secure Sockets Layer (SSL) technology protects user information using both server authentication and data encryption, ensuring that user data is safe, secure, and available only to authorised persons.

14. Other ethical risks

	Yes	No
Are there any other ethical issues or risks of harm raised by your project that have not been covered by previous questions?		**No**
If you have answered YES, please explain: the nature of these issues and risks why you need to incur them, and how you propose to deal with them		

15 Research with non-human vertebrates in their natural settings or behavioural work involving invertebrate species not covered by the Animals Scientific Procedures Act (1986).[2]

	Yes	No
Will any part of your project involve the study of animals in their natural habitat?		**No**
Will your project involve the recording of behaviour of animals in a non-natural setting that is outside of the control of the researcher?		**No**
Will your field work involve any direct intervention other than recording the behaviour of the animals available for observation?		**No**
Is the species you plan to research endangered, locally rare or part of sensitive ecosystem protected by legislation?		**No**
Is there any significant possibility that the welfare of the target species or		

[2] The Animals Scientific Procedures Act (1986) was amended in 1993. As a result the common octopus (*Octopus vulgaris*), as an invertebrate species, is now covered by the act.

those sharing the local environment/habitat will be detrimentally affected?		**No**
Is there any significant possibility that the habitat of the animals will be damaged by the project, such that their health and survival will be endangered?		**No**
Will project work involve intervention work in a non-natural setting in relation to invertebrate species other than *Octopus vulgaris*?		**No**

If you have answered Yes to any of these questions, please explain:

the reasons for conducting the project in the way you propose, and the academic benefits that will flow from it
the nature of the risks to the animals and their habitat
how you propose to mitigate these risks

Principal Investigator's Declaration

Please tick all the boxes relevant to your project, and sign this form. Doctoral students must ask their Director of Studies to countersign it before it is submitted.

I believe that this project does not require the approval of a research ethics committee. I have completed Sections 1-2 and kept a copy for my own records	
I request that this project is exempt from review by the College Research Ethics Committee, because it will be, or has been, reviewed by an external REC. I have completed Sections 1-4 and attach/will attach a copy of the favourable ethical review issued by the external REC Please give the name of the external REC here	
I request a statement of ethical approval from the College of BLSS Research Ethics Committee, and confirm that I have answered all relevant questions in this form honestly	✓
I confirm that I will carry out the project in the ways described above, and that I will request a fresh ethical approval if the project subsequently changes in ways that materially affect the information I have given in this form	✓
I confirm that I have read and agree to abide by the code of research ethics issued by the relevant national learned society, and that I have ensured that all members of my research team (if any) also do so	✓
I confirm that I have read and agree to abide by the University's Research Governance Framework, and that I have ensured that those members of my research team (if any) who are employees of Nottingham Trent University also do so	✓

Signed:  (Doctoral student)

Date: 20/12/2011

I have read this form, and confirm that it covers all the ethical issues raised by this project fully and frankly. I also confirm that these issues have been discussed with the candidate, and will continue to be reviewed in the course of supervision.

Countersigned: Dr Francis Neshamba (Director of Studies)
Date: 18/12/2011

Note: If you are submitting this form by email, you should type your name in the signature space: an email attachment sent from your university inbox will be assumed to have been virtually signed by you.

If you are a doctoral student and are submitting this form by email, please attach an email from your DoS confirming that they are prepared to make the declaration above and to countersign this form: this email will be taken as a virtual countersignature

For office use only

Date form initially received:

Initial assessment in office

(1) Risk assessment required Yes No

(2) CRB check required Yes No

(3) Exempted on grounds that will be submitted to an external REC Yes No

Name of external REC:_____

Copy of external ethical clearance received (date):

(4) Committee Reviewer(s)

Review 1:

Date:

Review 2:

Date:

(5) Decision (Consultation with Chair)

Approve Yes No

Approve with conditions (specify) Yes No

Date of letter to applicant:

(6) Date of receipt of resubmission:

(7) Date sent to reviewers:

(8) Decision (Consultation with Chair)

Approve Yes No

Approve with conditions (specify) Yes No

Date of letter to applicant

(9) Date referred to CREC:

(10) Tabled at CREC (date):

(11) Decision

Approve Yes No

Approve with conditions (specify) Yes No

Date of letter to applicant:

(12) Date of receipt of resubmission:

(13) Decision

Approve Yes No

Approve with conditions (specify) Yes No

Date of letter to applicant:

(14) Final decision recorded

Date:

Signature (Chair of CREC):

Appendix 3: Introductory letter

Amon Simba (Post graduate researcher)
Nottingham Business School
Division of Management
Burton Street, 8th Floor, Newton Building, Nottingham, NG14BU
Tel: 0115 848 500 ext. 85822
Email: amon.simba@ntu.ac.uk

The Chief Executive Officer
XenoGesis Ltd.
BioCity Nottingham
Pennyfoot Street, Nottingham, UK
NG1 1GF

1 May, 2012

Dear Dr Weaver

Bio-tech Collaborations in the East Midlands

I am currently researching about the above, in order to investigate this topical and important issue in science. I am a post graduate researcher in the Business School at Nottingham Trent.

You have experience that would be of value to this research and I would very much like to know your views on how you bio-tech firms generate scientific knowledge and technical know-how. I have currently undertaken 2 interviews with other small bio-tech firms within the East Midlands region and my target is to do 5 interviews. I started the interviews in November of 2011 and they are on-going until June 2012. An outline of the interview structure is attached, although it is not my intention to follow this slavishly.

I am aware of the need to treat my findings with the utmost confidentiality. No source, individual or organisation, will be identified or comment attributed without the express permission of the originator. The intended outputs of the research will be presented in my thesis and research papers of which I will send a copy directly to you and all the other participants. I hope you are able to help me and should be grateful if you would return the attached consent form.
I will contact you on receipt to confirm arrangements for me to visit you for the interview. If you prefer to contact me with a suitable time and venue convenient for you please let me know by phone or email.

In the meantime if require any further information please do not hesitate to get in touch.

Yours sincerely

Amon Simba 

Appendix 4: Consent form

Data Protection Act 1998

Consent Form for company data to be used for research

Project name:	Biotechnology collaborative activities in the East Midlands
Name of project leader:	Amon Simba
Contact details:	Nottingham Business School, 8th Floor, Newton Building, Burton Street, NG14BU, email: amon.simba@ntu.ac.uk, tel: 0115 848 500 ext. 85822
Scope of the project:	The data are used for the purpose of a PhD project, and research publications
Any other details:	N/A

Name of the data subject:	XenoGesis Ltd
Contact details for the data subject:	Richard Weaver, Chief Executive Officer, XenoGesis Ltd

The main data to be used for this research is about your collaborative activities within and outside the East Midlands region. I will also use data from your company website and published material at BioCity about your networking activities. I have attached a transcribed copy of the conversation/interview that I did with you regarding this subject for you to verify the contents. All the data used for the purpose of this research will be kept secure according to the guidelines of research ethics as stipulated by the Research Ethics Committee at Nottingham Trent University, College of Business, Law and Social Sciences. Thank you

Please complete the following:

I consent to data about my company, as outlined above, to be used for the research project detailed above.

Signature: R. Weaver (PhD)
Date: 10.07.2013

NOTTINGHAM TRENT UNIVERSITY

Data Protection Act 1998
Consent Form for company data to be used for research

Project name:	Biotechnology collaborative activities in the East Midlands
Name of project leader:	Amon Simba
Contact details:	Nottingham Business School, 8th Floor, Newton Building, Burton Street, NG14BU, email: amon.simba@ntu.ac.uk, tel: 0115 848 500 ext. 85822
Scope of the project:	The data are used for the purpose of a PhD project, and research publications
Any other details:	N/A

Name of the data subject:	BAST ~~Incl.~~ Inc Limited
Contact details for the data subject:	Joachim Grevel, ~~Chief Executive~~ Scientific Director Officer, BAST Incl. Limited

The main data to be used for this research is about your collaborative activities within and outside the East Midlands region. I will also use data from your company website and published material at BioCity about your networking activities. I have attached a transcribed copy of the conversation/interview that I did with you regarding this subject for you to verify the contents. All the data used for the purpose of this research will be kept secure according to the guidelines of research ethics as stipulated by the Research Ethics Committee at Nottingham Trent University, College of Business, Law and Social Sciences. Thank you

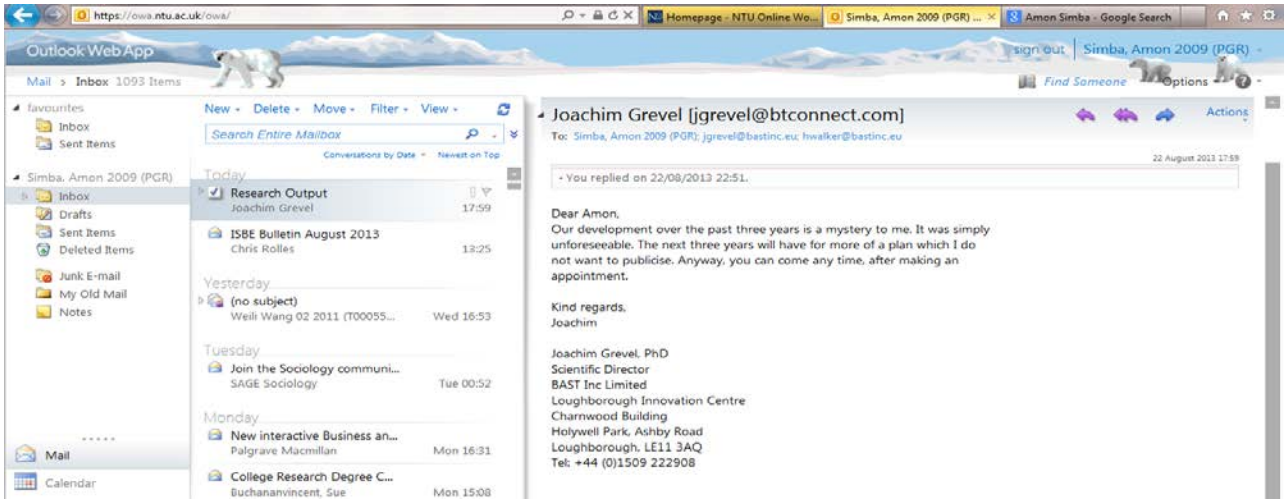
Please complete the following:

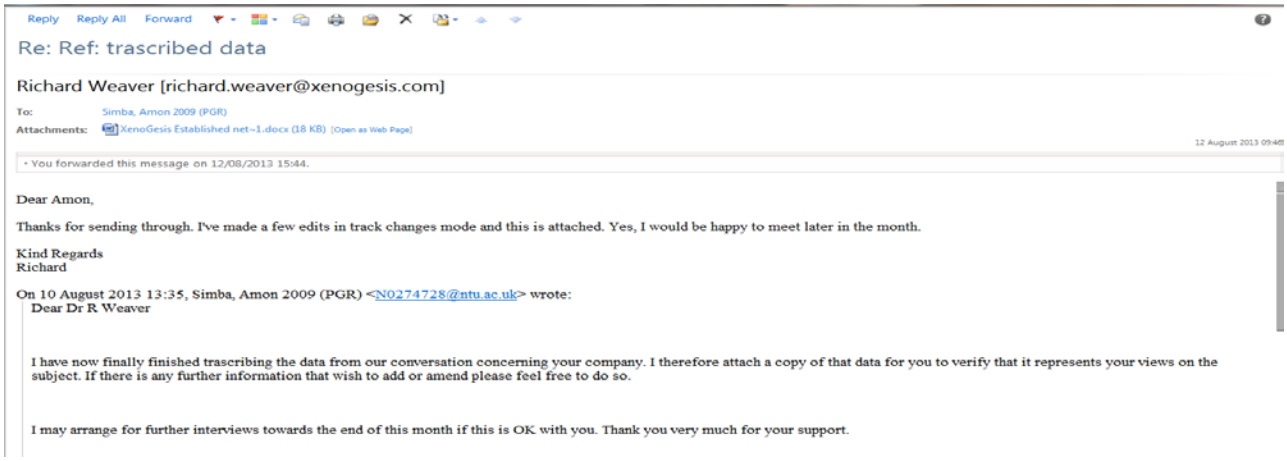
I consent to data about my company, as outlined above, to be used for the research project detailed above.

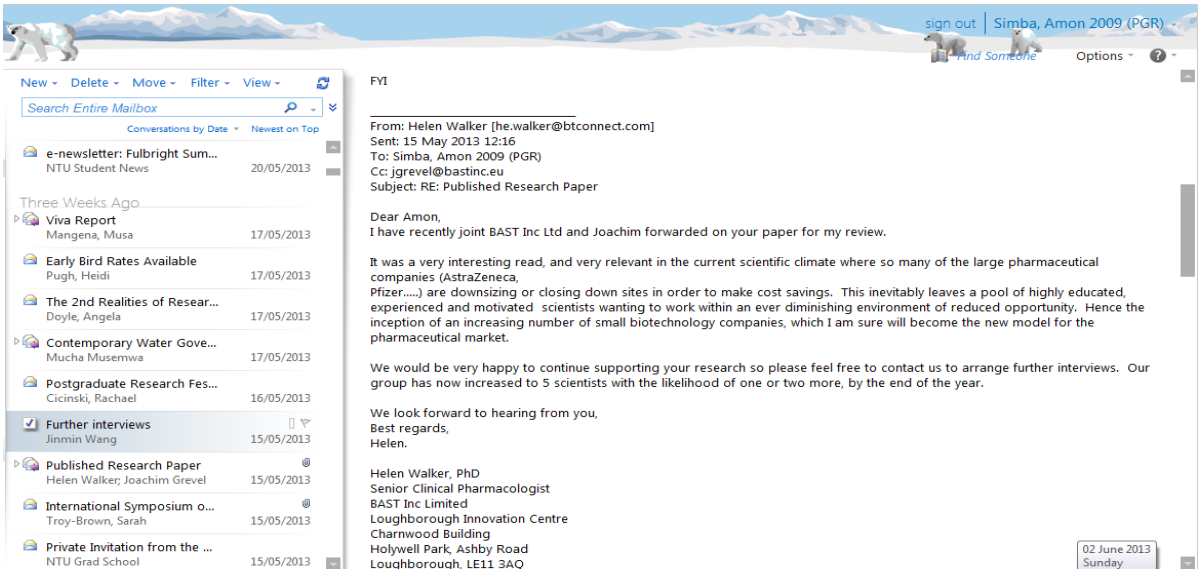
Signature: J. Grevel

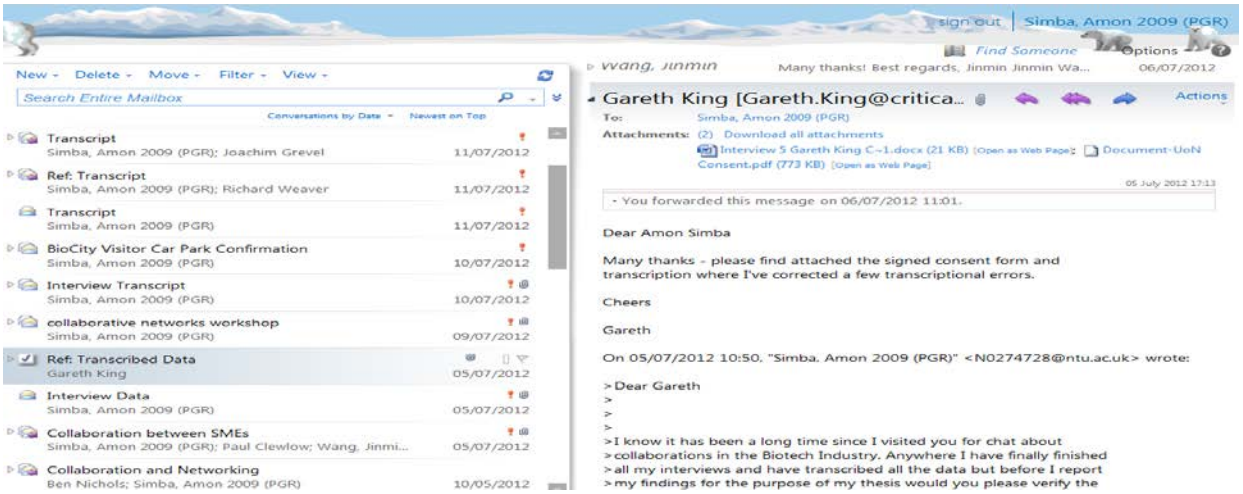
Date: 05 July 2012

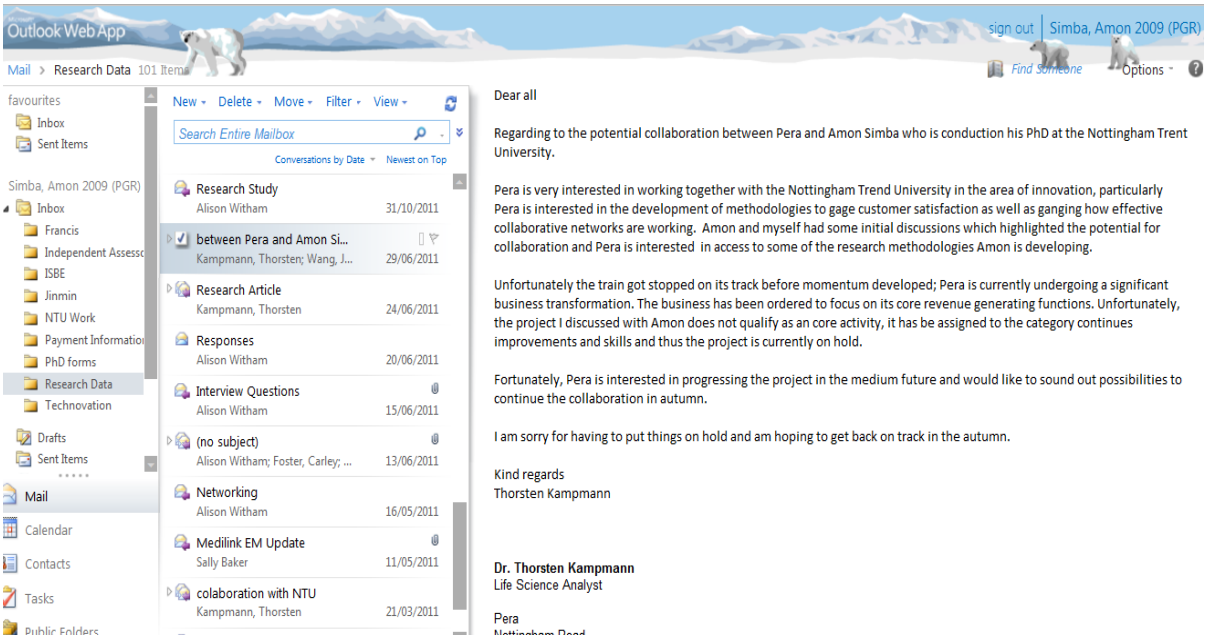
Appendix 5: Evidence of email communications

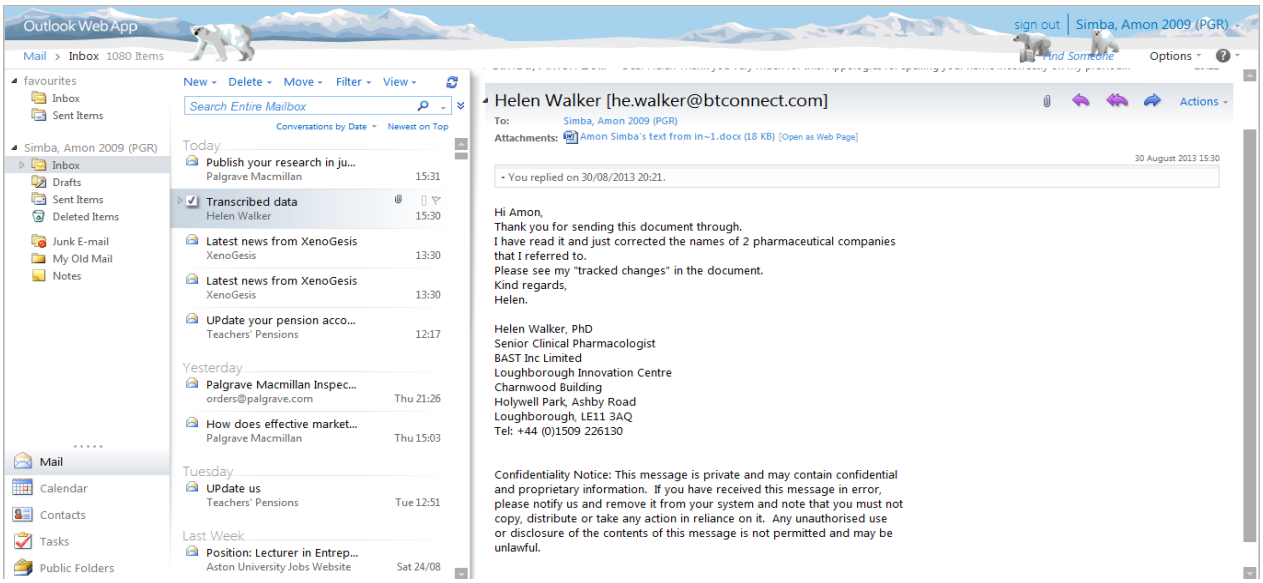







sign out | Simba, Amon 2009 (PGR)
Find Someone
Options
New Delete Move Filter View
Search Entire Mailbox
Conversations by Date Newest on Top
Transcript
Simba, Amon 2009 (PGR); Joachim Grevel 11/07/2012
Ref: Transcript
Simba, Amon 2009 (PGR); Richard Weaver 11/07/2012
Transcript
Simba, Amon 2009 (PGR) 11/07/2012
BioCity Visitor Car Park Confirmation
Simba, Amon 2009 (PGR) 10/07/2012
Interview Transcript
Simba, Amon 2009 (PGR) 10/07/2012
collaborative networks workshop
Simba, Amon 2009 (PGR) 09/07/2012
Ref: Transcribed Data
Gareth King 05/07/2012
Interview Data
Simba, Amon 2009 (PGR) 05/07/2012
Collaboration between SMEs
Simba, Amon 2009 (PGR); Paul Clewlow; Wang, Jinmi... 05/07/2012
Collaboration and Networking
Ben Nichols; Simba, Amon 2009 (PGR) 10/05/2012
Wang, Jinmin
Many thanks! Best regards, Jinmin Jinmin Wa... 06/07/2012
Gareth King [Gareth.King@critica...
Actions
To: Simba, Amon 2009 (PGR)
Attachments: (2) Download all attachments
Interview 5 Gareth King C~1.docx (21 KB) [Open as Web Page]
Document-UoN Consent.pdf (773 KB) [Open as Web Page]
05 July 2012 17:13
You forwarded this message on 06/07/2012 11:01.
Dear Amon Simba
Many thanks - please find attached the signed consent form and transcription where I've corrected a few transcriptional errors.
Cheers
Gareth
On 05/07/2012 10:50, "Simba, Amon 2009 (PGR)" <N0274728@ntu.ac.uk> wrote:
>Dear Gareth
>I know it has been a long time since I visited you for chat about
>collaborations in the Biotech Industry. Anywhere I have finally finished
>all my interviews and have transcribed all the data but before I report
>my findings for the purpose of my thesis would you please verify the


Outlook Web App
sign out | Simba, Amon 2009 (PGR)
Mail > Research Data 101 Items
Find Someone
Options
favourites
Inbox
Sent Items
Simba, Amon 2009 (PGR)
Inbox
Francis
Independent Assessc
ISBE
Jinmin
NTU Work
Payment Informatio
PhD forms
Research Data
Technovation
Drafts
Sent Items
Mail
Calendar
Contacts
Tasks
Public Folders
New Delete Move Filter View
Search Entire Mailbox
Conversations by Date Newest on Top
Research Study
Alison Witham 31/10/2011
between Pera and Amon Si...
Kampmann, Thorsten; Wang, J... 29/06/2011
Research Article
Kampmann, Thorsten 24/06/2011
Responses
Alison Witham 20/06/2011
Interview Questions
Alison Witham 15/06/2011
(no subject)
Alison Witham; Foster, Carley; ... 13/06/2011
Networking
Alison Witham 16/05/2011
Medilink EM Update
Sally Baker 11/05/2011
colaboration with NTU
Kampmann, Thorsten 21/03/2011
Dear all
Regarding to the potential collaboration between Pera and Amon Simba who is conduction his PhD at the Nottingham Trent University.
Pera is very interested in working together with the Nottingham Trend University in the area of innovation, particularly Pera is interested in the development of methodologies to gage customer satisfaction as well as ganging how effective collaborative networks are working. Amon and myself had some initial discussions which highlighted the potential for collaboration and Pera is interested in access to some of the research methodologies Amon is developing.
Unfortunately the train got stopped on its track before momentum developed; Pera is currently undergoing a significant business transformation. The business has been ordered to focus on its core revenue generating functions. Unfortunately, the project I discussed with Amon does not qualify as an core activity, it has be assigned to the category continues improvements and skills and thus the project is currently on hold.
Fortunately, Pera is interested in progressing the project in the medium future and would like to sound out possibilities to continue the collaboration in autumn.
I am sorry for having to put things on hold and am hoping to get back on track in the autumn.
Kind regards
Thorsten Kampmann
Dr. Thorsten Kampmann
Life Science Analyst
Pera


Outlook Web App
sign out | Simba, Amon 2009 (PGR)
Mail > Inbox 1080 Items
Find Someone
Options
favourites
Inbox
Sent Items
Simba, Amon 2009 (PGR)
Inbox
Drafts
Sent Items
Deleted Items
Junk E-mail
My Old Mail
Notes
Mail
Calendar
Contacts
Tasks
Public Folders
New Delete Move Filter View
Search Entire Mailbox
Conversations by Date Newest on Top
Today
Publish your research in ju...
Palgrave Macmillan 15:31
Transcribed data
Helen Walker 15:30
Latest news from XenoGesis
XenoGesis 13:30
Latest news from XenoGesis
XenoGesis 13:30
UPdate your pension acco...
Teachers' Pensions 12:17
Yesterday
Palgrave Macmillan Inspec...
orders@palgrave.com Thu 21:26
How does effective market...
Palgrave Macmillan Thu 15:03
Tuesday
UPdate us
Teachers' Pensions Tue 12:51
Last Week
Position: Lecturer in Entrep...
Aston University Jobs Website Sat 24/08
Helen Walker [he.walker@btconnect.com]
Actions
To: Simba, Amon 2009 (PGR)
Attachments: Amon Simba's text from in~1.docx (18 KB) [Open as Web Page]
30 August 2013 15:30
You replied on 30/08/2013 20:21.
Hi Amon,
Thank you for sending this document through.
I have read it and just corrected the names of 2 pharmaceutical companies that I referred to.
Please see my "tracked changes" in the document.
Kind regards,
Helen.
Helen Walker, PhD
Senior Clinical Pharmacologist
BAST Inc Limited
Loughborough Innovation Centre
Charnwood Building
Holywell Park, Ashby Road
Loughborough, LE11 3AQ
Tel: +44 (0)1509 226130
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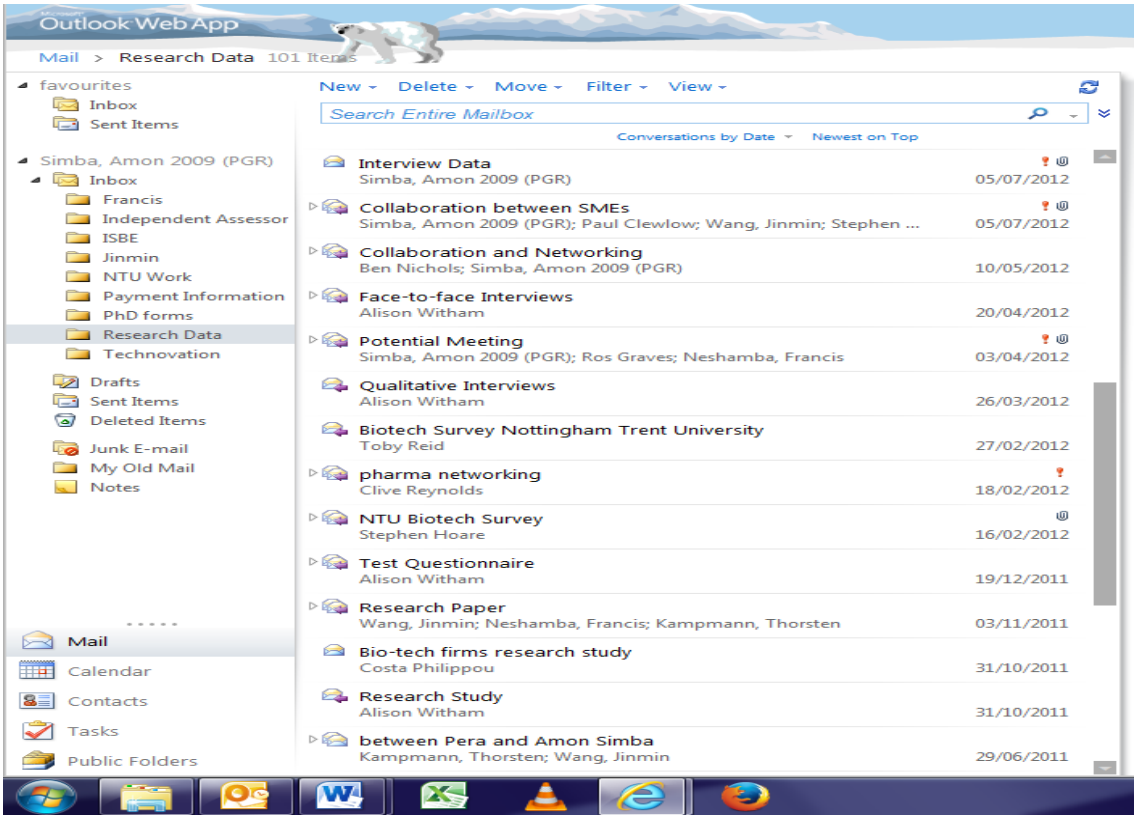
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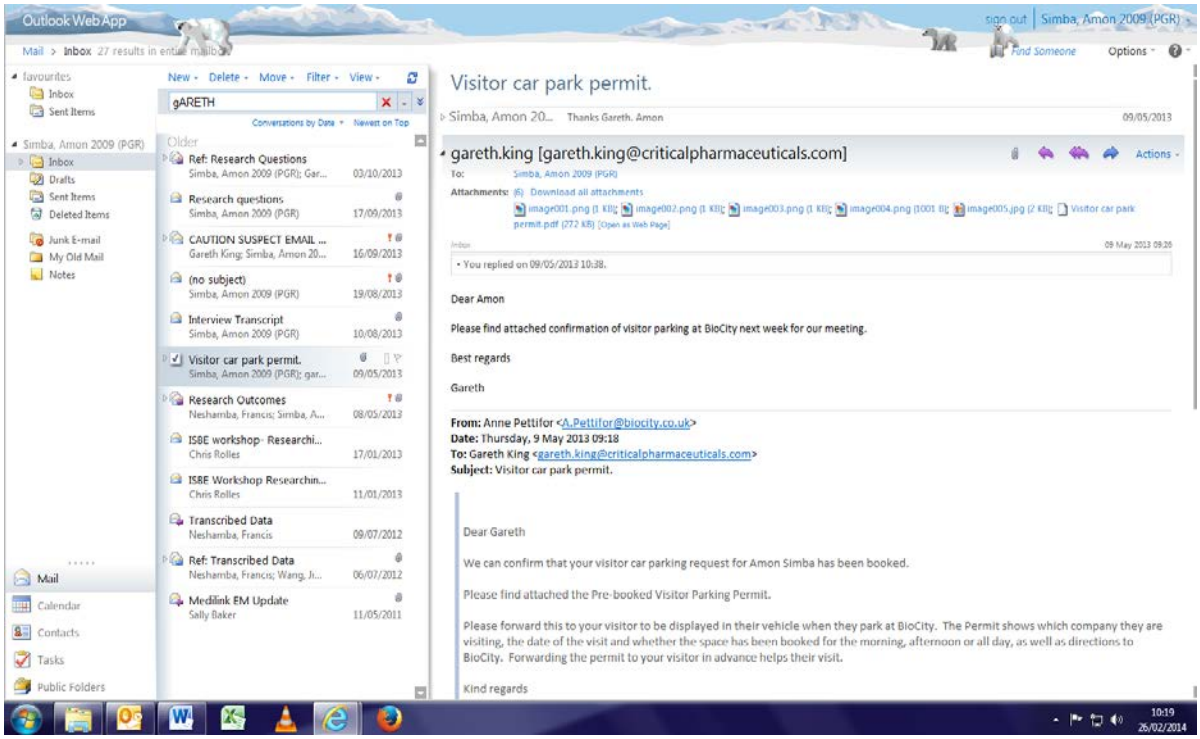
Interview Data
Simba, Amon 2009 (PGR) 05/07/2012
Collaboration between SMEs
Simba, Amon 2009 (PGR); Paul Clewlow; Wang, Jinmin; Stephen ... 05/07/2012
Collaboration and Networking
Ben Nichols; Simba, Amon 2009 (PGR) 10/05/2012
Face-to-face Interviews
Alison Witham 20/04/2012
Potential Meeting
Simba, Amon 2009 (PGR); Ros Graves; Neshamba, Francis 03/04/2012
Qualitative Interviews
Alison Witham 26/03/2012
Biotech Survey Nottingham Trent University
Toby Reid 27/02/2012
pharma networking
Clive Reynolds 18/02/2012
NTU Biotech Survey
Stephen Hoare 16/02/2012
Test Questionnaire
Alison Witham 19/12/2011
Research Paper
Wang, Jinmin; Neshamba, Francis; Kampmann, Thorsten 03/11/2011
Bio-tech firms research study
Costa Philippou 31/10/2011
Research Study
Alison Witham 31/10/2011
between Pera and Amon Simba
Kampmann, Thorsten; Wang, Jinmin 29/06/2011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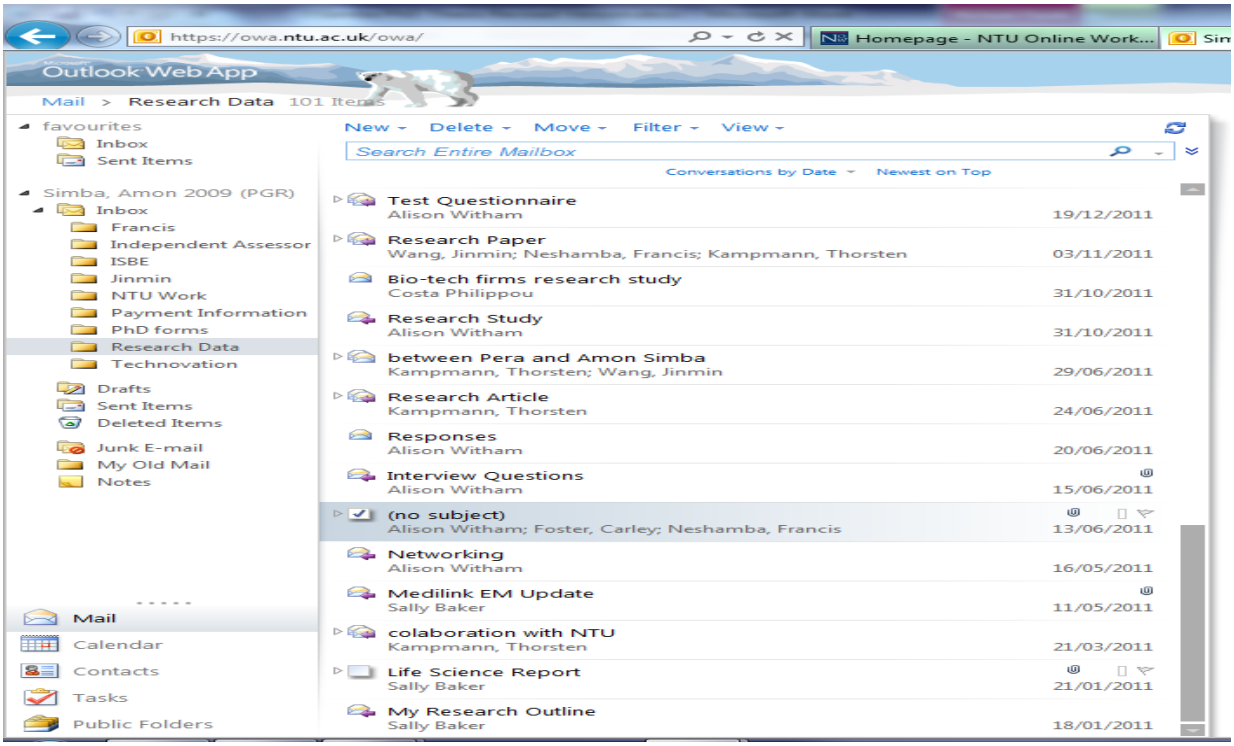
gARETH
Visitor car park permit.
gareth.king [gareth.king@criticalpharmaceuticals.com]
Actions
Dear Amon
Please find attached confirmation of visitor parking at BioCity next week for our meeting.
Best regards
Gareth
From: Anne Pettifor <A.Pettifor@biocity.co.uk>
Date: Thursday, 9 May 2013 09:18
To: Gareth King <gareth.king@criticalpharmaceuticals.com>
Subject: Visitor car park permit.
Dear Gareth
We can confirm that your visitor car parking request for Amon Simba has been booked.
Please find attached the Pre-booked Visitor Parking Permit.
Please forward this to your visitor to be displayed in their vehicle when they park at BioCity. The Permit shows which company they are visiting, the date of the visit and whether the space has been booked for the morning, afternoon or all day, as well as directions to BioCity. Forwarding the permit to your visitor in advance helps their visit.
Kind regards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Test Questionnaire
Alison Witham
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Research Paper
Wang, Jinmin; Neshamba, Francis; Kampmann, Thorsten
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Bio-tech firms research study
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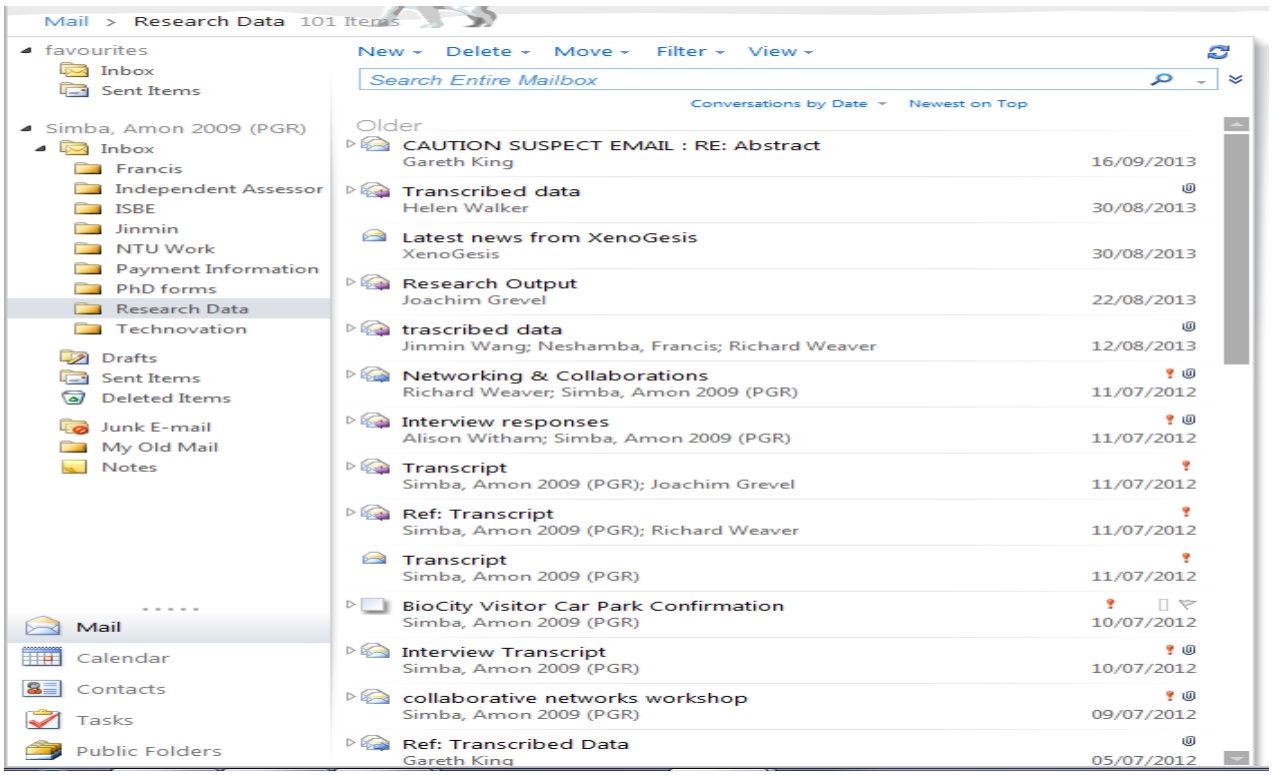
31/10/2011
Research Study
Alison Witham
31/10/2011
between Pera and Amon Simba
Kampmann, Thorsten; Wang, Jinmin
29/06/2011
Research Article
Kampmann, Thorsten
24/06/2011
Responses
Alison Witham
20/06/2011
Interview Questions
Alison Witham
15/06/2011
(no subject)
Alison Witham; Foster, Carley; Neshamba, Francis
13/06/2011
Networking
Alison Witham
16/05/2011
Medilink EM Update
Sally Baker
11/05/2011
colaboration with NTU
Kampmann, Thorsten
21/03/2011
Life Science Report
Sally Baker
21/01/2011
My Research Outline
Sally Baker
18/01/2011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Search Entire Mailbox
Conversations by Date
Newest on Top
Older
CAUTION SUSPECT EMAIL : RE: Abstract
Gareth King
16/09/2013
Transcribed data
Helen Walker
30/08/2013
Latest news from XenoGesis
XenoGesis
30/08/2013
Research Output
Joachim Grevel
22/08/2013
trascribed data
Jinmin Wang; Neshamba, Francis; Richard Weaver
12/08/2013
Networking & Collaborations
Richard Weaver; Simba, Amon 2009 (PGR)
11/07/2012
Interview responses
Alison Witham; Simba, Amon 2009 (PGR)
11/07/2012
Transcript
Simba, Amon 2009 (PGR); Joachim Grevel
11/07/2012
Ref: Transcript
Simba, Amon 2009 (PGR); Richard Weaver
11/07/2012
Transcript
Simba, Amon 2009 (PGR)
11/07/2012
BioCity Visitor Car Park Confirmation
Simba, Amon 2009 (PGR)
10/07/2012
Interview Transcript
Simba, Amon 2009 (PGR)
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collaborative networks workshop
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Gareth King
05/07/2012

Appendix 6: Example of a questionnaire

NOTTINGHAM TRENT UNIVERSITY

Nottingham Business
Division of Management

2011/12 International Survey of biotechnology firms

YOUR CONTRIBUTION TO THE LIFE-SAVING BUSINESS SECTOR IS VERY VALUABLE

This questionnaire is designed to be answered by a variety of UK and Europe based bio-tech firms. Please answer as many questions as you can. Estimates are acceptable answers to factual questions.
Data will be held securely and confidentially in accordance with the Nottingham Trent University Data Protection Policy; no individual firms will be identified, and only aggregated findings will be made public. Data will be used for academic research and to inform bio-tech firms and to help policy-makers including the UK government and the EU Commission.

FOR EVERY COMPLETED QUESTIONNAIRE A CONTRIBUTION WILL BE MADE TO CANCER RESEARCH UK

Please direct any questions about the survey to:

Amon Simba
Postgraduate Researcher
Division of Management
Nottingham Business School
Burton Street, Nottingham
NG1 4BU
Tel: 0115 848 500 ext. 85822
Email: amon.simba@ntu.ac.uk

BIOTECHNOLOGY SECTOR & BUSINESS STRATEGY

Q1. In which market category or categories would you say your firm/business operates in? *Please select all that applies*

Medical technology markets, used to define companies included in the medical technology and diagnostics sector ☐

Medical biotechnological markets, pharmaceutical companies that develop or manufacture medical biotechnology products ☐

Industrial biotechnology markets, companies that are developing, manufacturing and marketing industrial products and services based on biotechnology ☐

Q2. Please indicate the extent to which you disagree or agree with the following statements with regards to overseas markets: Please circle your responses

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Our firm has operations in more than one country	1	2	3	4	5
Our firm is part of a network of other firms in the UK and overseas	1	2	3	4	5
Our goal for networking with other firm(s) overseas is to take advantage of the overseas markets	1	2	3	4	5
We source new technology inside the UK and overseas	1	2	3	4	5
We seek new ideas from overseas to enable us to continuously produce new products	1	2	3	4	5
Some markets are attractive in terms of opportunities to maximise profit returns	1	2	3	4	5
We seek lower costs	1	2	3	4	5
We go to overseas markets as a way of avoiding local competition	1	2	3	4	5
Our business has developed significantly as a result of venturing into foreign markets	1	2	3	4	5
With our overseas partners we have jointly developed innovative products	1	2	3	4	5
We are benefiting more from our overseas business partners	1	2	3	4	5
We seek scientific knowledge which is not available in our business	1	2	3	4	5

Q3. Do you have international business partners that can be classified in any of the following categories?

Please select all that applies.

Private research lab ☐

University/Hospital ☐

Government Lab ☐

Established biopharmaceutical companies ☐

Other bio-tech firms ☐

Other, Please specify _____

Q4. Reasons for networking with a foreign partner or foreign partners
Using a scale of LOW to HIGH IMPORTANCE rate the following reasons, of forming business networks or corporative arrangements with a foreign partner, according to how they influence your decision of doing so

	Importance Low → High 1 2 3 4 5
Research and development R&D	○ ○ ○ ○ ○
Regulatory affairs	○ ○ ○ ○ ○
Production/manufacturing	○ ○ ○ ○ ○
Access international markets/distribution channels	○ ○ ○ ○ ○
Access to capital (venture capitalists, EU funding, government funding etc.)	○ ○ ○ ○ ○
Access to intellectual property (IP) from international partner	○ ○ ○ ○ ○
Access others' knowledge and skills	○ ○ ○ ○
Other, please specify	○ ○ ○ ○ ○

Q5. Please rate each of the following strategies on your firm's global performance since your firm entered the overseas markets through a networking

knowledge development strategies on the international scene	Importance Low → High 1 2 3 4 5
Captured and used knowledge obtained from other industry sources including: partner's industry associations, competitors, clients and foreign suppliers	○ ○ ○ ○ ○
Captured and used knowledge obtained from public research institutions including government laboratories through foreign partner	○ ○ ○ ○ ○
Developed new knowledge through collaborative arrangements with foreign partners	○ ○ ○ ○ ○
Used and updated databases of scientific information	○ ○ ○ ○ ○
Developed firm policies and practices for knowledge/intellectual property protection	○ ○ ○ ○ ○

Developed/encouraged staff education/upgrading	○	○	○	○	○
International Business Strategies					
Increased firm size through international joint ventures	○	○	○	○	○
Began new research & development projects	○	○	○	○	○
Allowed us to expand into foreign markets	○	○	○	○	○
Entered product trials/adapted products or processes for increased market penetration	○	○	○	○	○
Other, Please specify	○	○	○	○	○

Q6. In the last 5 to 10 years was your firm involved in biotechnology related cooperative/collaborative arrangements with other foreign firms, academic institutions, research centres or hospitals? In the table below, select collaboration/co-operation arrangements by each partner type and their geographic location:

Country/ Region	**Partner Type**				
	Biotechnology firm	Non-biotechnology firm	Academic Institution/Hospital	Incubators/Research centres/knowledge centres	Other, Please specify _____
USA	○	○	○	○	○
Europe	○	○	○	○	○
Asia	○	○	○	○	○
Other, Please specify _____	○	○	○	○	○

Q7. Do you think there is anything unique about developing science technology with an overseas business partner? ☐ ☐

If yes would you say the capabilities are…….

Please select all that applies

Unique (they cannot be found anywhere in my home markets) ☐

Novel (new) ☐

Difficult to imitate (they cannot be easily copied) ☐

Significantly improve your product innovation ☐

Significantly improve business processes ☐

Q8. In the last 5 to 10 years has your firm introduced any new or significantly changed bio-tech products?

Yes ☐ **No** ☐

If you answered yes to the above question please continue to question 8a and b

(a) Were any of these new products new to your overseas market(s) as well as to your firm?

Yes ☐ **No** ☐

(State NO if all new products were essentially similar to those already available from competitors)

(b) Relative to your firm's objective of taking advantage of your business networks in the overseas markets please rate your performance in the following:

Please circle ◯ your responses

	Poor	OK	Average	Good	Very Good
Speed of product innovation and project completion	1	2	3	4	5
Market Share achieved as a result of overseas networking	1	2	3	4	5
Sales of your innovative products/services achieved as a result of your overseas partnership(s)	1	2	3	4	5
Return on investment (i.e. investment in terms of time, human capital or financial capital)	1	2	3	4	5
Profitability of the new markets	1	2	3	4	5

Q9. Access to international talent i.e. highly skilled staff and deep talent pool
Please rate the level of importance of the following in relation to your internationalisation strategy

	Very Important	Important	Somewhat Important	Not Important	No Opinion
Skilled new graduates with world class	◯	◯	◯	◯	◯

technical training					
Pool of experienced entrepreneurs	◯	◯	◯	◯	◯
Access to bio-tech executives	◯	◯	◯	◯	◯
Scientific experts	◯	◯	◯	◯	◯
Experienced investors (i.e. venture capitalists, angels or private equity	◯	◯	◯	◯	◯

Q10. Knowledge management strategies adopted for the international venture

Please select all that applies to your business

We protect knowledge using intellectual property protection law ☐

We enter into confidentiality agreements with our international partners ☐

We code knowledge into processed information and store it in a secure database ☐

Give people access rights to specific company information/data ☐

We create good working conditions that encourage knowledgeable individuals to stay in my company for longer both domestically and internationally ☐

Q11. What is your role in the business? Please select all that applies

Business Owner (bio-entrepreneur) ☐

Co-owner ☐

Scientist ☐

Business Development Manager ☐

Academic consultant ☐

Other, please specify

Q12. How old would you say your firm is?

0-5 years ☐

5-10 years ☐

10-15 years ☐

15 years + ☐

Q13. Which of the following would you say is your home market?

United Kingdom ☐

EU (European Union) ☐

Asia-Pacific ☐

USA ☐

Other, please specify

_ _

Thank You!
Thank you very much for your time in completing this survey which I hope will enhance the development of life-saving products and services.

Please note that your information will be completely anonymous and shown only in aggregated form. For your participation I will send you a report of the combined results and findings.

Part B: Personal Development

Research articles extracted from the thesis

Paper 1
Simba, A., (2013). A new model of knowledge and innovative capability development for small born-global bio-tech firms: Evidence from the East Midlands, UK. *The International Journal of Entrepreneurship and Innovation Management,* Special Issue on: "Inter-Firm Cooperation and Innovation, Inderscience. In Press

Paper 2
Simba, A., (2013). The impact of global R&D networks on the innovative capabilities of born-global biotech firms: A multi-case approach. *The International Journal of Entrepreneurship and Small Business,* Vol.20, No.3, pp.342–362

Research articles under review

Paper 3
Simba, A., (2013). The learning experiences and the absorptive capacity of bio-entrepreneurs: A case of the East Midlands Region, UK. *International Journal of Business Administration*

Paper 4 (paper not included in this thesis**)**
Simba, A., and Ndlovu, T., (2014). The entrepreneurial marketing management and commercialisation arrangements of born global bio-enterprises: The case of UK companies. Paper submitted to *International Business Review*

Conference Proceedings

Paper 4
Simba, A, Wang, J, & Neshamba, F, (2011). The impact of knowledge networks and clusters on the Innovative capabilities of bio-entrepreneurs, in the United Kingdom, The article was presented in Nov 2011 at the Octagon Conference in Sheffield (ISBE)

A new model of knowledge and innovative capability development for small born-global bio-tech firms: Evidence from the East Midlands, UK

Amon Simba[1]

Abstract

In the last two decades, the rapid transformation in information and communication technologies together with the adoption of more liberal structures governing trade as well as the modularisation of production and services has resulted in the proliferation of small born-global bio-tech firms. The firms have an international flair and they rapidly globalise their operations. Their strategic intent is to develop unique innovative capabilities through networking. In science-based industries such as the biotechnology sector the ability to innovate can only occur if a firm is able to both generate and integrate knowledge from inside and outside its boundaries. In that respect, this article employs a multi-case approach to construct a frame of reference for developing innovative capabilities that complement firm-based competences. The main focus is on small born-global bio-tech firms in the East Midlands region of the United Kingdom. The newly developed framework is invaluable to researchers, small born-global bio-tech and large bio-pharmaceutical firms. More so, it contributes to the concepts of dynamic capabilities and networking.

Keywords

Born-global, networks, knowledge, internationalisation, absorptive capacity, inter-organisational collaborations, innovation ecosystems

Introduction

Born-global bio-tech firms are entrepreneurial enterprises which develop complex international resource configurations (Karra *et al.,* 2008). Scholars universally agree that when a firm ventures beyond its immediate vicinity, it is exposed to unique resource combinations (Schumpeter, 1950; Oviatt & McDougall, 1994; Cooke, 2001; Owen-Smith & Powell, 2004; Johnson & Vahlne, 2009). Born-global bio-tech firms exhibit characteristics of traditional entrepreneurial firms. For example, they are proactive and, innovative and they take risks but in an exceedingly complex fashion involving significant degrees of uncertainty synonymous with global markets (Burns, 2012). As we strive to understand how these new types of international ventures complement their firm-based competences fresh and more nuanced theories are needed. From that perspective, the article proposes a theoretical framework for born-global bio-tech firms illustrating the complex processes and mechanisms in their knowledge supply-chain. Empirical evidence from multiple cases of bio-tech firms, in the East Midlands region of the United Kingdom, is used to construct a new model of *"Knowledge and Innovative Capability Development"*. The model is anchored on the ideas of Freeman *et al.* (2010). An understanding of how born-global bio-tech firms view their social world helps us to interpret and comprehend the meanings they attach to their lived world (Pittaway, 2000; Saunders *et al.,* 2007).

[1]Nottingham Business School

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A definition of Born-global bio-tech firms

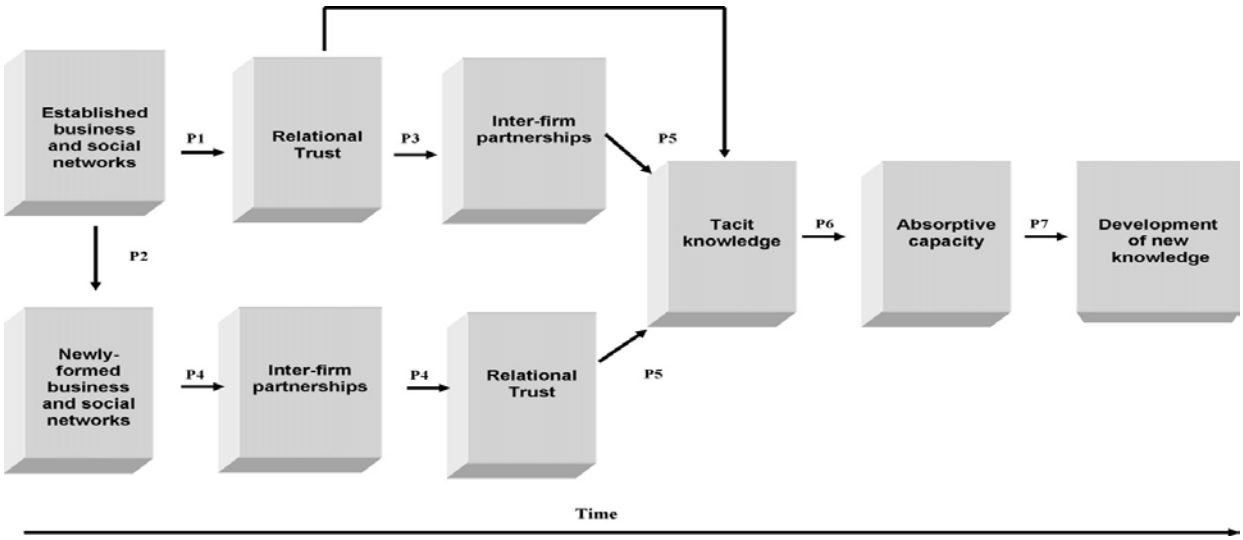
Born-globals are defined in a number of different ways. For example, Oviatt & McDougall (1994) define them as international ventures that seek to derive competitive advantage from the use of resources and the sale of outputs in multiple countries. Other scholars (see Knight & Cavusgil, 1996; Knight, 2001) use a variety of measures as criteria for defining these international ventures such as: the vision and strategy to become global, time of internationalisation and overseas sales volumes. Considering the different labels used to define born-globals a distinguishing feature in all their definitions is that, they adopt a global strategy evidenced by their structural dimension which encompasses various actors in multiple countries (Oviatt & McDougall, 1994). Regardless, of this distinctive feature there still is no universal agreement to a single definition of born-globals. In all the confusion and misconceptions regarding the definition of born-global firms, the author is of the view that researchers should base their definitions on observable traits. Particularly, behaviours that are embedded in the design of the ventures should form the basis of how we define them. For example; they should be based on three prominent multi-dimensional constructs of social capital identified in the literature as structural, relational and cognitive dimensions. Structural dimension is related to global network ties and their overall configuration (Burt, 2002; Ahuja, 2000). Relational dimension focuses on trust, trustworthiness, norms and obligations in a global network (Fukuyama, 1995; Putnam, 1993). Cognitive dimension refers to those resources providing 'shared representations, interpretations, and systems of meaning among parties' (Nahapiet & Ghoshal, 1998, p.244). From that perspective, it suffices to define born-globals as small bio-tech firms which have an international flair and rapidly globalise their operations without any preceding long-term domestic or internationalisation period.

Theoretical Background

Scholarship on the internationalisation of small firms is littered with various models aimed at explaining their internationalisation processes. From early on Johnson & Vahlne (1977) developed the inspirational Uppsala internationalisation model (U-model) and it became a widely used model in business management. The model was based on the assumption that an enterprise develops in foreign markets by adopting a process which evolves incrementally in stages 'progressing like rings in the water' Bhowmick (2004, p.760). Put in a different way, the enterprise passes from one stage to another as it acquires more and more international experience as well as deepening its resource commitments. Other management scholars (e.g. Rogers, 1962) have developed the Innovation Diffusion Model (I-model) which focusses on internationalisation as innovation for the firms. These two models (U and I) became the bedrock of stages theory that explained the incremental internationalisation process of small firms. According to Anderson (1993, p.212) 'both the U and I models can be properly regarded as behaviourally oriented'. Arguably, the gradual process of internationalisation, as denoted on the U and I models, can be seen as a risk-averse strategy adopted by firms as an entry mode into foreign markets. Moving forward in 1997 Teece, Pisano, and Shuen proposed the dynamic capabilities theory, they defined the theory as "the ability to integrate, build, and reconfigure internal and external competences to address rapidly-changing environments". The dynamic capabilities view is based on the notion that externally acquired dynamic capabilities attempt to bridge a firm's capability gaps by adopting a process approach: and by acting as a buffer between firm resources and the changing business environment (Teece *et al.,* 1997). According to Helfat & Peteraf (2003) dynamic resources help a firm to adjust its resource mix thereby enhancing its innovative capabilities which underpins its ability to make new innovations.

More recently, Freeman *et al.,* (2010) proposed an inspirational model for rapid knowledge development for smaller born-global firms. Their model, similar to the dynamic capabilities concept extends the resource-based view (RBV) and network theory specifying the level of interaction required for the development of the new knowledge process to occur in rapidly internationalising smaller born-global firms. Freeman and others instrumental model is illustrated in the figure below.

Figure 1: A Model of Rapid Knowledge Development: The Smaller Born-global Firm



Sources: Freeman, Hutching and Lazaris, 2010, p.76

Building on the ideas by Freeman *et al.* (2010) the new theory of *"Knowledge and Innovative Capability Development"* for small born-global bio-tech firms is developed as a result of inference from new empirical evidence and secondary data. The new model is anchored on the model of rapid knowledge development for the smaller born-global firm. Adjustments to Freeman and others inspirational model are made so that the new framework adequately explains the process of acquiring innovative capabilities specific to small born-global bio-tech firms.

The intention is not to undermine the categorisation of the concepts contained in the model of rapid knowledge development for smaller born-global firms but rather, to adapt it so that it suites the emerging phenomenon in the bio-tech sector. Learning from Gerring's 2001; Turnbull's (1987); Anderson's (1983) and Bhowmick's (2004) critical analyses of the stages models it is a plausible thing to adjust a theory to meet the specific needs of the research phenomenon. The scholars suggest that contextual range i.e. the scope, reach and stretch of a concept determines whether it needs to be adjusted to accommodate and to maximise its performance. Indeed, when examining specific units of a phenomenon e.g. born-global bio-tech firms being examined for this study, their contextual range can be a decisive factor in terms of the extent to which the new conceptual framework can be generalised (Gerring, 2001; Santori, 1970). This is consistent with the views of Yin (2009, 2003) who argues for *analytical generalisation* of case-oriented research strategy. Yin suggests that; *analytical generalisation* denotes a process where generalisation takes place from data to theory rather than to population.

Approach

To inform the process of theory-building the author uses a multi-case approach (Yin, 2009). The main focus is on small born-global bio-tech firms in the East Midlands region of the United Kingdom. Yin (2003) and Stake (1995) advise that to avoid pursuing a study that has too many objectives, it is necessary to determine your case(s). From that perspective, the author uses a technique known as case-binding which includes: using time and place (Creswell, 2003); time and activity (Stake, 1995); and by definition and context (Huberman & Miles, 1994). Baxter & Susan (2008, p.546) support the use of a case-binding technique claiming that, 'binding the case will ensure that your study remains reasonable in scope'. Data is collected from a systematically selected sample of five biotechnology firms identified as having an international flair. Expert opinion is also sought from three key science research institutions in the East Midlands region of the United Kingdom that were identified as "champions of innovation". The main reason for using the multi-case research approach for this study is to allow the author to examine the research subject(s) more closely so that rich data is collected. This ensures the validity and the reliability of the new conceptual framework (Bellamy & Perri, 2011). More so, it demonstrates that the new concepts on the model of knowledge and innovative capability development are grounded within and across cases of small born-global bio-tech firms. Results achieved in this way can be taken to be reliable (see Gerring, 2005; Huberman & Miles, 1994; Yin, 2009). Baxter & Susan (2008) affirm that a multiple case-study (Yin, 2003) or a collective case-study (Stake, 1995) allows a researcher to analyse data within and across settings. Crucially, the author preferred this method of research in particular because the evidence it generates is considered to be robust and reliable (see Huberman & Miles, 1994).

Methodology

Cases used in this study have been carefully chosen primarily for the following reasons: (1) to understand the world of small born-global bio-tech firms and (2) to contribute to theoretical concepts of dynamic capabilities and networking. The seemingly dated but still influential work by Eckstein (1975) identified five ways in which case material can be useful as follows: configurative idiographic studies, descriptive configurative studies, heuristics case studies, plausible probes and critical case studies. In light of this, the author is mainly interested in heuristic case-study types because choosing cases using this way enabled him to develop some theoretical concepts which are useful in explaining the capability development process of small born-global bio-tech firms.

Data Collection

The author interviewed senior managers who were responsible for spearheading their firm's operational strategies. In the majority of cases the founders were also the CEOs/science directors of the visited firms and had vast experience in the biotechnology sector either from their previous posts or through years of operating as key players in the sector. For a period of about six to eight months commencing from November 2011 to June 2012, a total of about eleven face-to-face qualitative discussions were conducted ranging from 35 minutes to 45 minutes in length with an average duration of about 40 mins. Table 1 on p.5 provides an array of data describing the small born-global bio-tech firms that were visited during the data collection stage.

Table 1: Description of Small Born-global Firms comprising the sample

Firms	Origins	Bio-tech Activity	Year Founded	No. of Interviews
Critical Pharmaceuticals	UK-based biotechnology spinout company from the University of Nottingham	Involved in drug delivery technologies for the sustained release and nasal delivery of proteins and peptides and labile or insoluble small molecules. Delivers Advanced Therapeutics	2002	4
XenoGesis Ltd	UK based founded after the closure of AstraZeneca	Specialises in pre-clinical drug metabolism and pharmacokinetics (DMPK), quantitative bioanalysis and expert interpretation	2012	3
Haemostatix Ltd	Spin-out firm from the University of Leicester – UK based	Develops a pipeline of haemostats based on its new class of active ingredients that replace thrombin. The firm also commercialises its new technology platform based upon a specific peptide sequence that binds to fibrinogen – a protein essential to the formation of clots.	2003	4
Sygnature Discoveries	Founded in BioCity Nottingham	Provides integrated drug discovery services. The company is also involved in a wide spectrum of drug discovery programmes and the outsourcing of discovery projects to contract research organisations (CROs)	2004	4
BAST Incl.	Spin-off business launched after the announcement of the closure of the AstraZeneca	The pharmaceutical company is involved in a new drug development process known as Model-based Drug Development (MBDD) where investment decisions are supported by a simulation of the probability of success. The company is part of a collaborative network of twenty four other organisations with the East Midlands and internationally.	2010	3

To achieve internal validity the author adhered to an interview guide. In cases where interesting lines of enquiry emerged follow-up questions were asked to explore the subject further. The interview guide included questions about the influence of various factors within the knowledge supply-chain of small born-global bio-tech firms identified as: business & social networks, inter-organisational collaborations, competence & goodwill trust, tacit & explicit knowledge, prior learning & absorptive capacity. The questions also focused on their personal experiences in business and social networks and how they developed trust in those relationships. The schedule guide also included questions that were aimed at getting the interviewees to explain the perceived risks of their operational strategies.

Analysis

The study follows an inductive analysis style with elements of deduction. The cases chosen for analysis consist of CEOs/founders who are former employees of AstraZeneca or have vast experience in the bio-tech industry accumulated over years of operating in the sector. The next step in the analytical process was to investigate the sampled cases in order to identify patterns and trends in relation to how they generate knowledge in each case (Bellamy & Perri, 2009; Miles & Huberman, 1994). Yin (2009) suggests that using pattern-matching logic in case-oriented studies is the most appropriate technique for case analysis. Similar cases with identical features seen as typical born-globals were closely scrutinised. Taking into perspective the emerging themes, regarding the processes of generating scientific knowledge for small born-global firms, a causal link between various factors including networking, collaborating, trust, knowledge sharing, prior learning and absorptive capacity was formed.

This way of analysing data is consistent with other scholars'. For example, Muller (1982) and Miller (1983) suggest that the process of analytic induction starts with a tentative hypothesis to explain something. Data collected from each firm was sorted and transformed into a chronological order and using thematic analysis in each case history (see Table 2 below). Thematic analysis is multi-discipline; it is used in education research (Cohen *et al.,* 2007), by research clinicians (see Newfield *et al.,* 1991; William, 1992), and in political science (Easterby-Smith *et al.,* 2012). Identifiable themes for this study are related to business & social networks, inter-organisational collaborations, competence & goodwill trust, tacit & explicit knowledge, prior learning & absorptive capacity.

The study takes the stance that these concepts are the building blocks to the process of developing the innovative capabilities of small born-global bio-tech firms operating in a hypercompetitive environment driven, among other things; by the wealth of information a firm can have access to (Shilling, 2008). The emerging themes from qualitative conversations enabled the author to piece together and form a comprehensive picture of small born-global bio-tech firm's collective experience of business & social networks, inter-organisational collaborations, trust building, knowledge sharing, prior learning & absorptive capacity in networks. This is in line with Taylor & Bogdan (1984, p.131) who define themes/concepts as units derived from patterns such as 'conversation topics, vocabulary, recurring activities, meanings or feelings'.

Table 2: The Outcomes of the global activities of small born-global firms

	Building blocks essential for developing innovative capabilities					
	Business & Social Networks	**Competence & Goodwill trust**	**Inter-organisational Collaborations**	**Tacit & Explicit Knowledge**	**Prior learning & Absorptive Capacity**	**Innovative Capabilities**
Critical Pharmaceuticals	Strong academic, personal & institutional networks. VC are also part of the network	Trust is build based on the reputation of the partner	Engages in collaborative projects with other firms in the East Midlands and overseas. Work with Universities & scientists on specific projects.	The firm sponsors biochemistry students to work on projects and to study at University. Data from projects is stored on a database. Students are also bonded	Experience is seen as essential in order to understand what knowledge should be acquired	Nano-enabled intranasal formulation of teriparatide for the treatment of osteoporosis as a result of result of working with an academic institution
XenoGesis Ltd.	Same as BAST Inc.	Trust is built in escalating series but in cases of a partner whose cognitive distance is big that is seen as the basis for trust	The firm work with scientist from their clients to bridge the knowledge gap.	Same as Critical Pharmaceuticals	Same as Critical Pharmaceuticals	Data interpretation techniques necessary for new drug testing as a result of working with other firm
Haemostatix Ltd	Same as Critical Pharmaceuticals & XenoGesis	Trust is portrayed as key to knowledge exchange	Same as XenoGesis	Most of the board members have experience in product development and commercialisation	Board members have vast experience in drug discoveries which helps to understand the needs of the firm	Haemostats technology used by surgeons to manage problematic bleeding. Funding was key to the development of the technology

Sygnature Discovery	Same as XenoGesis & Critical Pharmaceuticals	Trust is built in escalating series with partners	Same as all the other participants	Same as	Same as above	Gold standard' techniques in pain, metabolic and CNS disorders, inflammatory disease and in vivo pharmacokinetics
BAST Inc.	The firm has a strong network of 24 other firms. The CEO has personal connections with expert scientists & connections developed from his previous employment	Same as Critical Pharmaceuticals	Collaborations are seen as the route to new drug discoveries	Same as XenoGesis	Same as with all the other firms	New statistical tools in parameter estimation and optimal design e.g. Risk and Utility Assessment through Mechanistic Modelling

Findings

Innovative Capabilities' Knowledge Supply-chain

This part explains the impact of the building blocks, including: business & social networks, competence & goodwill trust, inter-organisational collaborations, tacit & explicit knowledge, prior learning & absorptive capacity, on the abilities of small born-global bio-tech firms to build their innovative capabilities. It draws upon results from within and cross case analysis using the various factors, which mitigate the knowledge supply-chain of born-global firms, as the main themes. It also outlines the authors' propositions based on the information obtained from within and across cases. Secondary data analysis is also used to provide some insight and to support empirical evidence. This leads to the development of a model of *"Knowledge and Innovative Capability Development"* for small born-global bio-tech firms.

Business & Social Networks

For small born-global bio-tech firms business and social networks are essential to their success. The interaction between individuals, firms or organisations with varied skills, experience and knowledge provides synergy for small firms with limited resources. They provide them with access to a wide range of economic effects (Ho & Wilson, 2006) including: access to specialised input and labour, novel information inflows and knowledge as well as access to research institutions and government R&D support services (Martin *et al.,* 2011). Breschi & Malebra (2005, p.47) suggest that, "resource pooling, risk sharing and the formation of critical masses provide incentives to create a group of inter-linked agents". Powell *et al.* (1996, p.46) affirms that, 'when the sources of expertise are disparate, collaborative R&D opens an organisation's eyes to the need for accessing ideas and information from a variety of sources'. This was evident when the author conducted a case by case examination of their networking activities. He found that small born-global firms link up with other firms, scientists, research and academic institutions within and outside their vicinity to jointly develop new drugs and share technical know-how. This was reflected in the response given by the President at Sygnature Discovery when asked about whether his company engages in networking. He commented that:

> Our scientists work with other scientists from other businesses, research institutions and strategic alliances to jointly test and develop drugs. We work in a highly collaborative way e.g. in our molecule synthesising process. We have secure data bases that we use to share data with our partners and clients from wherever they might be either in San Francisco or Santiago. We have realised that we do not have all the capabilities and we feel that it is important to collaborate with other companies for example, we collaborate with Cyprotex Discovery. They have better knowledge about how the drug dissolves in the body. What is important is we share capabilities.

We feel that we have modelled our business in a 'hub and spoke' model i.e. we are in the middle and we are networking with other companies.

In light of this evidence, indicating that bio-tech firms in the East Midlands region in the United Kingdom are forging global networks to enhance their capability development, the author can confidently conclude that the business and social networks in the knowledge supply-chain of small born-global bio-tech firms significantly influence how they acquire scientific knowledge and technical know-how. Accordingly, Nahapiet & Ghoshal (1998) and Tsai & Ghoshal (1998) suggest that social capital embedded in a firm saves as a conduit that facilitates and enables positive conditions for the exchange of knowledge and the combination of resources to occur. When discussing with an expert working in a knowledge 'hub' the author was fully convinced that the business and social networks of small born-global bio-tech firms play a decisive role in how they develop their innovative capabilities. The innovation advisor, Rosamund Graves, commented that:

We help firms and industry sectors access information, opportunities and partners on a global scale through specialist networks and business intelligence. On behalf of national government agencies, we deliver programmes to stimulate international inward investment, technology transfer, partnering and access to high growth global markets for UK companies. We provide business intelligence and contacts to help UK firms identify and realise international opportunities.

Her statement endorses that forging networks within and outside a firm's local industry *milieu* plays a key role in the process of acquiring knowledge and technical know-how. In that regard, it is plausible to claim that business and social networks are part of the jigsaw puzzle needed to complete the process of generating novel information for small born-global bio-tech firms.

Proposition 1: *business and social networks act as a catalyst for small born-global bio-tech firms in their process of developing innovative capabilities*

Social capital and network ties have a positive impact on international start-ups, new ventures and SMEs' performance (Johanson & Vahlne, 2003; Oviatt & McDougall, 1994; Oviatt & McDougall, 2005). Furthermore, Hughes *et al.* (2009) stress that for a firm to gain access to knowledge and technical know-how it is essential to collaborate in networks and engage with a range of advisors that include: scientists, academia and agencies. This was echoed in the conversations with the CEO at XenoGesis Ltd, and the Science Director at BAST Inc. Ltd. When discussing about how wide-spread their networks are the CEO, and the Science Director of the firms mentioned above explained that:

I have a good network of ex-colleagues that I used to work with at AstraZeneca and such connections are vital for sharing scientific knowledge and technical know-how. I think collaborating with other businesses and academia is essential in the bio-tech industry and it is important that businesses join to work on new discoveries. That is the way things are heading towards nowadays given the nature of the markets. Apart from using my business or social connections as conduits of scientific knowledge I also publish papers. *CEO at XenoGesis Ltd;*

And,

I engage in networking activities both locally and internationally with firms and organisations in the USA, Asia for example. I personally have some contacts in America where my business started way back in 1998 as a model based on a drug development firm. *Science director at BAST Inc. Ltd*

Their responses boldly underline the essence of business and social networks. Indeed, the evidence is strong and this indicates that in the globalised markets of the biotechnology sector, going it alone is no longer the best option because it is so difficult for small firms to possess all the necessary capabilities. Lasserre (2012) argues that firms can benefit in globalised networks by accessing and taking advantage of geographical clusters of knowledge creation and development. In that sense, business and social networks of small born-global firms can be seen as channels through which they can access scientific knowledge and technical know-how. Considering the suggestions from the CEO of XenoGesis, and the Science Director at BAST Inc. Ltd quoted above it is plausible to conclude that small born-global bio-tech firms use networks to generate knowledge so as to leverage their internal science capabilities with a view to discovering new drugs. Thus, giving them greater flexibility needed to survive in a hypercompetitive business environment (Shilling, 2008; Lasserre, 2012; Hisrich 2012). Shilling (2008, p.158) further affirms that 'as firms forge collective relationships they weave a network path between them that act as a conduit for information and other resources'.

Funding institutions are also a key player in the networks of small born-global firms. Mobius Life Sciences - an investment arm of BioCity Nottingham (BCN) work alongside Nottingham City Council (NCC) to provide financial support 'seed investments' in high potential life science businesses. Crocker (2012) explains that the investment arm has a highly experienced and well networked team. This gives the author strong belief that financial support for bio-tech firms significantly boosts their limited resources and it adds value to their businesses which ultimately enhances their capacity to innovate. The CEO at Haemostatix said this:

> While business networks facilitate the flow of novel information, financial investments are a 'shot in the arm' in that they also provide a company with the opportunity to develop innovative technology. In our case we were presented with the opportunity to develop an innovative haemostat technology.

This shows that business links that include funding institutions are the bedrock for small firms seeking to make crucial innovations. What is happening in the East Midlands has striking resemblance to networking activities documented elsewhere e.g. in the Golden Triangle of Cambridge, London and Oxford, the Silicon Valley and the Boston metropolitan area. The Cambridge Cluster Report of 2004 reports that over the last decade the cluster has acted as a magnet attracting supportive infrastructure comprising of number of key players such as: venture capitalists firms, banks, marketing experts and patent agents.

Competence & Goodwill Trust

Strong relationships that allow the free flow of information to occur were found to exist between parties involved in a well-established network and trust was the most important component of that process. Results from within and across cases show that small bio-tech firms trust their collaborating partners based on their technical prowess (competence trust) and good intentions (goodwill trust) within the life science sector. In this study, the author uses Blomqvist's (1997, p.3) definition of trust expressed as an 'actor's expectation of the other party's competence, goodwill and behaviour'.

Consistent with Blomqvist's definition, Gubbins & MacCurtain (2008) claim that to trust an individual's ability is to trust in his or her skill and competencies to do the job. Evidently, all the participants in this study indicated that trust is established when they know that their collaborating partner is skilled and very capable. Especially, in a specific area of science which complements their knowledge gaps. In a discussion with the CEO at XenoGesis about how trust is developed in networks he expressed that:

> We build trust by first conducting due diligence (i.e. we do a search on their level of technical capabilities, their reputation which we get from people who have worked with them before). In other words we look for partners who have higher skills and are well established/known in the industry. This is all done in a trial and error method.

The interpretation from this statement, which is supported in the literature (see Blomqvist, 1997; Sengun, 2009), demonstrates the relevance of competence (technical capabilities, skills and know-how) in the biotechnology sector and it shows that it is a necessary antecedent and basis for trust in professional relationships within a business context. Networking with organisations that have better skills levels is an important factor in building trust in the bio-tech sector particularly, in instances where potential partners are assumed to have technological knowledge and competences (Blomqvist, 1997).

Furthermore, the statement highlights that the reputation of a partner, including: moral responsibility and positive intentions towards the other, was an important factor that influenced his firms' decision to accept a potentially vulnerable position (risk inherent by partnering). Welter (2012, p.194) claims that 'trust is seen to assist in lowering the transaction costs of commercial actions and the risks inherent in entrepreneurship'. In the majority of the firms in the sample, trust was built in escalating series using a 'trial and error' method. This discovery contributes to the social exchange theory (Pretty & Ward, 2001; Inkpen & Tsang, 2005; Whitener *et al.*, 1998) which suggests that information, advice, social support and recognition are important means of building trust created through repeated interactions and reciprocity.

In addition to the main meaning of the social exchange theory, when asked about how trust was built in his firm the President at Sygnature Discoveries stressed that:

> Our partners I guess they also do a due diligence to assess whether we fit into what they are looking for. With our alliances we are well connected actually, before establishing this connection we first test the partners trustworthiness through engaging in small projects and we take it step by step until we are fully convinced that a stronger partnership can be established. Competence and reputation play a key role in building new networks.

This is further evidence suggesting that in order to build trust a wide scope of information is necessary for small born-global bio-tech firms because different types of information including relational-emotional, socio-economic and tacit-explicit significantly impact on the trust experienced. With all the firms in the sample, trust was naturally developed within their business community at BCN but with organisations and institutions outside their locality there was more of 'trial and error' requiring a lot of information search. The process of due diligence was done mainly to test the trustworthiness of a potential business partner in particular, their intentions which is related to the goodwill dimension of trust. The process of testing a partners' trustworthiness through small projects was targeted at identifying positive or negative signs and signals which Blomqvist (1997) claims are visible and easier to evaluate when the relationship is developing. This was found to be a vital activity for small born-global firms and it was critical to how they developed innovative capabilities in newly established networks.

Responding to the same question on trust building in newly formed networks which they develop in a global context, the CEO at XenoGesis stressed that: 'it is very important to try different combinations to ensure that we end up working with people who share the same values as us'. In this case it was the CEO's envisaged strategy that his organisation should develop trust with its partners based on the soundness of their strategy and vision. In the relevant literature (Mishra 1996; Sydow 1998) the competences of an organisation are seen as a basic and profound source of trust in asymmetric technological partnerships. Blomqvist, (1999) suggests that competence trust may be born out of a firm's technical capabilities, financial resource-base and partnering competences. Thus, the author proposes that:

Proposition 2: *For small born-global firms competence and goodwill trust are major factors that reduce friction and perceived risks allowing the free flow of fluid scientific knowledge and technical know-how through established or newly developed business partners.*

The most common form of trust that was evident in the research sample was the sense of benevolence; meaning that scientific knowledge and technical know-how developed with partners were protected within the trusted group/network (Hoy & Tschannen, 1999). The firms relied on the goodwill of their partners to act in the best interest of both parties. In on-going relationships future behaviour was not specified but there was a mutual attitude of goodwill. As illustrated in the *"Knowledge and Innovative Capability Development Model"* on p.17, trust was the basis on which inter-organisational collaborations stemmed from in the capability development process of small born-global bio-tech firms. More importantly, trust was a pre-requisite to knowledge sharing and the exchange of technical know-how.

Inter-organisational Collaborations

Data collected from sampled firms demonstrates that there was a strong relationship between collaboration and innovation. Through conducting a detailed case by case analysis it was found that the main reason why small born-global bio-tech firms collaborate with other firms/research institutions was to learn from them in order to enhance their innovative capabilities. Zucker *et al.* (1998) posit that learning underpins organisational innovation and according to Basile (2010, p.3) innovation 'is a complex and interactive process that involves a variety of actors'. In the biotechnology sector where scientific knowledge is both complex and ever-expanding in search of new discoveries the sources of expertise are widely dispersed. In such sectors, Powell *et al.* (1996) postulates that the locus of innovation is usually found in networks of learning as opposed to going it alone. The CEO at Critical Pharmaceuticals revealed that:

> In the bio-tech industry you need various skills and knowledge, in addition to our in-house knowledge we collaborate with other institutions such as universities, other companies - large or small both locally and internationally and along with that we have different levels of collaboration. We collaborate with companies in the USA, EU. We also have intense collaborations with companies near to us who have expertise in areas of interest we therefore work with them to access the expertise that we do not have.

This evidence powerfully demonstrates that small born-global bio-tech firms maintain a broad scope of interactions with a wide range of actors in the bio-technology sector with a view to complement their knowledge bases. Scholarship on inter-organisational networks argues that firms should look further than their own boundaries to acquire strategic resources (Subramanian & Soh 2010; Feldman, *et al.*, 2002). The traditional model of large pharmaceutical companies where all research activities were done in-house is slowly fading into the horizon.

The managing director at BioCity Nottingham (BCN) observed that: 'The large Pharma used to employ a large number of scientists under one roof and that structure is fragmenting giving rise to the formation of smaller research-based organisations'. The re-structuring exercise happening at AstraZeneca and Boots in the East Midlands and at Lund in Sweden typifies this. The pharmaceutical giants are undergoing a strategic shift towards outsourcing their R&D activities to small bio-tech firms. This heralds a significant move towards more collaboration between organisations in the biotechnology sector where smaller firms such as those investigated for this study are taking the centre stage. Large pharmaceuticals continue to provide marketing, commercial capabilities and financial resources. Similar studies (see Stuart *et al.,* 2007; Zucker *et al.,* 1998) have reported a growing trend, in the biotechnology, sector where small firms are being contracted to do the research for large pharmaceutical companies. More recently, Kang & Park (2012, p.70) reported that 'while the new biotechnology firm specialises in specific types of knowledge, products and applications large established firms have expertise in the commercialisation of new inventions that involve large scale production, marketing and distribution, and regulatory processes'. The CEO at Critical Pharmaceuticals expressed that:

> We acquire financial support to back up our products, expertise, marketing, PR, scientific knowledge and these are things that we do not have in house and they are needed to achieve our goals. The only way to achieve this is through linking up with people who have been there and done it and are well established in the market.

This highlights the significance of inter-organisational collaborations in terms of: (1) bridging the knowledge gap of small born-global bio-tech firms; (2) enabling them access to markets; (3) providing them with financial back-up and (4) getting help from science experts who have vast experience in life science.

In support of these findings, Schilling (2008) makes similar observations and she postulates that, small biotechnology firms form partnerships with large pharmaceutical firms for their mutual benefit: pharmaceutical firms gain access to the drug discoveries of the biotechnology companies and likewise small bio-tech firms gain access to the capital resources, manufacturing & distribution capabilities of these large pharmaceutical firms. The author discovered a growing trend of these mergers and consolidations. For example, Critical Pharmaceuticals worked closely with academia to develop a highly innovative formulation of *teriparatide*. The University of Leicester (UoL) played a crucial role in supporting Haemostatix Ltd during its early stages of development. The firm received support in the form of clinical laboratories as well as opening up links with other institutions and organisations. As a result of Haemostatix Ltd's links with the UoL, it received start-up funding of £250,000 from The Lachesis University Challenge Fund and an initial investment from NESTA. The founder of Haemostatix expressed her profound gratitude in 2006 when her organisation received support from Quester, 'Quester has worked with us (Haemostatix Ltd) since 2002 and we are pleased to have their financial support and strategic input to take the business forward'.

Proposition 3: *Inter-organisational collaborations are an important step in the knowledge supply-chain of small born-global firms and they influence their process of developing innovative capabilities*

However much seemingly important inter-organisational collaborations are; the study discovered that trust played a significant role in allowing the exchange and transfer of knowledge between collaborating partners to occur. It was found that for small born-global bio-tech firms with global foci; their inter-organisational collaborations were based on competence and goodwill trust. Şengün & Önder (2011, p.796) claim that, 'trust in competence refers to the perceptions of the trustor concerning the trustee's technical, cognitive and communicative competences'. At the inter-organisational exchange level small born-global firms collaborated with organisations they believed to have expertise and experience. This enabled them to successfully develop or test drug combinations. When the president at Sygnature Discovery was asked about the importance of firm-based competencies and goodwill in trust building this is what he had to say:

> We build trust with potential partners based on their science and technical capabilities. We also receive advice from BioCity, Medilink and UKTI about potential partners and I guess it is part of due diligence.

The above statement also brings to light the fact that firms intending to enter into partnerships with other firms can use a third party to gather information about their scientific capabilities and technical know-how, more so, for those which are geographically distant. In all the firms that took part in the interviews this was important as their intentions were to work with global partners. When seeking global partners these firms relied on the advice they received from BCN, Medilink East Midlands, UK Trade and Investment (UKTI), and from their established connections. The innovations manager at Medilink explained this more fully when asked about the role her organisation plays in facilitating inter-organisational collaborations. She stated that:

> We would facilitate for companies that intend to relocate to the East Midlands by providing them with the necessary information. We support both domestic and international organisations and recently we had a company that came from India intending to establish in the East Midlands. In that case we supported them by providing them with information to enable them to achieve their goal.

Bachmann & Inkpen (2011) agree that in cases where face-to-face interactions with a potential partner are not possible a third party may operate as a guarantor. The managing director at BCN echoed these sentiments explaining that for their tenants they 'guarantee a certain level of competence and quality of a potential partner but after that they take a step back and let people work and learn on their own'. A strong bond was gradually developed between collaborating firms, whether local or foreign, over a period of time through a 'trial and error' method. When the relationship got stronger the level of trust was increased accordingly thereby allowing the free flow and exchange of scientific capabilities as well as technical know-how. In the literature regarding trust, high levels of trust are associated with a decrease in perceived risk and they are cast as being fundamental to the formation of strong relationships. Thus, strong relationships are a precursor to trusting that a business partner will act in the best interest of both parties (Şengün & Önder, 2011). Evidently, some form of connection existed between firms which used a pre-existing business network such as BCN as their base but for partners outside their locality a 'trial and error' method taking the form of smaller projects was the main method of assessing the trustworthiness of prospective partners. As such the author's fourth proposition is that:

Proposition 4: *Small born-global bio-tech firms build trust with their prospective partners in escalating series basing it on their partner observations from inter-organisational collaborative projects*

Tacit & Explicit Knowledge

The process of acquiring knowledge is a very complex process which involves participating in generating and disseminating it in a way that benefits all the people involved (Powell & Grodal, 2005). There was cogent evidence indicating that small born-global bio-tech firms aim to develop stronger ties with local and international partners in order to ensure that they continue to receive crucial scientific knowledge. Ideas and knowledge generated from science-related projects involving sampled firms were codified and retained in the firm for future developments. This was reflected in the discussion with the CEO at Critical Pharmaceuticals regarding how his firm managed data accumulated from collaborative projects. To this end, he explained that:

> From a scientific perspective for a lot of the key projects we trap the knowledge that people have used in a project and we have project management systems to make sure that we capture all the knowledge e.g. by monitoring projects, gantt charts and project reports.

Managing scientific information this way was not only unique to Critical Pharmaceuticals. All the firms echoed the same sentiments. They also revealed that knowledge management was a crucial part of their drug discovery process. The findings are consistent with a number of scholars (see Daud & Yusoff, 2010; Hughes *et al.*, 2009; Nonaka *et al.* 2000) who discuss the concept of knowledge externalisation. They postulate that externalisation allows knowledge that exists in the head of the knower to be codified into rules, specifications and formulas that can be used and become the basis of new knowledge. All the firms that participated in the discussions regarding developing innovative capabilities in the biotechnology sector placed great value on both tacit and explicit knowledge they acquired from their trusted partners. The firms went beyond their immediate environment in search of a new context and a new world-view. Todtling *et al.* (2009) suggest that sector-based innovations are not bound by geographical location; they often have international or even global reach. Global networking in search of new insights was a dominant characteristic in the majority of the firms that took part in the survey. Nonaka *et al.* (2000) point out that the process of creating knowledge is a continuous one and it transcends beyond one's immediate environment. In a discussion with the CEO at Critical Pharmaceuticals he acknowledged that since his firm started to operate 15 years ago he has witnessed a significant transformation in the way his business now generates new knowledge. He emphasised that:

> The way we do business in the bio-tech industry has changed; when I started at Critical Pharmaceuticals most of the knowledge was only in-house. We now have access to a lot of external resources and nowadays there is a huge push towards accessing knowledge from outside for non-core areas. I would say the industry has changed somewhat it is now more open and there are a lot of collaborations with academics and research institutions and I think that has been good for the industry.

From that perspective, the interaction between individuals or a group of firms is vital in terms of facilitating knowledge transfer. As tacit knowledge exists in the head of the knower (Hughes *et al.*, 2009), small born-global bio-tech firms work in collaborative projects with scientists, research institutions and other firms with a view to stimulate its transfer. Porter *et al.* (2005) point to the amalgamation of intellectual capital of clinical researchers and research academics as key to the success of the commercial world of biotechnology in the Boston metropolitan area. Similarly, Todtling *et al.* (2009, p.67) claim that, 'universities are regarded as key knowledge sources of firms for more advanced innovations'. This bears striking resemblance with the patterns of knowledge development emerging from the East Midlands region in the UK. There is cogent evidence of the existence of strong ties and relational-like trust in the sampled firms that are located at BCN, the region's science 'hub'.

Based on their shared values and common beliefs invested at BCN the firms naturally formed business connections and the intentions of all the firms were predictable. Boschma (2005); Asheim & Gartler (2005) make similar observations and they highlight that interactions that occur in an institutional context facilitate the transfer of tacit and explicit knowledge. Through strong ties and relational-like trust, knowledge was freely exchanged. Discussions with the participants yielded two main forms of knowledge-sharing in the biotechnology sector. One form of knowledge-sharing that was clear was the idea of complementing each other's core competences. The strategy was evident across all the sampled cases. The collaboration between Critical Pharmaceuticals and PolyTherics is an example of complementary knowledge assets. Critical Pharmaceuticals specialises in injectable products and PolyTherics Limited are innovators in precision improvement of proteins and peptides. In that sense, their expertise and knowledge capabilities complemented Critical Pharmaceuticals' technology of human injectable drugs. The second form of knowledge-sharing was in the mould process re-configuration. It is, however, important to note that in both forms of knowledge-sharing the process of transferring knowledge occurred after the establishment of the intentions of the partnering firm(s) or institution(s). BAST Ltd as a contract research organisation (CRO) exchanged knowledge with its collaborating partners by re-arranging science apparatus in such a way that it enhances new drug discoveries. When responding to the question about how his firm's collaborative partners utilise the knowledge acquired in collaborative drug discovery projects the science director at BAST Ltd explained that:

> We use the information that we share with them to enhance their innovations and to accelerate their business processes. Basically, our ideas would change the next developments that they have which helps them to reduce costs and even sharpen their innovations and the way they put their resources together e.g. their operations and product development strategies.

With the first form of knowledge-sharing where both parties provide valuable input to the project, there was high commitment to generate both tacit and explicit knowledge. The firms developed relational capacities pooling together the skills of specialised participants who ultimately played an important role in the overall flow of information and resources in the network. The exchange and transfer of specialised scientific knowledge and skills between the firms engaged in collaborative projects or in the wider network at BCN had a significant impact on how they build their innovative capabilities. This brings to light the fact that both tacit and explicit knowledge are important factors that have an impact on the knowledge supply-chain of small born-global bio-tech firms. Nonaka & Takeuchi (1995) suggest that the creation of new knowledge is predominantly characterised by the interaction between two main forms of knowledge i.e. tacit and explicit knowledge. Thus, the author proposes that:

Proposition 5: *Tacit and explicit knowledge generated in the collaborative projects of small born-global bio-tech firms influence how they develop their innovative capabilities*

Prior Learning & Absorptive Capacity

Building on earlier studies by Cohen & Levinthal (1990); Jansen *et al.* (2005) on prior learning and absorptive capacity evidence from qualitative conversations with the founders/science directors of small born-global bio-tech firms suggests that their experience in science was crucial in the process of assimilating useful scientific knowledge.

Small born-global bio-tech firms gather science-related information from a wide range of sources and the science knowledge levels of their management teams played a crucial role during the process of acquiring information which was specific to their needs. The CEO at XenoGesis explained this more fully when asked about the importance of prior learning in terms of understanding the specific knowledge that is useful for their science in business and social networks that span beyond their proximity. This is how he put it:

> One has to understand the relevance of the acquired knowledge to science and experience in that respect plays an important role. Given the experience our team of experts have in bio-tech we are in a better position to acquire the science that is necessary for our service.

The same sentiments were echoed by the CEO at Haemostatix he explained that:

> Experience in science plays an important role when it comes to selecting the right type of knowledge that is needed to develop new technology.

This demonstrates that their ability to recognise and assimilate external knowledge was crucial to their process of developing innovative capabilities. Cohen & Levinthal (1990) argue that a firm's ability to evaluate and utilise information is heavily influenced by prior related knowledge. Within case analysis revealed that for all the sampled firms, their management structure was composed of individuals who had vast experience in science and had worked for large bio-pharmaceutical firms. As such, their wealth of experience was vital in terms of understanding the knowledge gap in their firms. To get a different perspective on this the topic about prior learning and absorptive capacity was presented to an innovation expert at Medilink East Midlands as a point of discussion and she commented that:

> Working with other organisations to share knowledge and ideas is great, but what is important is that one has to have some understanding about the knowledge that will help his/her business to take that one step forward.

In all of the above statements, made by the participants, there is clear evidence that experience and prior learning have a significant impact on how a firm selects useful knowledge to complement its knowledge gap. Evidently, working with other firms or science institutions whose complementary foci is at some cognitive distance results in the accumulation of vast amounts of information but recognising what a firm needs significantly increases its capacity to innovative. Indeed, working in collaboration accelerates the firm's process and product improvements. Schilling (2008) suggests that a firm's prior related experience shapes its ability to recognise the value of new information and its ability to utilise that information effectively. Thus the author proposes that:

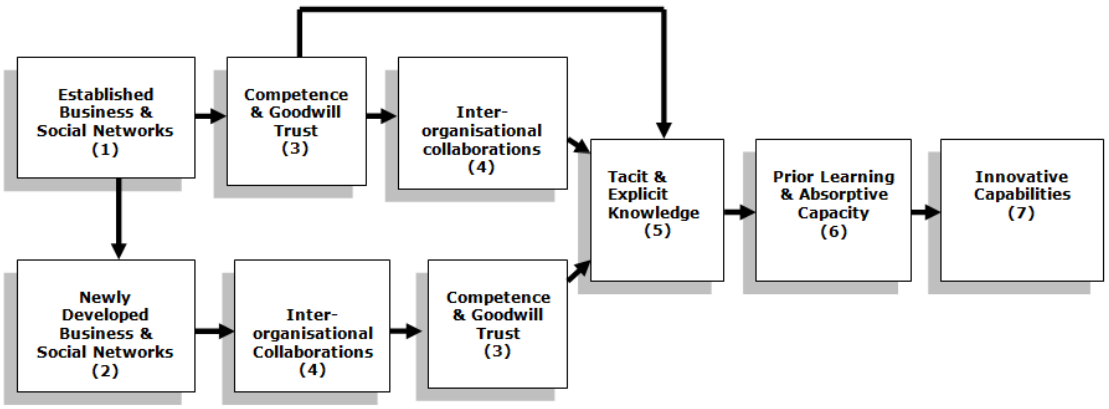
Proposition 6: *The experiences of small born-global bio-tech firms are essential to their ability to recognise, assimilate and apply knowledge from their business and social relationships in a way that enhances their capacity to innovate*

It is also important to inform the reader that the concept of learning has not been fully explored here because it is beyond the remit of this study. Although the concept has been discussed in a limited fashion it has been an important part of the process of understanding its role in the development process of innovative capabilities small born-global bio-tech firms. Following an in-depth account of various factors within the knowledge supply-chain of these entrepreneurial ventures the author proposes a refined conceptual framework of knowledge and innovative capability development.

A Model of Knowledge and Innovative Capability Development

The formation of theories in social science is fundamental to how we explain what we are trying to talk about (Gerring, 2005). Precisely, theories are instrumental in social science as they help us to make connections between the world people live in and how they interpret it (Gerring, 2001). Bellamy & Perri (2009, p.90) point out that regardless of one's research philosophy developing an adequate conceptual framework provides a roadmap that guides how the researcher explores the social world and for those working with variables and correlations they are able to 'establish valid measures and apply them reliably'. Building on the inspirational work of Freeman *et al.* (2010) regarding how smaller firms rapidly develop new knowledge in their internationalisation process; this study proposes a new improved framework for small born-global bio-tech firms. Using existing literature, empirical evidence from within and across cases the study proposes the "*Knowledge and Innovative Capability Development Model*". Sigglekow (2007) affirms that using rich data acquired through closely examining instances of occurrences in cases can inspire new ideas in theory construction. In the same vein, Eisenhardt & Graebner (2007) express that the output of case-oriented research designs take various forms including: a new concept, theoretical construct, conceptual framework, propositions, and in other cases a mid-range theory. Similarly, Ridder *et al.,* (2009) agree that case studies have the potential to uncover unusual phenomena and of repeating or countering the replication of findings of other cases which eliminates alternative explanations and elaborates the emerging theory. From these perspectives the author presents Figure 2 below which neatly illustrates the proposed conceptual framework as a result of new evidence.

Figure 2: Knowledge and Innovative Capability Development Model



Source: Modified from Freeman *et al.* 2010 "A Process Model of Rapid Knowledge Development: The Smaller Born-global firm" and author's ideas

Small born-global bio-tech firms operate in a very complex and sophisticated business sector which is exceedingly dynamic. Therefore, it is imperative that they formulate strategies to enable them to continue to produce innovative life-saving products. The primary aim should be to enhance their innovative capabilities which enable them to make crucial innovations (Powell & Grodal, 2005). The firms used in this sample were all resident at BCN implying that they exist in a network which is already established where they have developed strong business and social ties. They demonstrated an entrepreneurial flair by venturing into the global markets in search of global partners. As denoted in figure 2 above, the establishment of business and social networks, described as innovation networks by Powell & Grodal (2005), is the key building block within the knowledge supply-chain of small born-global bio-tech firms.

Elfring & Hulsink (2003) make an important observation about entrepreneurial firms by suggesting that networks (business & social) contribute significantly to the venturing process of entrepreneurial small firms by presenting them with access to knowledge and unique capabilities. In their local network at BCN and the wider East Midlands region the firms were aware of the competences and the intentions of their potential collaborative partners thus, trust was built at a very early stage. This quickened the process of knowledge transfer as well as the exchange of technical know-how. So, established networks are credited with building trust which leads to inter-organisational collaborations. Established networks also led to newly-formed business and social networks (see Davis, 1970; Wall, 2009). In newly developed networks, trust was quite superficial and in some cases non-existent. Therefore, for R&D institutions, firms or scientists located in foreign markets inter-organisational collaborations in the form of smaller projects were used as 'trial and error' conduits to test the trustworthiness of the prospective partner. Indeed, in their process of developing innovative capabilities small born-global bio-tech firms embarked on a number of different, often unsuccessful, configurations and techniques before finding the right combination that worked well for them (Lichtenthaler & Lichtenthaler, 2009). Schilling (2008) explains this process of experimentation and learning more clearly asserting that this stage in the knowledge supply-chain is vital in the sense that it allows the firm to build a base of knowledge about how key components behave, what alternatives are more likely to be successful than others, and what types of projects the firm is most successful in.

Small bio-tech firms were forced to adopt the experimentation approach because of the dynamic nature of the biotechnology sector i.e. its heavy reliance on highly fluid scientific knowledge and technology to make new drug discoveries and the speed with which these types of firms form and disintegrate required high levels of trust (Maxwell & Lévesque, 2011; Welter 2012). This strongly suggests that trust is ever-more critical for the transient and the high speed environment of the small born-global bio-tech firms as the basis for knowledge sharing (Freeman *et al.,* 2010). As such, trust was built in escalating series because of the risks associated with developing new partnerships. Sitkin & Pablo (1992) discuss risk perception by referring to the assessment of the risk inherent to a situation. In all of the five small born-global firms the assessment of the risks associated with knowledge-sharing with new partners was done in a carefully orchestrated logical step-by-step approach. Once trust was built, whether in established or newly developed business and social networks, it paved the way for effective knowledge-sharing. Similarly, Hill (1990) claims that, it is highly likely that a firm will engage in knowledge transfer with partners who have demonstrated their trustworthiness and co-operative abilities in their other relations.

The process of knowledge-sharing is embedded in pre-existing business and social connections. Hutchings & Michailova (2006) suggest that sharing knowledge depends on the pre-existence of insider relationships and a disposition towards co-operative interdependence. Scholarship on entrepreneurship generally agree that small firms with limited resources have a tendency to soak as much information as is possible with the hope that something magical will materialise. The proposed model suggests that for small born-global firms prior understanding of the complementary resources needed for the firm to develop new life-saving drugs or technical products is essential otherwise engaging in collaborative projects will count to nothing in the way of innovations. The underlying assumptions of the model are that, by acquiring new scientific knowledge and technical know-how the firm enhances its innovative capabilities that underpin the development of new products and services in the life science industry.

Furthermore, the process of generating innovative capabilities is directly anchored on the greater connectivity and enhanced collaborations in the life science's innovation 'ecosystems' described by Booth (2009, p.705) as a 'brave new world'. Indeed, the connectivity and collaboration between various actors within the East Midlands network performed a key part in the process of ensuring continued development of scientific knowledge and technical know-how by providing financial support and infrastructure. BCN provided the firms specialised premises with state of the art lab equipment while NCC and Mobius provided seed funding to promising ventures. A similar observation was made by Laine *et al.* (2008), the scholars maintain that, at the core of innovation 'ecosystems' are firms and enterprises which are involved in innovative collaborations with academic institutions and investors. A convincing argument regarding the logic behind facilitating the development of innovation 'ecosystems' similar to those appearing in the East Midlands region, was made by Hautamäki (2007). Hautamäki argues that the 'ecosystems' approach places great emphasis on close co-operation and a culture of creativity which refers to adventurism, entrepreneurship and innovativeness.

The evidence is clear in the East Midlands region suggesting that born-global bio-tech firms are involved in local innovation 'ecosystems' that considerably influence the movement of knowledge within their knowledge supply-chain. Adner (2006) insists that an innovation 'ecosystem' facilitates *integration risks* of having the solution adopted across the value-chain. This is consistent with Bramwell *et al.* (2012) conceptualisation of an innovation 'ecosystem' approach. The scholars see it as a sophisticated way of holistically looking at mechanisms that interact within an economic system. Crucially, for policy makers such innovation systems will 'enable them to pay close attention to the collaborative, inter-dependent nature of the innovation processes and to identify the best means of stimulating productive networks and relationships within and across disciplines and sectors of comparative advantage' (Bramwell *et al.,* 2012, p.49). Additionally, Wolfe *et al.* (2011a) describes the regional knowledge 'ecosystem' approach insisting that it leverages regional infrastructures with a view to stimulate/support regional innovation processes through the collaborations of multiple partners that include: research and academic institutions, investors, other firms and investors. Wolfe and others description of regional knowledge 'ecosystems' has a striking resemblance with the innovation 'ecosystems' within the East Midlands region that are supporting the process of generating innovative capabilities denoted on figure 2 p.17.

Discussions

Rationale for stretching the model

Freeman *et al.* (2010) invite other scholars to carry out more research to develop further their model of rapid knowledge development for smaller born-global firms. This stretches its reach. In particular, they recommend the need for further studies to refine their conceptual framework and its applicability to the internationalisation processes of smaller born-global firms, and the network perspectives. As such, the advent of bio-tech firms with an international flair necessitates the modification of their model to accurately capture the specific world of this new phenomenon. The firms build their innovative capabilities by participating in evolving global R&D networks (Simba, 2012) hence; the need to develop a conceptual framework that adequately captures the changing terrain. As Swain (2012, p.12) noted, 'The Big Pharma model is undergoing a painful evolution, moving from competition to collaboration, from one-size-fits-all to more tailored approaches, and a longer-term view of basic research'. During the restructuring phase occurring in Europe and America (Rafols *et al.,* 2012); scientists are taking centre stage in global R&D activities.

They are forming science-based firms (small born-global bio-tech firms) which are exceedingly productive (Simba, 2012). Evidence in the literature, from within and cross cases demonstrates that the business and social connections of the scientists which were developed during their previous employment have become part of the structural dimension of their new ventures. According to Munos (2009) the business and social connections of these scientists are used as channels for scientific knowledge, technical know-how and market-related intelligence. Their cognitive dimension consists of experienced scientists implying that they have vast knowledge in science. As such, Freeman's *et al.* (2010) model was stretched to accommodate this new empirical evidence. By doing so, the newly constructed model of knowledge and innovative capability development significantly contributes to the understanding of the concepts of dynamic capabilities and networking theories that already exist (e.g. Rogers, 1962; Johnson & Vahlne, 1977; Teece *et al.* 1997; Freeman *et al.,* 2010).

Conclusion

The new propositions and a revised model presented in this paper increase the performance of Freeman's *et al.* (2010) model of rapid knowledge development for smaller born-global firms. The new model develops new and alternative understanding of the new types of bio-tech firms developing in the biotechnology industry which are conceived with global foci. The study reveals the importance of horizontal networks and the interplay between firms, research institutions and academics that have complementary technologies and science within the knowledge supply-chain of small born-global bio-tech firms (Shilling, 2008). The author believes that the newly formulated theory of innovative capability development contributes to the understanding of the network approach which focusses on specific, well-selected relationships in the innovation process with specific actors within the same innovation *milieu* and beyond (Cooke, 2003; Breschi & Malerba, 2005). The study also demonstrates that for small born-global firms to receive and share tacit and explicit knowledge some form of trust between the collaborating parties has to be established. In that sense, competence trust i.e. trust which is based on the scientific and technical capabilities of the prospective partner and goodwill trust referring to the intentions of the prospective partner were identified as critical to inter-organisational collaborations that occur in the biotechnology sector.

The study also brings to light that trust, in the collaborative projects of bio-tech firms, is built in escalating series. In established science centres relational-like trust naturally exist among resident firms. But, in newly developed networks trust exists casually or does not exist at all. With newly developed relationships the study found that the 'trial and error' method was evoked. The process was observed as starting with firms engaging in smaller projects aimed at testing the trustworthiness of a prospective partner. This potentially led to more collaboration(s). This observation is consistent with Shilling (2008) who claims that experimenting by linking up with different partners during the stage of establishing a partnership is necessary for high-tech firms as collaborating is not without risks. Within the knowledge supply-chain of small born-global bio-tech firms the previous learning and sector-based experiences of the CEOs, bio-entrepreneurs or science directors are crucial in terms of absorbing specific capabilities or choosing the right partner with specific skills or knowledge that complements their firm's internal capabilities. As much as the research approach adopted for this study is presumed appropriate the author is aware of its inherent limits. For example, using computer software SPSS which generates quantitative data would add to the validity of the proposed concepts.

The study is limited to five participants from the East Midlands region in the United Kingdom. Nonetheless, the output which is "*Knowledge and Innovative Capability Development Model*" illuminates the salient mechanisms and process that mitigate the knowledge supply-chain of small born-global bio-tech firms. Finally, the author makes two important recommendations. He recommends studies that test the extent to which independent variables such as: business, social networks, competence, goodwill trust, prior learning and absorptive capacity influence the innovative capability development process of small born-global bio-tech firms. The traditionally held view that large bio-pharmaceuticals are the most dominant force in global markets might well be evolving. The advent of small born-global bio-tech firms on the global stage in substantial numbers, worldwide, reflects an emerging business model with the potential to perhaps become the most dominant in the harsh economic times in which large organisations are feeling the strain. In that regard, the born-global phenomenon requires great attention because it heralds the emergence of a new phase in international exchange systems whereby regardless of the size of a business, it can play an important role in global markets. From that perspective, he also recommends future studies that investigate how small born-global bio-tech firms learn to cope with the complexity of global markets given their cultural diverse nature. This will help us to deepen our understanding of how born-global firms organise the exchange of ideas, technologies, people and information in global networks.

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The role of global R&D networks in generating social capital for born-global bio-tech firms: A multi-case approach

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Abstract

The traditionally auspicious 'Big Pharma' business model in the pharmaceutical industry is rapidly evolving. Large pharmaceutical companies are re-configuring their business models to achieve operational efficiency. The preferred option appears to be out-sourcing science-related R&D as opposed to conducting the research in-house. This has marked the 'birth' of born-global bio-tech firms which operate as contract research organisations. The firms are owner-managed by entrepreneurial scientists who generate social capital in the form of scientific knowledge and technical know-how by participating in multifarious global R&D networks. In that sense, this empirical study utilises multiple cases of born-global bio-tech firms sampled from the East Midlands in the United Kingdom to investigate how various mechanisms in their knowledge supply-chain (global networks), including complex business and social relationships, shape their social capital generating strategies. By doing so, the study contributes to the concept of dynamic capabilities and networking. The study is also invaluable to a number of stakeholders including: large & small firms, other researchers, and policy makers.

Keywords: Born global, Global R&D Networks, Innovative Capabilities, Trust, Knowledge, Inter-organisational Collaborations, Social Capital

1. Introduction

The life science industry is currently undergoing substantial transformation whereby large bio-pharmaceutical companies are streamlining their R&D facilities in favour of out-sourcing the services (Rafols *et al.,* 2012). As a consequence of this unfolding strategic move a new form of entrepreneurial ventures identified in the literature as born-global firms have proliferated (see Knight & Cavusgil, 1996; Oviatt & McDougall, 1994; Mathews & Zander, 2007, Gabrielsson & Kirpalani, 2004). Outside the Golden Triangle of Cambridge, London and Oxford in the United Kingdom, there is enthralling evidence from the East Midlands region showing an exponential rise of small firms in the biotechnology sector that are conceived with an international flair. The firms engage in complex global networks of innovation. Kalantaridis & Vassilev (2008) suggest that this is made possible by the liberal global structures governing trade today. As such, born-global bio-tech firms have designed their business operations in a way that boosts their capacity to generate fluid scientific knowledge and technical know-how (Shilling, 2008; Lasserre, 2012). In this article the term social capital which means, 'the sum of the actual and potential resources embedded within, available through and derived from the network of relationships possessed by an individual or social unit' (de Wever *et al*., 2005, p.1525) is used to refer to scientific knowledge and technical know-how.

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The structural dimension of born-global bio-tech firms includes global academic networks and research labs, other firms, and international science parks (Lindstrand *et al.,* 2011; Todtling *et al.,* 2009). There is a near universal acknowledgement that the business and social connections of born-global firms perform a fundamental role as conduits for their capability development (see Freeman *et al.,* 2010; Sharma & Blomstermo, 2003; Karra *et al.,* 2008). From that perspective, the ability to be innovative in the science intensive biotechnology sector can only occur if a firm is able to both generate and integrate knowledge from inside and outside its proximity (Powell & Grodal, 2005). While it is often assumed that business networks yield innovation (Owen-Smith & Powell, 2004) more research still needs to be carried out to understand the various mechanisms that manifest in the knowledge supply-chain of born-global bio-tech firms. More importantly, how these mechanisms shape the processes involved in generating scientific knowledge and technical know-how. As such, this article investigates the role of global networks which are part of the knowledge supply-chain of born-global bio-tech firms. A look into the knowledge supply-chain of these international ventures will exact a better understanding of the complexity of global networks and their strategic effect or fit.

2. Literature Review

2.1 The Characteristics of Born-global Bio-tech Firms

The term born-global is used in this study to describe small bio-tech firms, trading in the biotechnology industry, which engage in global R&D activities i.e. they take part in science-related projects on a global scale (Simba, 2012). This rather new and emerging strategy of acquiring innovative capabilities is gaining momentum in the biotechnology sector. Scholarship on firm internationalisation attributes this developing operational strategy to the availability of advanced information systems and technology, efficient means of transportation, and the liberalisation of world markets (Shelling, 2008; Lasserre 2007/2012; Ferreira *et al.,* 2010; Kalantaridis & Vassilev, 2008). The liberalisation of global trade markets significantly gives rise to the formation of entrepreneurial firms with an international flair. Early studies (see Schumpeter 1934's theory of innovation) closely associate entrepreneurial behaviour with innovation. In Anderson (2000); Mathews & Zander (2007) innovative and entrepreneurial firms were described as business ventures that have the vision and the flexibility needed to identify and exploit the benefits offered by existing and new overseas markets. Hisrich (2012) affirms that global markets offer entrepreneurial firms new market opportunities. The extant literature on international entrepreneurship (see Oviatt & McDougall, 1994; Li & Ferreira, 2006) characterises born-global firms as enterprises which take risks, innovate and have the vision to anticipate economic events. This is necessary because in science-intensive industries, technology and firm-based capabilities evolve at a fast pace. According to Gurău *et al.* (2010, p.452) 'Rapid change, increased competition, faster life cycles, globalisation, new process models, breakthrough technologies – all contribute to the complexity of the organisational and business context of modern biopharmaceutical firms'. In that context, born-global bio-tech firms operating in these constantly evolving market conditions, escapades that involve risk such as networking across the globe can be crucial for bridging the knowledge and capabilities gap (Ferreira *et al.,* 2010) or in enabling new resource combinations (Schumpeter, 1950).

2.2 The Global R&D Networks of Born-global Bio-tech Firms

Networks are defined as a set of nodes (persons or organisations) linked by a set of social or friendship connections of a specific type (Cooke, 2001; Breschi & Malebra, 2005). They are distinct from hierarchical or market relationships in their reliance on reciprocity, collaboration, complementary independence and orientation towards mutual gain. Thus, the global R&D networks of born-global firms provide them with four key benefits that include: proximity to markets, access to geographical clusters of knowledge creation and development, learning and access to low cost and good quality scientists and engineers (Lasserre, 2012). More so, Breschi & Malebra (2005, p.47) claim that, 'resource pooling, risk sharing and the formation of critical masses provide an incentive to create a group of inter-linked agents'. Adding to the growing discourse on business relationships, a recent study by Johnson & Vahlne (2009) provides two core arguments. Firstly, the study suggests that markets are networks of relationships where firms are connected to each other in different formats including complex and visible patterns. This perspective is critical in understanding the collaborative activities of entrepreneurial firms or born-global bio-tech firms. Secondly, the study draws attention to the fact that relationships developed at an organisational level facilitate learning and the potential to develop trust. This is crucial for the resource-impecunious born-global bio-tech firms which rely, to a greater extent, on strategic alliances to jointly develop new science technology and life-saving drugs. The social exchange theory accentuates the differences between business relationships that have a positive connection and the ones that have a negative one. In a business-like relationship where the connection is positive the flow and exchange of information is bi-directional whereas in those relationships with a negative connection information flows in one direction (Cooke, 2003; Ahuja, 2000).

Innovation has always been the backbone and underlying strength of the pharmaceutical industry. The core concept of networking in business is that the co-ordination of activities between the parties involved in a business-like relationship has to take place within a wider network context (Anderson *et al.,* 1994; Ahuja, 2000; Owen-Smith & Powell, 2004). Accordingly, in well-established business networks, within the knowledge supply value-chain of born-global bio-tech firms, strong business connections are developed which enable learning through social exchange overtime (Anderson *et al.,* 1994). Stanek (2004) emphasises that a network can often be superior for a stand-alone firm due to its greater knowledge diversity and a pool of talent found within. Freeman & Cavusgil (2007) claim that strong *camaraderie* is found to exist between born-global firms and their foreign partners and it is frequently based on long standing past associations of the senior management team.

2.3 Innovation and R&D Capacity

According to Khanna (2012, p.1088) 'innovation has always been the backbone and underlying strength of the pharmaceutical industry'. A strong R&D base, within a network, can provide the ideas and products for future development (Cooke, 2001). Certainly, for born-global bio-tech firms global R&D networks are vital sources of new ideas and technology. According to the UK's Department for Technology and Innovation (2004) the term innovation refers to product or process development while R&D is mainly concerned with the development of new knowledge. Drucker (1985, p.8) conceptualises knowledge in the form of science and technology as 'superstars of entrepreneurship' and Tushman & Anderson (1997) claim that, successful innovation is the output of an R&D process.

Like Drucker (1985) and Tushman & Anderson (1997) the author takes the views that global networks accelerate firm-based innovations. Su *et al.* (2009, p.312) suggest that, 'a firm's R&D capability reflects its ability to generate new scientific discoveries and technological breakthroughs'. Shilling (2008) echoes similar sentiments suggesting that, a firm's R&D capability demonstrates its drive to generate new scientific discoveries and technological breakthroughs. After undertaking a study involving five high-tech firms Danneels (2002) found that a firm's R&D is sturdily linked to product innovation.

2.3 Social Capital and Born-global Bio-tech Firms

Social capital refers to the long-standing aspect of human relationships (Bridge & O'Neill, 2013) and it has been a focus of interest by many scholars from a wide-range of disciplines. The term social capital can be traced back to the early 19th century specifically, to the work by Hanifan in 1916. In the last quarter of the century the concept was advanced by Bourdieu (1986), Coleman (1990), and Putman (1995). Their conceptualisation of social capital assumes various dimensions and their work does not produce a uniform understanding of social capital which can be confusing (Bridge & O'Neill, 2013). For instance, Bourdieu (1986, p.248) defines social capital as 'the aggregate of the actual or potential resources which are linked to possessing of a durable network of more or less institutionalised relationships of mutual acquaintance or recognition'. Coleman (1990) defines social capital by its function. Coleman argues that social capital consist of some form of social structure that facilitates certain actions by actors within it. Putman (1995) appears to treat social capital as a single dimension. Putman defines it as 'the networks, norms, and trust that enable participants to act together to effectively pursue shared objectives' (1995, p21).

From these various perceptions of social capital, one can identify its relevance to entrepreneurship and business. For example, MacMillan *et al.* (1985) examined new ventures and observed that as the new venture evolves it becomes apparent that 'who you know' is as important as 'what you know'. Crucially, MacMillan and others found that for entrepreneurs to develop support it is important that they develop rapport with their network contacts. Consistent with MacMillan and other's observation and recognising the importance of entrepreneurial behaviour of what they called 'know who' Peterson and Rondstadt (1986, p.11) proposed a formula: 'Entrepreneurial Success = New Venture Idea + Entrepreneurial Know-how + Entrepreneurial Know-who'. Thus, the social and business connections of born-global bio-tech firms in global R&D networks are an essential part of their ability to be innovative, to economically grow and develop in global markets.

3. Methodology

3.1 Research Goal

The study investigates the role of global R&D networks, in the knowledge supply-chain of born-global bio-tech firms especially, their effect on the firms' process of generating social capital. To satisfy the research issue the study utilises multiple cases. The participants include CEOs and science directors from five bio-tech firms identified as born-globals. The sample predominantly consists of firms which use the East Midlands region in the United Kingdom as their home market. The interviews took place between November 2011 and June 2012. Multiple steps were taken to identify sample cases.

First the author checked the BioCity Nottingham (BCN) web site, a regional 'incubator' to identify cases of firms that are active in drug discovery and global R&D projects. This is consistent with Flyvbjerg (2013 in Denzin & Colin, 2013, p.169) who suggests that, 'the decisive factor in defining a study as a case-study is the choice of an individual unit and the setting of its boundaries'. In other words, its 'casing' to use Ragin's (1992) felicitous term. The procedure generated about 20 East Midlands based bio-tech firms which were subsequently narrowed down to five based on their ability to illuminate various aspects of the research phenomenon. The case-study method is multi-discipline; historically it was used by clinicians to understand the 'person in particular' (Runyan, 1982) and in education it is used to help students to understand a concept (Cohen *et al.,* 2007), in law using a case law and in political science using case reports (Creswell, 2007). Furthermore, Creswell (2007) claims that because of its popularity in social science the case-study approach is familiar to social scientists.

In that sense, for the purpose of this study, which can be categorised within the discipline of business management, the research approach is used to extend our understanding of the role of global networks in generating social capital for born-global bio-tech firms. This is consistent with Yin (2009, p.18) who defines a case-study research as, 'an empirical enquiry that investigates a contemporary phenomenon in depth and within its real life context, especially when the boundaries between phenomenon and context are clearly evident'. Cohen *et al.* (2007, p.253) makes a strong case in support of researchers who assume a case-oriented approach by insisting that, 'case studies can establish cause and effect and one of their strengths is that they observe effects in real contexts, recognising that context is a powerful determinant of both cause and effects'. It is therefore based on these attributes of a case-oriented approach that attracted the author to use the research strategy for the purpose this study which investigates the cause (global networks) and the effect (social capital) of born-global bio-tech firms.

4. Case Findings

This section provides detailed findings within each case. It describes the actions of born-global bio-tech firms regarding how they generate their social capital. This is consistent with Eisenhardt (1989, p.540) who suggests that, 'within case analysis, typically involve detailed case-study write-ups for each site'. Crucially, it helps to describe what is happening in the complicated world of born-global bio-tech firms (Huberman & Miles, 1994). Scholars Gersick (1988) and Pettigrew (1988) agree that although within case analysis is purely descriptive the research technique is crucial in terms of enabling the reader to gain an insight into the research phenomenon. The main aim for doing within case analysis was to become intimately familiar with each bio-tech firm (Stake, 2005). Particularly, with all the factors that influence their capacity to generate social capital. This assisted the author to uniquely map out the pattern of each case prior to generalising across the cases (Eisenhardt, 1989). Table1 on p.6 provides an array of data describing born-global bio-tech firms and science parks. The data on science parks is provided to give the reader more information regarding their role in facilitating a geographic concentration of a critical mass of inter-connected companies and R&D science institutions (Engel & del-Palacio, 2009).

Table 1 Description of Born-global Biotech Firms comprising the sample

Firms	Origins	Bio-tech Activity	Year Founded	No. of Interviews
Critical Pharmaceuticals	UK-based biotechnology spinout company from the University of Nottingham	Involved in drug delivery technologies for the sustained release and nasal delivery of proteins and peptides and labile or insoluble small molecules. Delivers Advanced Therapeutics	2002	4
XenoGesis Ltd	UK based founded after the closure of AstraZeneca	Specialises in pre-clinical drug metabolism and pharmacokinetics (DMPK), quantitative bio-analysis and expert interpretation	2012	3
Haemostatix Ltd	Spin-out firm from the University of Leicester – UK based	Develops a pipeline of haemostats based on its new class of active ingredients that replace thrombin. The firm also commercialises its new technology platform based upon a specific peptide sequence that binds to fibrinogen – a protein essential to the formation of clots.	2003	4
Sygnature Discoveries	Founded in BioCity Nottingham	Provides integrated drug discovery services. The company is also involved in a wide spectrum of drug discovery programmes and the outsourcing of discovery projects to contract research organisations (CROs)	2004	4
BAST Incl.	Spin-off business launched after the announcement of the closure of the AstraZeneca	The pharmaceutical company is involved in a new drug development process known as Model-based Drug Development (MBDD) where investment decisions are supported by a simulation of the probability of success. The company is part of a collaborative network of twenty four other organisations with the East Midlands and internationally.	2010	3
Science Institutions		**Networking Activity**		
BioCity Nottingham (BCN)	A result of collaboration activities between Nottingham Trent University, The University of Nottingham and EMDA	UK's largest bio science innovation centre. Operates as an incubator for small firms within and outside the region. Currently houses advanced equipment and technology in over 12,000m2 of bespoke laboratory and office space and it is also the site of a new Nano-technology and micro-technology fabrication facility for the East Midlands region (BioCity, 2012).	2003	1
Medilink East Midlands	Part of Medilink UK which was established in 1999 operating in other parts of UK	It is a life science industry association, whose aim is to help companies establish, develop and grow and connects them with other global players. Its network consists of more than 4,000 contacts in over 600 organisations represents all aspects of the sector, including private and public institutions; from multinationals to high potential start-ups, as well as the NHS and universities.	2004	2
Pera Innovation Park	Part of a Europe network established 65 years ago to help UK & Europe businesses	Pera Technology helps hundreds of companies across Europe and beyond to harness the potential of science and technology to create new and valuable products and processes to create sustainable, valuable businesses. The innovation centre also provides integrated R&D services for firms of all sizes	2008	3
Midlands Enterprise Europe Network	Part of Enterprise Europe Network (EEN)	The Midlands Enterprise Europe Network is a local node within a network of 600 regionally based contact points covering the entire European Union and beyond. The Enterprise Europe Network is the official EC business support network for business cooperation and technology transfer, providing organisations with access to technology transfer for technological cooperation, research, licensing, manufacture and joint venture agreements.	2008	3

Case 1 – Critical Pharmaceuticals Ltd (CP)

Critical Pharmaceuticals Ltd is a spinout company from University of Nottingham (UoN) which was formed in 2002 by two researchers in chemistry and pharmacy (BCN, 2011). The firm received seed funding and it moved into new premises following the formation of BCN in 2003. As the company further developed its technology and products it attracted more funding from leading UK investors including: Catapult Venture Mangers, The Lachesis Fund, e-Synergy, East Midlands Business Angels and The Well-come Trust. The funding CP received from Wellcome Trust enabled the firm to transform the delivery of *hGH* a drug which treats human growth disorders in adults and children. For Critical Pharmaceutical, funding was a catalyst used to unlock its innovations.

The structural dimension i.e. CP's global business connections presented the firm with an opportunity to leverage its resource deficiencies. This was reflected in a conversation with the firm's CEO when discussing the resources that his firm acquired from its collaborative networks he said that:

We acquire technical and financial support from our business partners scattered throughout the world to back-up our internal expertise, marketing, PR, science knowledge that may be limited in-house yet we needed it to achieve our goals.

This evidence is strong and it indicates that the firm has a wide range of business connections on a global scale including funding institutions, academia, other firms and research institutions which it uses to generate social capital. XenoGesis, Haemostatix, Sygnature and BAST have crafted similar structures with a view to generate social capital. This is consistent with Granovetter (2005). Granovetter suggests that in close-knit ties there is a strong element of trust which makes it possible for the exchange of new ideas and knowledge. The CEO of CP commented that:

You should have trust with the people who you have business-like relationships so as to allow the free movement of knowledge and information to happen.

The management team at CP consists of well-experienced scientists of international stature and they all share the same view about the world of science. In that respect, global networks can be seen as an essential component of the jigsaw puzzle needed by small bio-tech firms in their process of developing innovative capabilities. Similarly, Yi *et al.* (2008) contend that integrating knowledge from diverse contexts is a pivotal part to a firm's ability to generate fluid information. This view was reflected by the CEO of CP when announcing the firm's collaborative project with UoN. This is what he had to say:

We are excited about working with internationally-recognised clinicians and scientists at The University of Nottingham and Nottingham University Hospitals NHS Trust to rapidly develop this highly innovative formulation of teriparatide.

His sentiments were also echoed by a research fellow at the UoN who expressed excitement at the prospect of collaborating with CP. He observed that, it was going to enable the UoN to jointly develop world leading research as well as share scientific knowledge and technical know-how. This highlights that the concept of working in collaborative projects is gaining prominence in the biotechnology sector. Scientists are of the opinion that collaborative projects are necessary for developing complementary assets (Shilling, 2008). The author found this form of co-operation to be crucial for CP in terms of generating fluid scientific knowledge. These collaborative projects also enabled CP to bridge its knowledge gaps. This observation is consistent with Helfat & Peteraf (2003) who agree that external resources help a firm adjust its resource mix. Undeniably, interacting with other firms or organisations with diverse skills (cognitive distance) provide synergy for firms with insufficient resources. In science-based industries the extent to which knowledge is spread, described as knowledge diversity in Nooteboom (2009), increases the innovative capabilities of small firms. More importantly, it significantly improves their business processes and also influences their ability to make crucial innovations.

When asked about the importance of working with firms within and outside their vicinity the CEO of CP explained that:

In the biotechnology sector you need various skills and knowledge. In addition to our in-house knowledge we collaborate with other institutions such as universities and other companies both locally and internationally. We have different levels of collaboration. We collaborate with small and large companies in the USA and the EU. We also have intense collaborations with companies near to us who have expertise in areas of interest to us we therefore work with them to access the expertise that we do not have.

This is compelling evidence indicating that CP is involved in global R&D networks. Its knowledge/market value-chain includes both domestic and international actors. From that perspective, the author can confidently claim that strategic alliances between businesses and research centres worldwide are the cornerstone to innovation given the globalised nature of the markets today. Lasserre (2012, p.293) concurs with this presupposition and he emphasises that, 'every process of globalisation implies some process of technological transfer'. Irrefutably, the statement made by the CEO of CP quoted above endorses this. Likewise, Teece (1986) supports this point of view by affirming that small firms can form alliances with big firms to tap into the larger firm's greater capital resources, distribution and marketing capabilities, or credibility. Similarly, Roudini *et al.* (2012, p.129) claim that in global networks, 'knowledge flow and exchange become possible through marketing connections and they foster communication between included groups, and establish a crucial channel for resource acquisition'. The firm's management team also performed a decisive role in unlocking its innovation conundrum. The team's years of experience in the biotechnology sector significantly enhanced the firm's capacity to make important drug discoveries. Thus, a good understanding of science by key people in the business increased the firm's chances of making rapid progress in developing nasal administered drugs. Oviatt & McDougall (1994) express similar views by claiming that the previous experience of the management team has affirmative influence in enhancing a firm's formation of capabilities.

Case 2 – XenoGesis Ltd

XenoGesis is a company that was formed in 2012 following the closure of AstraZeneca's R&D facilities in Loughborough in the East Midlands, UK. For its cognitive dimension, its management team is composed of scientists who are former employees of AstraZeneca and have vast experience in life science. Its founder who is also its CEO is a former Associate Principal Scientist in drug metabolism & pharmacokinetics (DMPK) at AstraZeneca. He has been involved in about 60 different projects during his time at the pharmaceutical giant and has delivered new medicines. Experience in science-based firms is a valuable asset that can be crucial to the performance of a firm. XenoGesis specialises in data-driven iterative drug design PK/PD study planning and interpretation, dosing regimen recommendations, toxic kinetic support and drug transport (XenoGesis, 2012). The founder of the firm considers his connections which were established during his time at AstraZeneca as central to the success that his company has enjoyed since its inception. Thus, the founder's structural social capital played a pivotal role in enabling XenoGesis to acquire crucial scientific knowledge, technical know-how and financial resources. The company's CEO commented that:

It is quite unusual for a new company working in this field to get off to such a flying start but we have the support of a strong Board of Directors and staff team, and several international partners.

In March 2012 Mobius Life Sciences Fund announced an investment in XenoGesis citing its fast growth as the main reason for investing. More importantly, Mobius funding comes with help and support from experts at BCN targeted at ensuring a firm's continued growth and creativity. Expert support and funding were very much part of XenoGesis structural dimension. This is similar with the other 4 firms sampled for this study which all benefited from the support offered at BCN. The Director of the Mobius Life Sciences Fund Dr Glenn Crocker (2012) explained more about why his organisation invested in XenoGesis:

XenoGesis has already shown its growth capability by winning significant contracts and exceeding its early targets. The highly experienced and committed management team are focussed and passionate about what they do. They are ambitious but also realistic in their plans. I believe XenoGesis is just the kind of venture Mobius Life Sciences is looking to invest in.

The firm has grown from strength to strength and in June last year (2012) it moved to a bigger office space at BCN. This was attributed to the firm's economic growth at the beginning of 2012. To demonstrate its entrepreneurial flair synonymous with born-global firms, the enterprise collaborates with other players in the biotechnology sector within its vicinity and on a global scale. In the recent past, its CEO was involved in conferences on biotechnology and science in London and Barcelona that took place in June of 2012. The conferences provided the firm with the opportunity to network with potential partners from 80 international experts in the field of drug metabolism presenting the firm with a chance to build its knowledge base. The widening of the firm's business and social connections (structural, relational and cognitive dimensions) has enabled it to grow at a fast pace and achieve scientific excellence and innovation. The CEO at Critical Pharmaceuticals uses conferences as a source of new technical know-how and fluid scientific knowledge.

Case 3 – Haemostatix Ltd

In 2003, a research group at the University of Leicester (UoL) became interested in developing a new class of active clotting agent, or 'haemostat' for the control of bleeding to mitigate the shortage of fresh donated platelets. Consequently, Sarah Middleton (CEO) and Professor Alison Goodall (CSO) formed Haemostatix in conjunction with the UoL. The University played a crucial supporting role in the company's early stages. For its relational dimension, in 2004 the company established a collaboration with the Scottish National Blood Transfusion Service to secure specialist production capabilities for its products. To enhance its capacity to further develop a new class of active clotting agent Haemostatix received start-up funding of £250,000 from The Lachesis University Challenge Fund and initial investment from NESTA. In 2008, the company received further funding in the region of £1.24 million from a network of investors (structural dimension) that included: Spark Ventures, Catapult and NESTA. The CEO of NESTA, Jonathan Kestenbaum explained that:

Haemostatix is a dynamic young company driving forward an innovative product that promises to change lives. We are excited to follow our original funding and look forward to working with them as the business continues to develop.

To further support the development of its innovative haemostat technology in 2011 the company received an investment of £250,000 from Esperante, an American company. This evidently shows that the firm's structural dimension consists of investor companies which not only supports, but appears to be vital to; it's continued product and process development. Locally, funding from Mobius and the Nottingham City Council (NCC) is aimed at assisting promising start-up firms located at BCN.

As such, Haemostatix uses BCN as its base presenting the firm with an opportunity to access support and help offered at the region's science 'incubator'. Kang & Park (2012) suggest that governments can encourage innovation and economic prosperity by supporting R&D projects that have the potential to generate social capital. When commenting about the financial support Haemostatix received from Mobius in 2010, Glenn Crocker CEO of Mobius explained that:

We have provided Haemostatix with a supportive business development environment for several years and recognise the enormous progress the company has made with its new product. Mobius Life Sciences Fund is designed to contribute to this kind of investment opportunity alongside major investors.

In addition to large investments that the company received in the last 8 years, it has a management board which consists of experienced members in commercialisation, science and financial investment. Its scientific advisory board is composed of high profile personnel from the UK and the EU. The company's efforts to design a cost effective alternative to platelet transfusion was anchored on the amalgamation of experienced, multi-skilled scientific, clinical and commercial leadership. Similarly, in the other four firms sampled for this study, their management structure consists of experienced personnel demonstrating that there is strong evidence pointing to the presence of knowledge diversity in all the firms that were investigated. In other words, all the firms are benefiting from the experience and knowledge its members have amassed from their previous roles in science-related businesses and global-oriented research groups over the years.

Case 4 – Sygnature Discovery Ltd

Sygnature Discovery Limited was formed in 2004 through an MBO of the Synthesis department of CombiPure Ltd. Its founder/CEO has experience in research gained from major pharmaceutical companies such as; AstraZeneca, OSI Pharmaceuticals and at CombiPure, where he was Managing Director and Director of Chemistry. The company offers integrated drug discovery solutions to pharmaceutical and biotechnology companies located in the USA and Europe. It operates in a global network of expert Contract Research Organisations (CROs) each specialising in their own area. The company grew from five chemists in 2004 to one that now employs 56 medical chemists, vitro biologists and the majority of them have PhDs with significant pharmaceutical industry drug discovery experience. This implicitly shows that the management team and all the employees share the same goals highlighting its cognitive dimension. Similar to the other four firms Sygnature benefited from the closure of AstraZeneca's Loughborough R&D site in 2011. The firm employed experienced former AstraZeneca medical chemists to deal with the demand of services from their clients in the USA and Europe. Scholars Dokko & Rosenkopf (2010) suggest that in addition to the knowledge and skills experienced individuals may have they also bring pre-existing relationships that facilitate the transfer of knowledge and technical know-how. Specifically, the science knowledge of its employees and the experiences of the management team made the firm trustworthy to investors and potential partners. The president of the firm explained that:

Our clients and business partners build trust basing it on our competence and reputation. Getting acknowledged by colleagues, clients at BioCity Nottingham and overseas because of the quality of the work that you do is very important in this business and that's all part of establishing credibility.

In 2006, the firm posted a turnover of £1 million and in the same year it received FP6 European project funding. Three years later the firm received a £390,000 Grant for Business Investment (GBI) awarded by the East Midlands Development Agency (EMDA) and the European Regional Development Fund (ERDF). The firm entered into a strategic alliance with Cyprotex in 2009 which was later extended in 2011 for a further 2 years. Cyprotex Discovery Ltd is the world's largest specialist ADME-Tox/PK pre-clinical discovery and it plays a major role in developing CROs. Similar to the other four firms sampled for this study, Sygnature Discovery's structural dimension consists of a network of companies with some cognitive distance but with complementary foci. Nooteboom (2006) suggests that when absorptive capacity is aligned with organisational goals and aims, it enhances organisational cognition. Indeed, interacting with other firms that may have different complementary foci at some cognitive distance solves what Nooteboom (2009) described as 'organisational myopia'. Put differently, the firm was able to bridge its knowledge and capabilities gaps. The main reason for the alliance was to expand its collaborative sales and marketing initiatives to provide a fully-integrated discovery chemistry/ADME-Tox/DMPK service as well as accelerate its clients' drug discovery projects into development. Anthony Baxter the CEO of Cyprotex commented that:

We are delighted to have extended our strategic alliance with Sygnature. The quality of their work and their desire to help customers achieve scientific success has enabled both of us to form a formidable combined offering in medicinal chemistry-driven integrated drug discovery and ADME-Tox services.

By using its structural and relational dimensions of social capital Sygnature was able to deliver innovative products and services to its clients/partners while saving significant amounts of resources in the form of time and financial capital. Crucially, the collaborating partners shared the risks associated with drug discovery. More recently, the firm entered into another strategic alliance with Pneumolabs (UK) Limited with a view to leverage its knowledge base by widening its structural dimension. The CEO at Pneumolabs made the following comment regarding the formation of a partnership between the two firms:

Our strategic alliance combines the complementary skills of Pneumolabs, a 'centre of excellence' for respiratory disease-focused pre-clinical research services, and Sygnature, a 'centre of excellence' for medicinal chemistry-driven integrated drug discovery

Sygnature Discovery's alliance with Pneumolabs enabled both firms to share their social capital. This form of inter-organisational collaboration was also evident in cases 1, 2, 3 and 5. Following the partnership, the company committed more resources by opening new purpose-designed research laboratories to show its commitment to new drug discoveries. By committing such amount of resources, there is concrete evidence disclosing that the firm had developed trust with its partner.

Case 5 – BAST Inc. Ltd

The founder of BAST first managed a similar business under an identical name in Houston, Texas, from 1991 to 1998 and the company stopped trading in 2000. Between 2007 and 2009 he worked for Merck Serono in Geneva. His tasks and responsibilities included: providing technical input to project-based work, coaching junior scientists, modelling and simulation. The founder's desire to work in a collaborative way enabling the free flow of scientific knowledge and technical know-how has always been abundantly clear. In 2010, he moved to the UK where he worked as a science consultant for a number of companies offering population-style data analysis. Following the closure of AstraZeneca's Loughborough R&D site he revived BAST Ltd Incl. where he has assumed the role of a science director.

The firm conducts *silico* research, either publicly or privately funded, in areas of oncology, autoimmunity (e.g. asthma) and drug delivery (Nano technology). BAST provides its drug discovery services to a global audience. For its structural dimension, the firm occupies science labs at BCN and Loughborough Science Park. This underscores the company's efforts to develop social capital through networking with other firms, scientists and research institutions. Similar to the other four cases, the firm's management team is composed of well-experienced scientists. The majority of them are former employees of large pharmaceutical companies such as AstraZeneca. This pattern of forming new ventures by small entrepreneurial firms was noted by Sharma & Blomstermo (2003). Sharma & Blomstermo observed that because born-globals are knowledge-intensive firms with an exceedingly high degree of knowledge content they employ individuals who possess high scientific knowledge.

The amalgamation of knowledgeable scientists was an important step for the firm towards developing innovative capabilities. The firm assembled scientists who are multi-skilled and vastly experienced in science which further underlines its cognitive dimension. To develop its social capital, the firm was committed to engaging with potential partners on a global scale e.g. its management intends to form a consortium which includes: NGOs, Universities and other SMEs with a view to submit a project proposal for funding from the EU Commission's FP6 programme. Wiedersheim-Paul *et al.* (1978) stress the importance of contact patterns explaining that they allow an efficient exchange of information as well as creating opportunities for knowledge transfer from partner firms. Furthermore, Burt (1992) and Gulati (1995) suggest that network research highlights the essential role inter-organisational ties perform in terms of facilitating knowledge acquisition and its utilisation. The Scientific Director at BAST Inc. said that:

We share knowledge with a number of actors in the biotechnology sector including knowledge centres in the East Midlands such as BioCity, science experts from Universities, other parts of UK and Europe. The idea is to share best practice as well as learn from other firms how they make innovations

The firm was aware that huge amounts of resources will be required to develop social capital and it committed to contribute model-based design and decision support to collaborative projects on innovative strategies for the prevention or treatment of poverty-related diseases. Its commitment to engage in international activities further demonstrates its desire to perform a key role in knowledge-sharing while taking advantage of the opportunities global markets offer. This strategic position can be directly attributed to the founder's experience with foreign markets given his time in Houston, Texas. Consistent with this observation, Madsen & Servais (1997, p.569) postulate that 'commitment decisions depend very much on experience, since they are a response to perceived uncertainty and opportunities in the market'. The main decisions about the strategic direction of BAST Ltd Incl. are predominantly done by its founder/science director. Europe and America are seen as destinations where the firm can engage with other actors in the biotechnology sector who complement its drug discovery services. Because its founder is multi-lingual, BAST Ltd Inc. was in a much stronger position to collaborate with other global-oriented firms or institutions.

Cross Case Findings

While more specific results can be found within each case, in this section the author is interested in extracting patterns and trends from field research to figure out various factors and mechanisms that are traceable in the knowledge supply-chain of small born-global biotech firms. Precisely, the primary goal is to develop a clear picture regarding the complex business-like relationships in the global networks of born-global biotech firms. The author sketches the structural, relational and cognitive dimensions as well as presents commonalities across all the firms (see table 2 below). The founders of all the firms are scientists who are exceedingly experienced in life science. Shane & Khurana (2001) observed that a founder's previous career experience is an important attribute that mitigates the problems associated with the liability of newness when establishing a new international venture. Ho & Wilson (2006) affirm that the experiences of the founders of biotechnology firms provide for existing social relationships which make it less complicated for them to obtain often scarce science-related resources. Evidence from cross-case analysis using structural, relational and cognitive dimensions (see table 2 below), reveal that all the founders had vast experience in the biotechnology sector which enabled them to acquire threshold capabilities essential for innovation and firm development in the biotechnology sector. Their influence played a significant part in crafting a global strategy that was pivotal in terms of acquiring knowledge and technical know-how for their firms. Cross-case analyses also show that funding institutions have become a strong part of the networks of born-global biotech firms.

Table 2 Structural, Relational & Cognitive dimensions of born-global bio-tech firms

	Critical Pharmaceuticals	**XenoGesis Ltd.**	**Haemostatix Ltd**	**BAST Inc.**	**Sygnature Discovery**
Structural Dimension	The acquisition of scientific knowledge is based on the firm's relationship with academic network and it's connections with other firms & research institutions	Similar to Critical Pharmaceuticals but the CEO interacts with his former work colleagues from AstraZeneca (global reach)	The firm's discovery activities are enhanced by venture capitalists (VC) and Technology Ventures such as Microbus	Similar to XenoGesis & CP the firm collaborates with other small to medium size enterprises (SME) and universities	Same as the other four firms and that the firm has strategic alliances with bioscience group
Relational Dimension	It is based on competence and goodwill trust and a long-term interaction with the firm's academic network & business network	Similar to CP and that trust is built in escalating series trying different using try and error method	Similar to XenoGesis and CP	Same with the other four firms and that obligations in a global network of 24 other firms	Based on competence & goodwill trust e.g. partnership with Cyprotex Discovery in 2007
Cognitive Dimension	The firm consists of experienced, multi-skilled scientific, clinical and commercial leadership team directed by a board of international standing with a broad base of expertise	Similar to CP and the top management consists of experienced scientists in bio-analysis	Similar to CP & BAST Incl.	Same as the other four firms	All the scientists have PhDs, post-doctoral experience gained from USA & Europe

The scientific competence and the benevolence of a firm was the basis on which partnerships were developed (see table 2, above). Evidently, the competence level in terms of the science base or depth of a firm was seen as a barometer to gauge the extent to which a firm can be trusted. Trust in competency refers to the perceptions of the *trustor* concerning the trustee's technical, cognitive and communicative competences (Şengün & Önder, 2011; and Nooteboom 2009).

Blomqvist (1997) and Ganesan (1994) express similar views claiming that competence trust is based on a high probability that agreed strategic objectives will be successfully accomplished. This they suggest increases the reliability and the predictability of global partners in a relationship. Good reputation along with firm-based competences were perceived to be crucial in terms of developing trust given the risks inherent in sharing important scientific combinations that are essential for drug development and testing.

Conclusion

The article has highlighted the fact that participating in global R&D networks including international research labs are necessary deeds that facilitate the process of capability development in the knowledge intensive bio-tech sector. Following the author's analysis of born-global biotech firms he found that they usually have limited resources and to mitigate their inadequacies they engage in collaborative activities with other firms within and beyond their vicinity. This led the research to conclude that global R&D networks have a huge impact on how they generate social capital. Precisely, knowledge diversity, trust and strategic alliances were the main variables, within their knowledge supply-chain, which had a significant bearing on how scientific knowledge and technical know-how was generated.

In the East Midlands region in the United Kingdom, science parks perform a strategic role in forging the global R&D networks of born-global bio-tech firms. The firms are given the opportunity to establish, grow and develop by establishing strategic alliances, and creating specialist forums for joint problem solving. They are also offered specialised support and given a chance to participate in science-related debates with a view to hone their new ideas and innovations. Debate forums in the East Midlands often feature international participants who have a wealth of experience in life science. The study also infers that the structural, relational and cognitive dimensions of born-global biotech firms are central in providing them with business partners that have complementary assets and it allows them to jointly develop new ideas and science knowledge. Entrepreneurial firms such as born-global firms are known for their financial resource deficiencies and as the study reveals within their structural dimension venture capitalists (VC) are increasingly performing a decisive role. They are providing the much-needed financial support which makes it possible for a proposed research project(s) to progress to the next level. The author recommends future studies that investigate the specific types of networks which are developed on a global scale.

Specifically, the number of actors that can participate in a network or cluster at a given time, the period it takes to establish a global R&D network and its life span? The author believes that such studies can potentially add to our understanding regarding the impact of global R&D networks of born-global firms in today's science markets that appear to have converged into a single global trading place.

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Prior-learning, cumulative science experiences and the absorptive capacity of bio-entrepreneurs: A case of the East Midlands Region, England

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Abstract

In the modern healthcare and medical sectors corporate bio-pharmaceutical firms continue to scale down their in-house research and development (R&D) activities in favour of outsourcing the services to bio-tech ventures. These small but, entrepreneurial research-oriented organisations have increased dramatically. They are predominantly owned by bio-entrepreneurs who are extensively experienced scientists. Innovation 'ecosystems' consisting of global business and social networks are a common feature of science-based industries. As such, entrepreneurial ventures operating in this transient business environment have to consistently source new knowledge from their innovation 'ecosystems' to complement their knowledge deficiencies. In that context, the paper sets out to investigate five bio-tech ventures in the East Midlands region in England. It particularly recites the role performed by prior-learning and the cumulative science experiences of bio-entrepreneurs in recognising, assimilating and productively applying science-related knowledge acquired from their innovation 'ecosystems' to argument firm-based competences.

Keywords: innovation ecosystems, bio-entrepreneurs, prior-learning, cumulative scientific experience, absorptive capacity

Introduction

Innovation 'ecosystems', in the science intensive healthcare and medical sectors, are the main source of economic effects that include knowledge and technical know-how (Ho & Wilson, 2006). Research labs, academic institutions, science parks, small and large organisations co-exist within the maze and they purposefully interact with each other. Collectively, they work towards supporting technology development and the free flow of information (Bramwell *et al.,* 2012). In such complex systems of multiple relationships, significant amounts of science-related data are generated. This has huge implications for bio-entrepreneurs in the sense, that they have to effectively utilise their history and experience (antecedent influences) in science in order to identify and acquire useful knowledge that can facilitate the development of their bio-tech ventures. Burns (2012) elaborates on the antecedent influences of entrepreneurs highlighting that they are shaped by their business and social connections, culture, previous employment, and educational attainment.

Noticeably, bio-tech ventures operate in a constantly changing business environment which has become global as a result of the liberal trade structures governing trade today (Kalantaridis & Vassilev, 2008). This requires constant resource re-configurations to sustain their economic development. In that sense, this study takes the view that, prior-learning and the cumulative science experiences of bio-entrepreneurs can be a catalyst that facilitates the economic development of their bio-tech ventures by assisting in the process of acquiring useful scientific knowledge from their innovation 'ecosystems'.

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Extant literature has paid much attention to the concept of inter-organisational learning largely focussing at the organisational level (see Dutta & Crossan 2005; Lumpkin & Lichtenstein 2005; Senge, 1990; Hibbert *et al.,* 2010). There is a dearth of studies that specifically examine the role of prior-learning and industry specific experiences of bio-entrepreneurs yet, a significant proportion of them imprint what Burns (2012) describes as 'entrepreneurial DNA' in their bio-tech ventures. In other words, they communicate their personality through the way they manage/run their bio-tech ventures and it merits a closer examination of their role to their economic development. Considering the operational structures within small entrepreneurial firms, there is sufficient evidence to signify that their bio-entrepreneurs are actively involved in formulating their business strategies (see Gurău, *et al.,* 2010; Burns, 2012; Bessant & Tidd 2011; Stokes & Wilson, 2006). From that perspective, there is logic in suggesting that their personality traits are replicated in their firms (Allen, 2012). In Storey (1994) seventeen multivariate studies were reviewed to examine the effects of antecedent influences on the development of entrepreneurial ventures. Storey's study inferred that there is a strong association between an entrepreneur's educational attainment (prior-learning) and the development of their venture. Kuratko (2013) contends that as entrepreneurs react to a diverse, multi-faceted, and imposing array of activities, events and developments they considerably influence the development of their ventures. Bessant & Tidd (2011) insist that the competences of owner-managers strongly influence the scope and the direction of their ventures. This opens up the debate regarding the wisdom to analyse entrepreneurs and their ventures as separate entities.

In light of Kuratko's, Bessant's and Tidd's views it makes it so difficult to examine entrepreneurs and their ventures as independent units. As such, in seeking to contribute to the entrepreneurial learning literature and the concept of absorptive capacity (AC), this paper recites the experiences of bio-entrepreneurs and their ability to 'soak-up' new science-related knowledge in their innovation 'ecosystems'. Particularly, it sets forth an empirical account of the role performed by their prior-learning and science-related experience in recognising, assimilating and productively applying new scientific knowledge in their bio-tech ventures. This answers the call of studies that focus their analysis of entrepreneurial learning at individual entrepreneurs (see Krueger 2007; Cope 2005; Corbett 2005). In Crossan *et al.* (1999) new insights and ideas are seen as a by-product of individual learning which, when proven successful are eventually embedded into the organisation. Scholarship on learning universally agrees that learning takes place at individual level (see Rothaermel and Hess, 2007; Lichtenthaler & Lichtenthaler 2009; Cohen and Levinthal, 1990) and from that point of view; it even makes more sense to commence the analysis of the concept of absorptive by reciting the ACs of individual entrepreneurs. Equally, a number of recent studies have directed their efforts towards the field of entrepreneurial learning primarily focussing on individual learning and AC (see for example, Fogg, 2012; Smith, 2011; Zhang & Hamilton, 2010; Gold & Thorpe, 2008).

Background Literature

Process and substantive learning characteristics show the distinction between the concept of learning in collaboration and learning through innovation 'ecosystems'. In technology-based industries, collaborative relationships make it possible for knowledge to be exchanged between individuals, firms, academic institutions, and other non-profit research organisations (Oliver, 2010). Indisputably, entrepreneurship is a concept embedded in cycles of continuous learning described as 'double-loop learning' in Burns (2012, p.477).

Kim (1993) conceptualises effective learning as a revolving wheel of learning. Based on Kim's account of effective learning, the science experience accumulated by bio-entrepreneurs from previous science-related assignments/projects within their innovation 'ecosystems' can be viewed through the lens of a revolving wheel of learning. Smilor (1997) maintains that, entrepreneurs learn by replicating the actions of other entrepreneurs.

Bio-entrepreneurial Learning & Experience

Effective entrepreneurs are exceptional learners (Smilor, 1997). Learning as concept is a very broad topic and it is by no means fully explored in this study. It is partially covered in this paper to inform the debate on entrepreneurial learning and AC. In Huczynski & Buchanan (2007, p.107) learning is described as the 'process of acquiring knowledge through experience which leads to an enduring change in behaviour'. From that perspective, the most effective strategies for recognising new scientific knowledge for bio-entrepreneurs are informed, to a large extent, by their prior-learning and experience in life science (Simba, 2013). Similarly, King & Lakhani (2011) agree that there is an association between individual learning and the stock of prior-related knowledge one holds. Continuing in the same vein, Huczynski & Buchanan (2007) discuss procedural and declarative learning. The scholars express that procedural learning or 'know how' is concerned with one's ability to carry out skilled actions. They also insist that declarative learning or 'know that' is one's ability to store factual knowledge. Concerning the unit of analysis for this research – bio-entrepreneurs/owner-managers, it is not a misplaced judgement to view their vast knowledge acquired from previous science-related events within the frame of declarative learning.

Furthermore, Kolb (1984, p.26) expounds the underlying principles of experimental learning stating that 'ideas are not fixed and immutable elements of thoughts but, are formed and re-formed through experience'. Scholarship on entrepreneurial learning collectively acknowledge that experimental learning is a process which attempts to explain how entrepreneurs acquire knowledge and enact new behaviours in recognising and acting on opportunities as well as organising and managing their ventures (see Petkova, 2008; Cobbett, 2007; Toiviainen, 2003; Cope, 2005). Deakins & Freel (1998) and Sarasvathy (2001) collectively claim that the majority of learning that occurs within an entrepreneurial context takes the form of an experiment. Schilling (2010) discusses experimentation that takes place in innovation 'ecosystems'. She maintains that the process of experimenting is an important step in the development process of science-based firms as it enables them to test what works and what doesn't. Similarly, Petkova (2008) presents a model of *entrepreneurial learning from performance errors* with a view to extend the psychology models of error-based learning. Petkova's (2008, p.4) model proposes that entrepreneurs,' 'prior knowledge and cognitive biases can perform a significant role at each stage of the learning process and may determine whether the processes of error-detection and error-correction that leads to learning will actually occur'. Schilling's and Petkova's propositions have huge implications for bio-tech ventures as they are directly intertwined in their mental modes of learning particularly, their bio-entrepreneurs. Using Kolb's (1984) view of learning by trying different configurations until one finds a combination that works, Cobbett (2005) makes a convincing argument. He argues that 'cognitive mechanisms' or the mental processes through which entrepreneurs acquire, store, transform, and use information are the output of individual learning.

Absorptive Capacity

A comprehensive understanding of the concept of AC at a firm level is essential to how this study explains the significance of learning by individual entrepreneurs in their innovation 'ecosystems'. According to Cohen & Levinthal (1990) AC is the ability of a firm to recognise, assimilate and apply external knowledge. In Zahra & George (2002) a clear distinction between potential and realised AC was made. Potential AC was related to knowledge acquisition and assimilation capabilities and realised AC was associated with knowledge transformation and exploitation. Lichtenthaler & Lichtenthaler (2009) conceptualises AC as the ability to explore external knowledge. King & Lakhani (2011, p.2) introduce the notion of 'adoption capacity' which means the ability of a firm to adopt ideas from external connections. This is consistent with Cope (2005, p.481) who maintains that individuals transform (using cognitive properties) their experiences (situative) into new knowledge.

Furthermore, Lichtenthaler & Lichtenthaler (2009) claim that new knowledge acquired from outside the firm (in innovation 'ecosystems') becomes useful when it is integrated with internal knowledge bases. A recent study by Jones *et al.* (2010) presents the idea of generative learning in global networks stressing that it is a critical step that informs the accumulation of specific and useful knowledge. Tidd & Bessant (2011) contend that AC is about accumulated learning and the embedding of capabilities. Crucially, in Cope & Down (2010, p.4) a strong link is constructed 'between the outcomes of learning (information, knowledge, expertise) that impact on the entrepreneur's cognitive frameworks and the participative process by which these socio-cognitive resources are acquired'. The dated but inspirational works by a number of scholars (see Estes, 1970; Ellis, 1965; Bower & Hilgard, 1981) highlight that an individual's learning is cumulative and that learning performance is enhanced when the primary goal of learning (to understand the new knowledge to be acquired) is related to what the individual already know. Cohen & Levinthal (1990) also make a crucial point suggesting that AC is a by-product of prior-innovation and problem solving which is dependent on individual ACs of members of an organisation.

When individual ACs of members in a firm and the firm's ability to value, assimilate and commercially utilise new external knowledge are combined Lane *et al.* (2006) and Kim (1993) collectively agree that the duality modifies mental modes. In other words, the dualism modifies assumptions about the lived world. This is a fundamental point to make in the sense that, for global-oriented bio-tech ventures their bio-entrepreneur's/owner-manager's prior-learning and science-related experience can modify their cognitive biases which plays a decisive role in their economic development given that they source scientific knowledge in multiple countries. Indeed, sourcing knowledge from established or newly developed business or social networks (innovation 'ecosystems') domestically and in other countries consequently lead to a point of 'knowledge saturation' hence sifting, sorting and decoding useful information requires prior-learning and industry-specific experience.

Research Approach

The study adopts a case-oriented research approach (COR). Ragin (1992) claims that researchers who employ a COR approach do so partly, because their studies are exclusively qualitative and that the methods are more suitable with small research samples. In light of this, this study utilises five cases of bio-tech ventures located in the East Midlands region in England primarily focussing on their bio-entrepreneurs. The logic for using multiple cases was to establish whether the findings from one case can be replicated across the entire research sample.

This enabled the study to make plausible concluding statements concerning the role performed by prior-learning and the cumulative science experiences of bio-entrepreneurs in acquiring useful scientific knowledge in innovation 'ecosystems' to develop their bio-tech ventures. Taking a cue from Saunders *et al.* (2012) view on choosing a research sample; cases of bio-entrepreneurs were systematically selected on the basis that similar results were predicted to be produced from each case. In Yin (2009); Huberman & Miles (1994) the procedure for selecting cases is termed *literal replication*. Cases for this study were designed to corroborate each other and to achieve this, a systematic sampling technique was deemed appropriate.

A trade-off was made between systematic sampling and stratified random, cluster, and multi-stage sampling techniques. Stratified random, cluster and multi-stage sampling techniques turn to follow a sophisticated research design which generates a number of data sub-sets; making it so complex to explain a research phenomenon (Saunders *et al.,* 2012). As such, the study preferred to use a systematic sampling technique for selecting a representative sample because of its features that include: (i) accuracy and easy to access the research sample; (ii) low costs; (iii) its suitability to the scope and size of the study; (iv) its ability to allow the study to choose bio-entrepreneurs from the same geographical concentration making it feasible to conduct face-to-face interviews; (v) its ability to facilitate the explanation of the role performed by prior-learning and the cumulative science experiences of bio-entrepreneurs in recognising, assimilating and productively applying science-related knowledge to argument firm-based competences. The criteria for selecting the research sample are presented under the data collection and analysis section.

To ensure *construct validity, internal validity, external validity and reliability* of the findings the study adopted ideas from Yin's (2003/2009); Farquhar's (2012); Stake's (2005) and Voss *et al.* (2002). During the data collection phase interviews and documentary evidence were used for *construct validity*. At the data analysis stage casual links (Huberman & Miles, 1994), between prior-learning, the cumulative experiences and the ACs of bio-entrepreneurs, were established as well as the identification of patterns across the bio-entrepreneurs with a view to enhance the *internal validity* of the findings within each case. The basis for designing the study with multiple bio-entrepreneurs was to achieve *external validity* using the *replication logic.* Pattern matching in case-oriented studies is the most appropriate technique for case analysis (Farquhar, 2012; Yin, 2009). Data collected from the participants was transcribed and sent back for them to confirm whether it is an accurate representation of their account of events. The desired effect was to increase the *reliability* of the data collected for analysis. Yin (1998) insists that researchers who follow these strategies tremendously increase the quality of their case-oriented studies and they help to overcome traditional criticisms of the weakness of case study research.

Data Collection and Analysis

The unit of analysis for this study are bio-entrepreneurs/founders of small bio-tech ventures. They were chosen based on their academic attainment, competence in science, life science experiences and their ability to 'soak-up' useful knowledge for their bio-tech ventures. The bio-entrepreneurs were also expected to be part of an innovation 'ecosystem'. Semi-structured interview questions were employed as a guide during discussions. The open-ended questions allowed the bio-entrepreneurs to tell a story about their experience in life science and achievements. The qualitative discussions with the bio-entrepreneurs lasted on average 20 minutes.

In addition to the interviews with them their publicly available career profiles were utilised to gather existing information about their accolades and educational attainment. Company and University websites were also used as another source of this type of data. The process of analysing data commenced during its collection phase. The empirical study constructs detailed profiles for each case. The logic for compiling detailed profiles for each case was to gain intimate knowledge of each of the individual cases as well as to understand each case on its terms (Huberman & Miles, 1994). Taking Bazeley's (2013) advice that studies which solidly relies on coding techniques such as NVivo run the danger of being superficial as such, this study prefers to maintain the perspective of the cases by profiling each case.

Additionally, Yin (2009) maintains that case descriptions and profiles summaries serve a much wider range of analytical purpose. Consistent with Yin, this study focusses on a representative sample from a large population of bio-entrepreneurs in the East Midlands in England. Bazeley (2013) insists that, in small-sample studies or for studies with a methodical or substantive focus on particular cases the preparation of a profile for each case is the most useful early step for both within-case and cross-case analysis. An important point relating to the strategy for data analysis adopted for this study is made by Stake (2005), he stresses that a case study can be both an analysis process and a product of analysis. In that sense, data analysis for this study is done inductively by using a case-by-case and across case analysis. The study also draws upon theories that exist in the literature in its analysis – pointing to elements of a deductive approach. Aronson (1994, p.3) supports this way of analysing data by suggesting that, 'when the literature is interwoven with the findings, the story that the interviewer constructs is one that stands with merit'. Perry (1998) makes a convincing argument for adopting the duality insisting that, a study which is purely inductive potentially prevents a researcher from enjoying the use of existing theory while one which purely deductive restricts a researcher from developing new and useful theory.

Case Findings

This part of the study presents the research findings. It establishes the critical role performed by prior-learning and the accumulate science experiences of bio-entrepreneurs/owner-managers to their venture development. In presenting the findings within each case, the study also draws upon secondary data which enables it to make strong inferences (Gerring, 2005, Huberman & Miles, 1994).

Case A

Bio-tech venture A's bio-entrepreneur holds a PhD. He is a former global leader of Pharmacometrics at a large pharmaceutical company which was based in the East Midlands region in England and he has also worked in both Switzerland and Italy. In 2010 he formed a new bio-tech venture in England. Before establishing the new venture he started and managed a similar business model in America from 1991 to 1998. The knowledge and experience he gained from his American venture were instrumental to his comprehension of the sequence of processes and procedures that were fundamental in crafting a sustainable business venture in the life science sector in England. The bio-entrepreneur revealed that his company is part of a consortium of 24 other firms and research institutions in multiple countries. He also disclosed that at his previous employment he was involved in global science-related programmes.

The bio-entrepreneur acknowledged the role of declarative learning or 'know that' in choosing a learning partner, described by Huczynski & Buchanan (2007) as one's ability to store factual knowledge and this is what he said:

Choosing a business partner is like choosing your partner for life. I learned early in the US, that you want to keep your business and social connections throughout the life cycle of your business.

This statement concerning the bio-entrepreneur's take on choosing a learning partner implies that the knowledge and experience he acquired from his previous business in the US was very useful in helping his venture to identify/locate a business partner with a 'strategic fit' – meaning the extent to which a potential business partner is prepared to achieve the proposed operational objectives. In the literature, Corbett (2005) forcefully argue that the 'cognitive mechanisms' or the mental processes through which entrepreneurs acquire, store, transform, and use information are the output of individual learning. The bio-entrepreneur was further probed about the degree of influence his learning, expertise and experience in science gained over the years has on his decision-making in the business. He categorically stressed that:

I think I use experience; it is really about developing a way of doing things and some of it is intuition - i.e. seeing things that are not connected and link them together to spark new product development. Some of this is also down to skills and knowledge. You could also say that a person who is successful uses intuition based on their learning and experience.

The evidence is convincing and it points to the fact that the bio-entrepreneur's knowledge, skills and intuition are a by-product of his science experience, personality and learning. More importantly, using his experience from his previous associations established during his time with a large pharmaceutical company the bio-entrepreneur was able to develop technical capabilities in the form of statistical software (SAS, S+, R, and Matlab) and design modelling software (NONMEM, WinBugs, Monolix, WinNonlin, Berkeley Madonna). His mathematical science combinations enabled him to add value to business processes within his venture which significantly assisted new drug discoveries. Crucially, using his knowledge in science, he designed formulas for drug development and testing. This facilitated the development and growth of his venture as well as recognition of his capabilities by other bio-enterprises involved in developing clinical equipment and drug discoveries. The bio-entrepreneur accepts that his experience in life science acquired from his role as a global leader of Pharmacometrics in his previous employment was instrumental to how he designed the mathematical science tools for use in his bio-tech venture to test new drug discoveries.

Case B

The founder/bio-entrepreneur of bio-tech venture B, similar to venture A's the bio-entrepreneur holds a PhD in medicinal chemistry and is educated to a post-doctorate level. In addition to his academic credentials, he has 14 years of experience in life science gained from his previous role at the world's fifth largest pharmaceutical company. His publicly available profile describes him as an expert in drug discovery who has led various drug development projects for his former employers. He concedes that, some experiments/projects that he was involved in were not successful and he suggests that it was part of the learning processes. This is consistent with Schilling's (2010) and Petkova's (2008) views regarding learning through experimenting and entrepreneurial performance errors.
Indeed, recalling a procedure that worked or did not work in the past is essential in drug discovery and development.

Clearly, learning from past performances was an important part of the process of developing his entrepreneurial capabilities to discover and exploit opportunities. According to his profile the founder has a record of delivering drug discovery processes for the world's fifth largest pharmaceutical company. From that perspective, it is plausible to suggest that his science experiences were decisive to the economic development of his bio-tech venture. To this end the bio-entrepreneur expressed that:

One has to understand the relevance of externally acquired knowledge to science and experience in previous science-related assignments play an important part of that. Given the experience our team of experts have in biotechnology we are in a better position to acquire the science that is necessary for our service.

The explanation of the role of prior-learning above also hints that in his company the science experiences of his top management team abetted the process of 'soaking-up' useful scientific knowledge. In the literature Cohen & Levinthal (1990) affirms that AC is a by-product of prior-innovation and problem solving which is dependent upon individual ACs of members of an organisation. In that sense, it is adequate to infer that one's previous history and experience in life science can add value to their bio-tech venture by assisting in assimilating useful information that can be fundamental to a firm's sustainable growth and development. Gurău *et al.* (2010) echo similar sentiments in their study concerning the role of human capital in successful entrepreneurial ventures. In their study the scholars concluded that the human capital available within an organisation can help the organisation to obtain positive business results. In the same vein, Murray (2004) found that in a firm where the founder was both the CEO and CSO, he rolled out the critical path to be followed as a blueprint in the process of acquiring essential technical capabilities to assist his venture to make new drug discoveries. This has a striking resemblance with the bio-entrepreneur in bio-tech venture A who directs science projects using his experience acquired from leading international science-related R&D projects.

Case C

The bio-entrepreneur of bio-tech venture C is a co-founder of the business. The bio-tech venture was formed in 2002. His record shows that he is an academia and a world-renowned scientist in the field of super-critical fluid processing with 15 years of experience in the life science sector. According to a University website profile for staff, it was publicised that the bio-entrepreneur is a professor and he is also a Chair of Chemistry at the University. He is also said to have published over 300 papers in high-level scientific journals. His record further documents that in the past decade, his research focused on the pharmaceutical formulation of drugs using super-critical fluids with ten patents filed. The record also discloses that he received a number of awards between 2001 and 2006 from the science community as recognition for his science ingenuity. Based on his antecedent influences, he was able to realise that super-critical carbon dioxide (scC02) could be used to mix sensitive substances into the polymers. This was the groundwork that his business needed to take-off. The bio-tech venture also grew by forging strategic alliances with other businesses which had complementary assets and those that had advanced technical know-how with a view to augment its internal capabilities. The bio-entrepreneur explains that the learning partners for his bio-tech venture were developed based on his past associations with them and the knowledge that the relationships will generate the required capabilities.

His philosophy of selecting learning partners is reinforced in the extant literature (see Petkova, 2008; Lane *et al.* 2006; Estes, 1970; Bower & Hilgard, 1981) which universally acknowledges that an individual's learning is cumulative and that learning performance is enhanced when the primary goal of learning is related to what the individual already knows. When commenting on the success of the bio-entrepreneur's firm a venture capitalist (VC) who provides growth funding to entrepreneurial ventures explained that:

By combining world-class research with knowledge of the real needs of the pharmaceutical sector, the firm has made rapid progress.

In that respect, the study can infer that knowing what is required to complement firm-based competences is an important developmental step for bio-tech ventures which operate in the life science sector and it earns support in the form of financial capital from private investors. More importantly, it facilitates the process of acquiring new knowledge especially, for bio-tech ventures whose bio-entrepreneurs source for new scientific knowledge from multiple countries.

Case D

The founder and CEO of bio-tech venture D is a medical chemist with 23 years' experience in the pharmaceutical industry. His record shows that he holds a PhD in synthetic organic chemistry and he took a post-doctoral research position at a University before starting his own venture in 2004. He has experience in science-related research projects which was acquired during his time at the world's fifth largest pharmaceutical company as well as in a commercial environment. In the past the bio-entrepreneur explains that he was involved in a wide range of drug discovery programmes. He states that the programmes ranged from lead generation libraries, hit-to-lead campaigns, all the way to successful lead optimisation projects and candidate drug selection. This highlights the idea of generative learning which is achieved through engaging in research projects that include a wide range of participants from multiple countries. Such innovation 'ecosystems' allow new product ideas to be generated, debated and honed. According to his bio-tech venture's website, in 2011, the bio-entrepreneur won the Science and Technology Entrepreneur of the Year Award as recognition for his significant personal contribution to the success of the company he established and runs. This endorses the view that bio-entrepreneurs emboss their 'DNA' in their ventures and they perform a major role in making their strategic choices using their cognitive biases. Over a period of 8 years, the bio-entrepreneur expressed that he has added to the growth of his bio-tech venture by developing science testing tools to enhance drug discovery and testing for their clients.

To underscore the importance of entrepreneurial learning at an individual level, the bio-entrepreneur explained that he is also involved in a European funded collaborative research programme which is aimed at speeding up the discovery of new drugs. He states that participants of the programme range from scientists working for large pharmaceutical companies to bio-entrepreneurs who manage bio-enterprises as well as academic researchers. As his company focuses on the delivery of integrated drug discovery taking part, in a drug discovery programme which involves international participants, can considerably enhance his cognitive biases which underpin his ability to acquire useful scientific knowledge which is essential for drug discovery and testing in his venture. Innovation 'ecosystems' in science-based industries are designed to aid the discovery of new products and are characterised by an array of experiments (Bramwell *et al.,* 2012).

In the literature (Cobbett, 2007; Petkova, 2008; Schilling, 2010; Cope & Down, 2010) the process of experimenting is viewed as an essential developmental step for entrepreneurial ventures in the sense that it allows entrepreneurs to test what works and what doesn't. Commenting on the opportunity to acquire new drug development processes that are necessary for his bio-tech venture the bio-entrepreneur explained that:

The really exciting aspect of this project is the opportunity to discover novel drugs through the collaboration of seven international pharmaceutical companies and an open call to academics and industry across Europe.

Learning through innovation 'ecosystems', described as a participative learning process by Cope & Down (2010) makes it possible for individuals to exchange scientific knowledge and technical know-how and it helps to bridge any knowledge shortages that might exist in a firm. This seems to be fairly consistent with Gordon & Jack's (2010) findings. In their study regarding higher education institutions' engagement with SMEs to develop social capital the scholars conclude that, a learning environment (innovation ecosystem) provide SMEs and their owners the opportunity to create social capital which has a positive impact on firm development.

Case E

According to her personal profile the bio-entrepreneur/founder of bio-tech venture E started her academic life as a bio-chemist. After finishing an undergraduate degree in biology, her *curriculum vitae* discloses that she went on to complete a PhD in bio-chemistry and then started to work with a group of immunologists at a Royal Free Hospital (RFH). She acknowledges that the experience gained from working with other immunologists at the RFH was fundamental to her decision to set up a *hybridoma* laboratory which was funded by a Technology Group. The bio-entrepreneur also explains that she was involved in a leading edge research developing *monoclonals* with potential commercial applications. Strikingly, her involvement with immunologists and research to develop *monoclonals* significantly influenced her decision to jointly establish a bio-tech venture.

Another point to make is that, her innovation 'ecosystems' were central to the development of the bio-tech venture because they formed part of her knowledge supply-chain. More importantly, her science background enabled her to contribute to the development of a new technology targeted at overcoming a number of deficiencies with platelet transfusion making the therapy more widely and easily available. Her passion to continue making new discoveries can be seen in the way she contributed to the development of the platelet transfusion technology which was pivotal to the economic prosperity of their venture. This is in line with Burns (2012) who takes the view that entrepreneurs engrave their 'entrepreneurial DNA' in their ventures. In that respect, the bio-entrepreneur explains that, 'for both of them the motivation is to develop the product and to see it work'. This may also imply that in making new technological developments for their bio-tech venture the bio-entrepreneur and her co-founder ensure that the new technology works by directing all their efforts in the form prior-learning and cumulative science experiences towards its success. According to a University website where she is employed as a Professor the bio-entrepreneur is currently not involved in teaching at the institution but, she is engaged in research. This emphasises her desire to continue learning which is vital to the process of 'soaking-up' useful scientific knowledge and for updating her cognitive biases.

The bio-entrepreneur explains that the process of setting up their bio-tech venture involved her increasing her knowledge of business – finding out 'the rules of the game'. Her statement is well-represented in the literature. Simba (2013) posits that bio-entrepreneurs engage in a 'trial and error' method until they find the right knowledge combinations that complement their internal knowledge bases. Schilling (2010) stresses that experimenting is an important step in the development process of science-based firms as it enables a firm to test what works and what doesn't.

Cross Case Findings

This part provides a cross-case synthesis (Yin, 2009) with a view to build a common narrative (Bazeley, 2013; Huberman & Miles, 1994) about the prior-learning and the cumulative experience of the founders of the bio-tech ventures. More importantly, the idea is to identify whether there are any relationships in their antecedent influences that assist them to 'soak-up' useful scientific knowledge necessary for development of their bio-tech ventures. Table 1 below illustrates the similarities and differences across the cases.

Table 1: A cross-case analysis of bio-entrepreneurs

	Bio-entrepreneur in case A	**Bio-entrepreneur in case B**	**Bio-entrepreneur in case C**	**Bio-entrepreneur in case D**	**Bio-entrepreneur in case E**
Structural Dimension	Strong global academic network and industrial-related business and social connections. Participated in science-related projects.	Same as bio-entrepreneur in case A	Same as bio-entrepreneur in case A but with a strong academia and he is a well-known science professor	Same as bio-entrepreneur in case A. He also participates in international drug discovery programmes	Same as bio-entrepreneur in case A. The venture also relies on VCs for funding to develop it technology
Relational Dimension	Trust is based on shared representations and interpretations of science	Same as bio-entrepreneur in case A	Same as bio-entrepreneur in case A	Same as bio-entrepreneur in case A	Trust is based on shared representations and interpretations of science
Cognitive Dimension	The top management team consists of experienced scientists in drug discovery projects with the bio-entrepreneur spearheading the operational strategies of the venture	Same as bio-entrepreneur in case A	Same as bio-entrepreneur in case A, but with a skew towards academia. Also his venture sponsors PhD research students	Same as bio-entrepreneur in case A	She is a co-founder of the venture. Their team consist of scientists and members with commercial experience
Prior-Learning	Started a similar company in America between 1991&1998. He holds a PhD qualification in Chemistry	Held various roles – leading science-related R&D projects globally. Hold a PhD	He has published over 300 science papers demonstrating that he is a researcher. Also he is a renowned world scientist	Same bio-entrepreneur in case B	Laboratory and hospital research related experience. She also holds a PhD
Cumulative Science Experience	He has over 20 years of science experience	Has 14 years science-related experience	Has 15 years of experience in science	He has 23 years' experience in the pharmaceutical industry	She has 16 years' experience in biochemistry, molecular biology and medicine

The role of prior-learning & the cumulative science experience on the ability recognise, assimilate and apply new knowledge productively in the venture

Developed firm-based competences	Recalling his experience and prior-learning in innovation 'ecosystems' The bio-entrepreneur designed Mathematical science tools for mechanistic modelling (R-sim & U-per). Used to test and predict performance of a diagnostic test	Similar to bio-entrepreneur in cases A & D he was instrumental in developing drug discovery and testing tools for this venture	The bio-entrepreneur realised, through his learning and science experience, that super-critical carbon dioxide (scC02) could be used to mix sensitive substances into the polymers	Using his cognitive biases the bio-entrepreneur was instrumental in developing new drug discovery and testing tools.	Recalling their cumulative science experience with a co-founder the bio-entrepreneurs developed a new technology that controls bleeding by binding to the blood protein, fibrinogen. The new type of treatment is seen as safer and easier to use

Synthesising data from the primary and secondary sources the study is able to construct a clearer picture regarding the role performed by prior-learning and the cumulative science experience of bio-entrepreneurs. In addition to the two factors (prior-learning and cumulative science experience) the process of combining information to determine their importance also considers the structural, relational and the cognitive dimensions which are related to how bio-entrepreneurs accumulated social capital through innovation 'ecosystems' which was indispensable for their bio-tech ventures.

In order to measure the impact of the antecedence influences of bio-entrepreneurs in recognising useful information for the venture the last variable on Table1 above explains the specific outcomes of individual learning. Strikingly, out of five bio-entrepreneurs one of them, i.e. (20%) of the research sample, was a female who jointly runs the venture with another female co-founder. This demonstrates evidence of women who are also involved in scientific entrepreneurship. It is also intriguing to note that all the bio-entrepreneurs in the sample have a strong academic background in chemistry and pharmaceuticals and they have previously worked, at the very least, for a large pharmaceutical company before starting their own ventures. They also have more than 14 years' experience in life science. Murray (2004) maintains that the inventor's (the equivalence of a bio-entrepreneur) role in their ventures is determined by a wide range of factors including: personal preferences, career stage, and professional norms.

Similarly, Burns (2012) comments that entrepreneurs influence the strategic direction of their ventures and they aim to engrave their 'DNA' in the venture. Science-related projects in innovation 'ecosystems' are characterised by experimentation with a view to make new discoveries and as such, all the bio-entrepreneurs, at some point, before establishing their bio-tech ventures participated in science-related projects which enriched their cognition of science. More importantly, they were able to experiment with different configurations until they discovered an effective one. Consequently, they were able to update their cognitive biases. This learning process was observed to be critical for their bio-tech ventures especially in informing the process of designing essential mathematical science combinations and chemical compounds necessary for new drug discoveries and for testing them. This observation is consistent with Gurau *et al.* (2010). The scholars insist that the strategic roadmap of new bio-tech firms requires competent directors for better performance and development.

A closer look across the profiles of all the bio-entrepreneurs further reveals that they are well-educated scientists with expertise in the bio-pharmaceutical technology and product development. It is also fascinating to note that 75% of the bio-entrepreneurs run their bio-tech ventures along with their academic commitments. Perhaps this explains their drive to continuously engage in drug discovery activities of learning with a view to constantly updating their cognitive biases and to sustain the development of their bio-tech venture. In that sense, it is safe for the study to suggest that the main fulcrum of a bio-tech venture is its bio-entrepreneur. Therefore, when analysing the AC of such small owner-managed ventures it is sensible to commence such an analysis at the individual level particularly, on the bio-entrepreneurs because of their degree of influence in their direction and scope. Similarly, Gurau *et al.* (2010) observe that, mainstream bio-pharmaceutical enterprises are developed by successful scientists who aim to transform their innovations in commercial applications. Furthermore, Sony & Iman (2005) observed that there is a strong correlation between entrepreneurial competences consisting of industry specific skills, opportunity spotting skills and technical skills and the growth of a venture. Indeed, this was evidently clear from all the bio-entrepreneurs who were under the spotlight for the purpose of this study. In ensuring that the human capital within their bio-tech ventures contribute to internal knowledge bases all the bio-entrepreneurs linked-up with experienced scientists who became part of their top management team. Equally, their structural dimension which consisted of their business and social connections established from their previous employment and their research groups were critical to their continued learning because they formed part of their innovation 'ecosystems' which facilitated the flow of scientific knowledge.

Conclusion

The research examined bio-entrepreneurs with a view to develop explanations about how their prior-learning and the cumulative science experience influence their ability to 'soak-up' useful scientific knowledge for their ventures. In that context, the profiling of each bio-entrepreneur and pattern matching cross the entire research sample enabled the study to conclude that prior-learning and the cumulative science experience of the bio-entrepreneur leads to enhanced AC. Indeed, as a consequence of their individual learning, bio-entrepreneurs were able to acquire, store, transform and use information from their innovation 'ecosystems' productively in their bio-tech ventures. Equally, by utilising their skills in science and competences developed from previous science-related projects/assignments the bio-entrepreneurs were able to update their cognitive biases which greatly assisted them in recognising and assimilating the right combination of resources necessary for designing or crafting new science technology for the economic development of their ventures. Furthermore, their antecedent influences shaped their decision-making process within their ventures including the process of selecting a learning partner and for formulating their operational strategies. The study discloses that bio-entrepreneurs who participated in the study are intimately attached to their bio-tech ventures and they have a strong desire to commercialise their discoveries. As such, it is plausible to infer that the study adopted a sensible approach in its endeavour to contribute to the concept of AC by placing the spotlight on the bio-entrepreneurs because of their huge influence on the direction and the scope of their bio-tech ventures. In that sense, in seeking to contribute to the literature on entrepreneurial learning and the concepts of AC there is logic in examining entrepreneurs and their ventures as inter-connected units.

A look into the career of the bio-entrepreneurs of the bio-tech ventures samples for this study demonstrates that all of them are well-educated in science. In addition to that, the study also discloses that the structural dimension of the bio-tech ventures consists of learning networks (innovation 'ecosystems') populated with scientists from multiple countries. In that web of connections the study infers that the most effective strategies for recognising useful scientific knowledge for bio-entrepreneurs are informed, to a large extent, by their ability to store factual knowledge about life science. More importantly, their ability to relate to new scientific knowledge which can be productively applied to their business processes with a view to complement/augment existing knowledge bases was meaningfully enhanced. Furthermore, the study discloses that in addition to rolling out the roadmap of their bio-tech ventures their cognitive dimension i.e. the top management team consisted of experienced scientists who also added value to their internal knowledge base thereby enhancing their AC. This underscores the essence of individual absorptive capacities to firm development.

As much as the study considers the chosen research approach for research to be appropriate however, there are inherent limits such as the generalisation of the research findings. In defence of the case-oriented research strategy adopted for this study the primary aim was not to generalise the findings to a large population but, to achieve what Yin (2009); Huberman & Miles (1994) describes as *analytical generalisation.* In terms of recommendations for future studies the research suggests a longitudinal variable-oriented research (VOR) study which utilises SPSS computer software to measure the impact factor of prior-learning and the industry specific experience over a predetermined period on the abilities of a bio-entrepreneur to 'soak-up' useful knowledge for their bio-tech ventures.

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The Impact of Knowledge Networks on the Innovative Capabilities of Bio-tech firms in the East Midlands Region, UK

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Key words: bio-tech firms, innovative capabilities, economic growth, cognitive distance, diverse knowledge networks

Abstract

***Objectives*:** The research aims to investigate the impact of knowledge networks on the innovative capabilities of bio-tech firms in the East Midlands region.

***Prior Work*:** In knowledge intensive sectors where the business environment is always changing there is a growing trend whereby firms are adopting a new open science paradigm of cooperation and collaboration (Garayannis and Wang, 2008). The interaction between firms or organisations with varied skills, experience and knowledge provides synergy for firms with limited resources by giving them access to a wide range of economic effects (Ho and Wilson, 2006) including: access to specialised input and labour, novel information inflows and knowledge as well as access to research institutions and government R&D support services (Martin *et al.,* 2011). Therefore, understanding the impact of knowledge networks and clusters becomes essential to the success of local innovative and multinational bio-tech firms. On that account, effective knowledge sharing is the most important target to seek for innovative bio-tech firms (Powell and Grodal, 2005).

***Approach*:** Primary data was collected through semi-structured interviews in the East Midlands region of the United Kingdom. Six interviews were conducted with bio-tech firms and knowledge network centres. The research sample composed of three influential knowledge network centres and three bio-tech firms involved in collaborative activities. Additionally, secondary literature sources were used to develop an understanding of and insight into previous research on dynamic capabilities and networking (Saunders *et al.,* 2003).

***Results*:** The paper argues that the innovative capabilities of bio-tech firms in a changing business environment are affected by the interaction of heterogeneous actors with different knowledge, competences and specialisation, with relationships ranging from formal to informal and from competitive to cooperative. In the East Midlands region, knowledge centres have played an important role in forging the knowledge network of bio-tech start-ups. Small bio-tech firms are given the opportunity to establish, grow and develop which is achieved by creating specialist forums for problem solving, specific help and debate. BioCity the region's most successful incubator use incubation as a means for bio-enterprise and capability development. The technology incubator fosters the growth of new technology based ventures by helping them to close the gaps in the innovation process and correct market failures. In sum the knowledge network centres in the region are acting as new bio-tech firms' "nurseries", "accelerators of innovation" and "greenhouses".

***Implications*:** The findings have practical implications for bio-tech firms, regional knowledge network centres and policy makers. Crucially, the findings enable these key stakeholders to evaluate whether their current networking strategies or support schemes are enhancing R&D activities and product innovations.

***Value*:** The importance of regional knowledge networks as bases for innovative capabilities for bio-tech firms is emphasised. Additionally, it highlights that for regional economic strategies, projects and frameworks for innovation to be effective policy makers have to rebuild knowledge bases and integrate them with government R&D centres.

Introduction

The advent of small bio-tech firms in the bio-tech sector significantly contributes to a wide range of economic effects including regional development, job creation, knowledge transfer and technological transfers (Ho and Wilson, 2006). Bio-tech firms have high expectations of growth and development due to economic return from everyday applications as well as the exponential industry growth which is evidenced by the number of biotechnology companies, an increase in the number of approved products as a result of biotechnology processes, market capitalisation and revenues (Kermani and Bonacossa, 2003). The bio-tech industry is one that is knowledge based and it is dominated by small firms that usually have connections with innovation centres (Ho and Wilson, 2006). Nowadays knowledge creation processes are composite, meaning that they combine many interacting pieces of knowledge coming from different sectors.

The knowledge intensive bio-tech industry heavily relies on continuous innovation. The ability to be innovative can only occur if an organisation is able to generate and integrate knowledge from both inside the organisation or through the formation of strategic alliances with other firms (Owen-Smith and Powell, 2004; Powell, 2009; Zheng, *et al.,* 2010; Zeller, 2011). There is a growing trend in the biotechnology sector where bio-tech firms work in collaborative projects sharing scientific knowledge and ideas in order to develop novel products (Vrande *et al.,* 2008; Chesbrough, 2006). There are two "predominant approaches to innovation research" (Su *et al.,* 2008, p.310). One approach suggests that the firm's internal capabilities are the main drivers of innovation while the resource based approach emphasises that a firm's innovative capacity is boasted through working in strategic alliances.

The paper mainly explores how the dynamic knowledge networks have impact on the innovative capabilities of bio-entrepreneurs in the East Midlands region of the United Kingdom. In particular, it examines how bio-entrepreneurs leverage their core competences with knowledge acquired from their knowledge networks for innovation and business development. We argue that the innovative capabilities of bio-tech firms in a changing business environment are affected by the interaction of heterogeneous actors with different knowledge, competences and specialisation, with relationships ranging from formal to informal and from competitive to cooperative (Malerba, 2005).

The paper is structured into six distinctive sections as follows. The second section critically reviews the concept of capability development and its multifaceted dimensions stressing the impact of knowledge networks on the innovative capabilities of bio-tech firms. Following a thorough literature review the section also outlines the theory construction process and proposes a conceptual framework. The third section outlines a detailed methodology of the empirical study. The fourth section provides an account of how bio-tech firms view the idea of collaboration. The fifth section builds on empirical evidence and it discusses in detail the special characteristics of collaborative activities in the East Midlands bio-tech sector. Additionally, comparisons are made with world class clusters such as Silicon Valley, Cambridge and Boston bio-tech clusters. This section also makes suggestions about how the key stakeholders in a network such as the bio-tech firms, the government and the EU can facilitate regional economic development as well assess whether their strategies are achieving the intended corporate goals. The last section concludes that collaborative activities are necessary for bio-tech firms to build innovative capabilities in order to respond to changing market conditions. For future research the section recommends an empirical study of the business incubation process of small bio-tech firms in their early development stages.

Literature Review

Autio *et al.* (2010, p. 18) define capabilities as "a combination or sequence of processes and its enabling resource commitments that have the potential to reliably achieve outputs congruent with organizational goals". The horizontal and vertical integration of firms in the bio-tech industry presents bio-tech firms with the opportunity to enhance their innovative capabilities (Visser, 2009). In other words, bio-entrepreneurs are able to improve their technical capabilities significantly as a result of interacting with other bio-tech firms who are superior in specific knowledge areas. Maskell (2001) suggests that where firms in the same line of business compete with each other, the innovative capabilities of the individuals are enhanced as a result of three specific conditions including spatial/physical proximity – a densely populated area of related economic activity and cognitive proximity in terms of domains and mental models.

Industrial clusters are the cornerstone for the regional and economic development, which makes it imperative for policy makers and central authorities to craft strategies that facilitate R&D activities and regional innovations to enable firms operating in the bio-tech sector, often hailed as the new wealth creator, to improve their business and thinking processes (Ho and Wilson, 2006). McDonald *et al.* (2007) concluded that established clusters with deep networks are desirable and that there is need to craft effective strategies and policies to preserve existing networks and facilitate further collaborations in order to give firms and bio-entrepreneurs involved an opportunity to improve their innovative capabilities. Nooteboom (2005) describes diversity in the context of clustering and networking and expresses that it is associated with a number of agents, people or firms who are involved in a process of learning or innovation by interaction. Diversity is linked to the different knowledge bases and skills that agents/people/firms bring into a relationship, which denotes the notion of cognitive distance (Nooteboom, 1992, 1999).

The Dynamic Capabilities View

The dynamic capabilities view builds on the resource-based view, which sees a firm as a bundle of static resources (McKelvie and Davidsson, 2009). According to Grant (1991), the resource-based view is based on the idea that rival firms possess varied resource repositories. Following the realisation of the static nature of the resource based view, scholars have emphasised the dynamic capabilities view since the late 1990s (Teece *at al.*, 1997; Narayanan *et al.*, 2009; and Dixon *et al.*, 2010). The dynamic capabilities based view sees a firm as a constant belt of novel information inflows. It highlights a firm's ability to adopt a flexible business model, which allows it to react to uncertainty and disruptive technology. McKelvie and Davidsson (2009, p. 36) argue that, "Dynamic capabilities can be seen as those processes where resources are acquired, integrated, transformed or reconfigured to generate new value-creating firm-based activities". Autio *et al.* (2010) interpret dynamic capabilities as a firm's capacity to deploy strategic resources and improve business processes with purpose in order to achieve its goals. Accordingly, Nelson and Winter (1982) and Winter (2003) contend that dynamic capabilities can be seen as routines or repetitive patterns that are project based involving multiple firms. From these analyses, there is evidence of a growing body of researchers who agree that dynamic capabilities have an impact on a firm's capacity to innovate (Wheeler, 2002; Teece, 2007; Narayanan *et al.*, 2009; and George *et al*, 2009). Additionally, Visser (2009) indicates a strong relationship between diverse knowledge networks and innovative capabilities.

Easterby-Smith *et al.* (2009) suggest that dynamic capabilities are a response to the need for change or new opportunities. Their observation is very useful for bio-tech firms who are faced with changing market conditions which require constant knowledge generation and business re-engineering. Dixon *et al.* (2010) posits that for a firm to be able to respond to changing market changes, there is need to make fundamental transformations in its organisational processes, the allocation of resources and operations. The crucial part of dynamic capabilities for bio-tech firms is their ability to facilitate the allocation and utilisation of its resources strategically in order to make crucial innovations (Teece *et al.*, 1997; Nooteboom, 2009). These resources can take various forms of economic effects including human capital, technological capital, knowledge-based capital, and tangible-asset-based capital (Easterby-Smith *et al.*, 2009). Since the introduction of the dynamic capabilities theory by Teece, Pisano and Shuen in 1997, many scholars emphasised the operational (zero level) and the dynamic nature of capabilities (Eisenhardt and Martin, 2000 and Winter, 2002/05) and heterogeneous learning of firms (Cobbett, 2007). Building on these topologies, Ambrosini *et al.* (2009) proposes three levels of capability development including incremental, renewing, and regenerative capabilities. Notably, the strategy of regenerative dynamic capabilities (Easterby-Smith *et al.*, 2009) is important because of its ability to completely overhaul existing business processes and adapt to new business processes that open new channels for novel information inflows. It is assumed that "organisations can have several different kinds of dynamic capabilities such as idea generation capabilities, market disruptiveness capabilities, new product development capabilities, marketing capabilities or new process development capabilities" (Easterby-Smith *et al.,* 2009, p. 4).

Furthermore, Teece (2007, p. 1319) suggests that "the capacity to sense and shape opportunities and threats, to seize opportunities, and to maintain competitiveness through enhancing, combining, protecting, and, when necessary, reconfiguring the business enterprise's intangible and tangible assets". In the context of bio-tech industry in which constant novel information inflows are crucial towards making innovations, it is important to reconstruct existing business processes to position the firm strategically on course to achieve its corporate strategy. The literature on organisational management (Mullins, 2006 and Torrington *et al.,* 2005) emphases on the need for top management to take the lead in shaping business processes and gearing the business towards its strategic goals. Similarly, developing dynamic capabilities requires a lot of input from bio-entrepreneurs in providing a vision for purpose aimed at shaping the types of capabilities to be sought after. Martin *et al.,* (2011) examine the process of dynamic capability development in a large pharmaceutical firm. Narayanan *et al.,* (2009) found that senior managers play a major role in the development of capabilities by imprinting an organisation with their specific cognitive orientation and then orchestrating the multi-level organisational routines necessary for actualisation of a capability. More importantly, their inspirational study identified key underlying processes and mechanisms that are pertinent to bio-tech firms in terms of capability development and these processes were identified as research and development (R&D) strategies, knowledge transfer processes, and knowledge exploring mechanisms. This highlights the impact of dynamic capabilities on the innovative capabilities of bio-entrepreneurs or bio-tech firms and the capacity to make innovations.

The Impact of Network Dynamics

Networks are defined as a set of nodes (persons, organisations) linked by a set of social, friendship of a specific type (Cooke, 2001; Breschi and Malebra, 2005). They are distinct from hierarchical or market relationships in their reliance on reciprocity, collaboration, complementary independence and orientation towards mutual gain. Breschi and Malebra (2005, p. 47) suggests that, "resource pooling, risk sharing and the formation of critical masses provide incentive to create a group of interlinked agents". Accordingly, Nooteboom (2009) focuses on network structure and network ties while Suire and Vicente (2009) examines networks from the perspective of social interactions under mimetic pressures. Nooteboom (2009) suggests that according to the novel architectural principles or basic logistics or design logistics, the expectation is that a volatile structure emerges at the early stages of exploration and experimentation of novel combinations of elements from pre-existing practices. He also noticed the volume of traffic such as frequent exit and entry of actors to allow for frequent and fast re-configuration of ties, a dense structure to allow for the hedging of relational bets that such volatility requires and the availability of high shared absorptive capacity (Lichtenthaler and Lichtenthaler, 2009).

Dense networks can be seen as being supportive of the casual discussions that may include novel information or reputation systems, which are crucial for governance especially in face-to-face uncertainty and fluid knowledge with consequent limits to governance by contract or hierarchy. At optimal cognitive distance, direct ties are sought and indirect ties play a vital role by providing the crucial links between nodes/actors/bio-entrepreneurs for governance and for crossing cognitive distance that is too large to deal with within a single firm. Nooteboom (2009) contends that participants with high betweenness centrality offer bridging of structural holes in ties with distant clusters as sources for new knowledge. Given these cluster dimensions, it is within reason to claim that firms that venture beyond their immediate surroundings for partnerships place themselves in a better position to acquire new knowledge. Regarding the strength of ties in a network, Nooteboom (2009) suggests that the main dominant characteristics should be wide scope (i.e. large complexity) in order to deal with a wide range of uncertainties (a common occurrence in knowledge based industries). This uncertainty can be concerned with both technical and commercial knowledge, network structures and membership, reputation concerning both competence and intentional reliability of potential partners (Owen-Smith and Powell, 2004; Breschi and Malebra, 2005). In such types of networks, high frequency of interaction is expected as a result of fast changing conditions, a great deal of trust building to compensate for difficulties of contract and monitoring on the basis of shared ethics, empathy and identification (Nooteboom, 2009). In the constantly changing market conditions, especially those of the bio-tech sector, ties between actors in a network should not be static but should offer some flexibility and avoid the dependency syndrome (Cooke, 2001).

In the literature on economic geography the idea of social interactions under mimetic pressures has gained momentum (Suire and Vicente, 2009; and Orle´an, 2006). The rationale of the concept is that interactions are always sequential. This assumption is vital due to the fact that it creates a situation whereby actors/bio-tech firm can observe the decisions of others in the network and to some extent, access "the black box of decision externalities leading to cumulative processes" (Suire and Vicente, 2009, p. 24). Suire and Vicente (2009) identified two key elements as: (1) uncertainty and legitimacy and (2) accessibility to and the exchange of knowledge.

With uncertainty and legitimacy, when agents are faced with uncertainty in their decision making unit, the expectation would be to try to learn from others in the network and make an informed decision based on "observational learning" (Suire and Vicente, 2009, p. 24). A herding behaviour model developed by Bikhchandani *et al.* (1992, 1998) highlight the fact that heterogeneous learning is a key criterion of sequential interactions. Legitimacy arises as a direct result of uncertainty oriented mimetic interactions. Suire and Vicente (2009) extends the concept of cognitive distance where start-up firms in a network learn from agents who are more experienced, have expertise, reputation and "can influence the trajectories of collective choices in the early stages of or during the clustering process" (Suire and Vicente, 2009, p. 24). Hedstrom (1998) posits that legitimacy can be seen as a strong source of rational imitative behaviour. In the bio-tech industry where collaborations between start-up firms and established bio-pharmaceutical firms appear to be prevalent, it would seem rational to imitate and follow the lead of those with experience and expertise.

The second drive for agents in a network is accessibility to and the exchange of knowledge explains the convergence in decision making through sequential and mimetic processes. In knowledge intensive industries such as the bio-tech industry, networks are seen as necessary as a source for novel information inflows as firms in a network usually have varied skills, knowledge, expertise and capabilities. Vicente and Suire (2007) suggest that the wider the connection of firms in a cluster, the more chances a firm has of accessing complementary bits of knowledge stemming from cognitively distant firms. This perspective is essential in understanding how firms access knowledge and engage in knowledge sharing activities with members of the network that are either in the same line of business (horizontal integration) or those who are not in the same line business (vertical integration) but have processes that can been be useful to the firm.

The Impact of Cognitive Distance

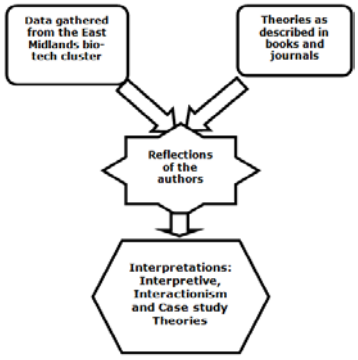
A firm's ability to generate new knowledge and ideas is directly linked to its ambition of developing strategic alliances in a given geographic area or even beyond in order to supplement its internal research and development (R&D) capacity. Su *et al.*, (2009, p. 312) indicate that, "A firm's R&D capability reflects its ability to generate new scientific discoveries and technological breakthroughs". The successful clusters such as the Cambridge cluster, Silicon Valley and the Boston metropolitan area are well known for their innovative capabilities and their push towards inter-organisational corporations and the sharing of ideas in those close knit communities (DTI, 2004). Powell and Grodal (2005) suggest that diversity is an essential condition which is facilitated by firms coming together and sharing capabilities, specialities, ideas and best practice.

The concept of cognitive distance emanates from a social constructivist view of knowledge, which advances the idea of perception, interpretation, understanding and value judgment. It entails mental constructions on the basis of mental categories that are developed in interaction with the physical and social world (Pittaway, 2000). At organisational level cognitive structures constitute absorptive capacity which relates to the idea of exploring knowledge (Lichtenthaler and Lichtenthaler, 2009). Accordingly, Nooteboom (2005) suggests that when absorptive capacity is aligned with organisational goals and aims not only does it enable organisational cognition, but also constrains what gives rise to organisational myopia that can only be compensated by interacting with other firms which may have a different complementary foci at some cognitive distance. Therefore, it is within reason to claim that external relationships give the organisation a new purpose for inter-firm collaboration the need for a firm to make a trade-off between its identity in terms of clear focus and the wide scope of its core competences (Johnson *et al.,* 2006). In the context of cluster dynamics the analysis of optimal cognitive distance has huge implication for innovation and the period an alliance is likely to last (Wuyts *et al.,* 2005).

According to Nooteboom (2005) cognitive distance between firms can be reduced in proportion to the life time of an alliance, particularly in cases where the alliance is restricted to a group of firms. Strategic alliances are usually developed between firms that share the same values and have high levels of trust. In those circumstances there is the danger of dependency syndrome which leads to reduced innovation activities (Cooke, 2001). Crucially, Nooteboom (2005) identified variables that have impact on the absorptive capacity of firms including: educational facilities, research and development (R&D) in firms, government R&D activities and the transfer of outcomes to firms. There are also other variables that include knowledge diversity and cognitive distance in the network, the life time of an alliance and external linkages such as international links can be seen as catalysts to innovation as they supply novel information inflows. This underlines the impact of cognitive distance and knowledge diversity on the innovative capabilities of a firm. The extant literature on cluster development emphasises on the social benefits of collaboration in science based industries, (Pittaway 2000; and Neergaard *et al.,* 2005). Nonetheless, more research needs to be done to understand the dynamic impact of networks on the innovative capabilities of bio-entrepreneurs.

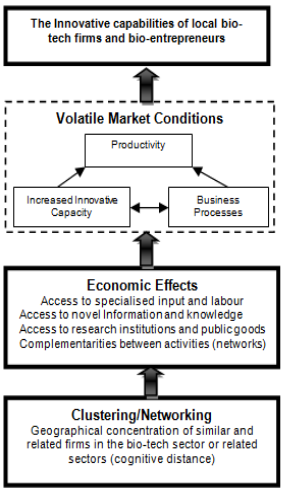
Conceptual Framework

By the time we become aware that Porter's model of clusters and competitive advantage could be relevant to capability development in knowledge networks we had a sizeable store of data that we had absorbed making it relatively easy to assess the applicability of the model. Our awareness that Porter's model was an appropriate means for explaining the phenomena we were investigating emerged through the research process as we collected, sifted, sorted and analysed data (Irvine and Gaffikin, 2006). We refined the model so that it becomes a more suitable description of our data. The process of developing theory diagram neatly illustrates how the data and our understanding of Porter's model informed both our perceptions and comprehension of the impact of knowledge networks on the innovative capabilities of bio-tech firms. This led to the development of a robust innovative capabilities model to capture the key themes.



Source: Irvine and Gaffikin, 2006, p. 134

The proposed conceptual framework recognises that the innovative capabilities of bio-tech firms in volatile markets are affected by the interaction of heterogeneous actors with different knowledge, competences and specialisation, with relationships that may range from formal to informal and from competitive to cooperative (Malerba, 2005). In the same vein, our model which is adapted from Porter's model of clusters and competitive advantage is a development from static models, regarding the effects of different network architectures on organisational performance, to dynamics of networks. It emphasises the dynamic capabilities view. In particular, it is based on the notion that dynamic capabilities attempt to bridge capability gaps by adopting a process approach: and by acting as a buffer between firm resources and the changing business environment. Dynamic resources help a firm adjust its resource mix thereby enhancing its innovative capabilities which underpins its ability to make innovations (Helfat and Peteraf, 2003). So, while the RBV emphasises resource choice or the selection of appropriate resources, dynamic capabilities emphasise resource development and renewal facilitated through collaborative activities. Indeed, interacting with other firms or organisations with varied skills (cognitive distance) provide synergy for firms, with limited resources or knowledge gaps, by providing access to a wide range of economic effects (Ho and Wilson, 2006), which include: the access to specialised input and labour, novel information inflows and knowledge, access to research institutions and government R&D support services. In science-based industries knowledge diversity can potentially lead to increased innovative capabilities and improved business processes which impacts on a firm's ability to make innovations.



Innovative Capabilities Model
(Adapted from Porter's model of clusters and competitive advantage)

Research Methods

A qualitative multiple case study approach is used to study the extent to which knowledge diversity and cognitive distance can have an impact on how bio-entrepreneurs develop their innovative capabilities in order to improve their business process as well as to respond to changing business conditions. According to Robson (2002, p. 178), a case study is "a strategy for doing research which involves an empirical investigation of a particular phenomenon with its real life context using multiple sources of evidence". The approach allowed us to study how bio-tech firms build their innovative capabilities. We chose to use the East Midlands region as a case study for the following reasons. Firstly, the region is home to leading pharmaceutical companies including Boots Plc. and AstraZeneca, the world's seventh largest biopharmaceutical company. Secondly, the region has seen the establishment of very successful incubators such as BioCity as a means for bio-enterprise development. Thirdly, the UK government and the European Union have spearheaded the development of network centres including Enterprise Europe Network Midlands (EEN), Medilink and the Pera Innovation Centres in the region. Furthermore, the region has world class scientific research institutions including Nottingham University, Nottingham Trent University, Leicester University and Loughborough University. The paper interviewed a good sample composed of three bio-tech firms with links to research centres and academic institutions and three knowledge network centres from November 2010 to May 2011. A sample provide a good alternative, Fink (1995, p.1) posits that, "a sample is a portion or subset of a larger group called population. The population is a universe to be sampled; a good representative sample is a miniature version of the population".

Semi-structured interviews were used to collect primary data. Qualitative research frequently entails the reconstruction of events by asking selected participants to think back over how they developed innovative capabilities as a way to respond to the constantly changing market conditions. To ensure that the same topics were fully exhausted in all the interviews, we used an interview guide with open-ended questions giving the interviewees the opportunity to tell a full story. The interview guide was based on our previous literature review. In that regard, the first part of data collection process can be described as deductive due to the fact that we began with a conceptual framework. By sticking to our interview guide, our aim was to achieve the validity of the data collected. However, when interesting lines of enquiry were brought up by the participant during the interview process, we asked them some follow up questions. We were aware of the danger of diverting from the main themes of our study, so our interview guide included questions that sought to gather information were mainly about the economic effects of knowledge networks. To ensure the accuracy of data collected, the interviewees were given the transcripts to validate the data (Bryman and Bell, 2011).

To analyse the data collected from bio-tech firms and bio-entrepreneurs, we used the principles of thematic analysis which is commonly used by research clinicians (Newfield et al., 1990, 1991; William, 1992). The method for analysing data was chosen because of its ability to focus on identifiable themes and patterns of behaviour (Aronson, 1994). Identifiable themes for this study are related to collaborative activities, cognitive distance, innovative capabilities, knowledge diversity, knowledge exchange and acquisition which were derived from interviews with bio-tech firms and knowledge network centres. According to Taylor and Bogdan, (1989, p.131) themes are defined as units derived from patterns such as "conversation topics, vocabulary, recurring activities, meanings or feelings". The emerging themes from our interviews helped us to piece together and form a comprehensive picture of bio-tech firm's collective experience of knowledge networks.

In addition to field research, secondary literature is also used in the paper. The literature sources are used to develop a good understanding of and insight into previous research which can be divided into three categories that include: primary, secondary and tertiary sources (Saunders *et al.,* 2003). The primary literature sources represent the flow of information from original sources such as government white papers on cluster development and organisational reports as well as information scripts from networking seminars. Published materials in books and journals about innovative capabilities, cognitive distance, knowledge diversity and regional cluster dynamics are sources that provided secondary literature for this study. Tertiary sources also known as search tools were used to locate primary and secondary literature and these include: abstracts, indexes as well as encyclopaedias and bibliographies. By reading related literature we were able to come up with key themes. In doing so, we gained valuable information about the economic effects of knowledge networks of bio-tech firms in the East Midlands region which allowed us to make inferences from the interviews. According to Aronson (1994, p. 3), "When the literature is interwoven with the findings, the story that the interviewer constructs is one that stands with merit".

Research Findings: Patterns of Knowledge Networks and Innovative Capabilities of Bio-tech Firms

Collaboration and Innovative Capabilities

Working in projects has become a very popular strategy in the bio-tech sector. To provide an in-depth account of how firms in the East Midlands are obtaining economic growth in their collaborative networks, we chose bio-tech firms in their early development stages and established knowledge network centres to represent the entire population. In line with prior studies that focussed on social benefits of networking (Pittaway, 2000; Owen-Smith and Powell, 2004), we selected bio-tech firms and knowledge network centres to represent the entire population based on their abilities to illuminate the various economic effects associated with the growth of bio-tech firms.

Our findings show that bio-entrepreneurs and bio-tech firms in the East Midlands region link up with other firms, institutions and knowledge networks to work on new product development initiatives and it is in those collaborative projects that valuable scientific knowledge and clinical products development ideas are shared and exchanged. This was reflected in the response given by *Firm C and Firm E* when asked about how their firms developed intellectual capital. Their responses were as follows:

"I think the idea of intellectual capital is important for both established organisations and small start-up firms and the idea of collaboration is key as it gives less established firms access to essential knowledge. It is basically an understanding that we share ideas, collaborate in projects and generate joint programmes and IP". (Firm C).

"The only thing I would say is that my business has changed, when I started the business most of the knowledge was only in-house. We now have access to a lot of external resources and nowadays there is a huge push towards accessing knowledge from outside for non-core areas. I would say the industry has changed somewhat. It is now more open and there are a lot of collaborations with academics and research institutions and I think that has been good to the industry. Cross function in biology seems to the way forward even for the world class companies such as AstraZeneca, which is outsourcing so as to get the expertise from outside for continuous development and innovation. They have more links with academia and I think that has been very productive. Therefore, I see collaborations as essential for growth and innovation especially in biology and chemistry". (Firm E).

In light of this evidence indicating that by forging knowledge networks, bio-tech firms can equip themselves with strategic resources needed to make new innovations, we were in a much stronger position to conclude that engaging in collaborations in the bio-tech sector is an important step to take as it has a positive impact on the innovative capabilities of the actors in the collaboration. Powell *et al.* (1996, p.46) made similar observations and affirmed that, "when the sources of expertise are disparate, collaborative R&D opens an organisation's eyes to the need for accessing ideas and information from a variety of sources, to exploit the research findings in a commercial context". Crucially, by engaging in collaborative activities, bio-tech firms place themselves in a good position to withstand changing market conditions. When the bio-entrepreneur in *Firm B* was asked about why he engages in collaborative activities he stated that;

"I go nationally and internationally as I am interested in the new technology in the bio-tech so the best way to gather that technology is to have links internationally". (Firm B)

However, many of these seemingly bold steps towards capability development, bio-tech firms need to have prior knowledge of what is to be absorbed especially in areas that were referred by *Firm E* as "non-core areas". Otherwise, their collaborative strategy will not yield a positive outcome for their business. It would be naive for us to ignore the barriers that may hinder knowledge exchange, transfer and the learning process in collaborative networks. When asked about whether his business shares knowledge freely in a network, the bio-entrepreneur in *Firm E* categorically stated that;

"We are not totally open but we are to people who fund us and those who collaborate with us on specific projects therefore people who are our partners will have full access to all the knowledge available for that specific project". (Firm E)

The statement highlights that some bio-tech firms in the East Midlands region are conservative; they are still secretive about their business operations which defeats the purpose of collaboration. These firms pick and choose their partners based on trust and their expected economic returns in an alliance. The "whats in it for me" attitude can hinder the process of knowledge sharing. This implies that acquiring innovative capabilities via networking depend on the depth and width of relationships and the strength of ties between actors in a geographical proximity. It is often assumed that strong ties in social networks usually yield high flow of information due to shared common values, aims, trust and the use of a common language for communication (Melkas and Harmaakorpi, 2008). Weak ties have been described, by a number of authors (Granovetter, 2005; Burt 2004; Zaheer and Bell, 2005), as productive for innovation to flourish because they are credited with allowing the flow of quality information or data directly to individuals in seemingly weak ties as opposed to strong ties. At optimal cognitive distance, direct ties are sought and indirect ties play a vital role by providing the crucial links between nodes/actors/bio-entrepreneurs for governance and for crossing cognitive distance that is too large to deal with within a single firm (Nooteboom, 2009; Visser, 2009).

Knowledge Diversity and Innovative Capabilities

Our interviews also indicate that having access to the knowledge from a wide range of organisations either in the same line of business or related business is a catalyst for capability development for bio-tech firms. Firms that venture beyond their immediate geographical proximity in search of novel information inflows offer their businesses better opportunities to acquire the much needed innovative capabilities including specialised skills, new ideas, human capital, financial capital and knowledge necessary to respond to the dynamic business conditions. In the interview with the project manager in *Knowledge Centre B* established in the East Midlands region, he made it clear that the knowledge centre provides access to global knowledge and markets;

> *"We help firms and industry sectors access information, opportunities and partners on a global scale through specialist networks and business intelligence. On behalf of national government agencies, we deliver programmes to stimulate international inward investment, technology transfer, partnering and access to high growth global markets for UK companies. We provide business intelligence and contacts to help UK firms identify and realise international opportunities"*.

Contacts outside the local industry *milieu* are crucial to the process of acquiring rich novel information inflows which underpins the generation of scientific knowledge for bio-tech firms. Furthermore, the same sentiments were echoed in our interview with the manager in *Knowledge Network A.* When asked about the impact of knowledge diversity on the innovative capabilities of bio-tech firms she explained that:

> *"One of the things that we encourage small and established firms in the East Midlands to do is to develop links with international organisations. The Animal corridor from the USA will be visiting the East Midlands in March this year to attend one of our networking conferences. We also had an alliance with bio-masters who specialise in cats and dogs. Some people came over from USA. We also promote international trade and I think international links are also important as they give organisations/firms a chance to acquire new knowledge. People exchange knowledge, ideas and best practice".*

This indicates that regional resources and collective networks are decisive for firms in their early development stages and for those intending to improve their business logistics and design. Indeed, in the face of globalisation, bio-tech firms are tied in evolving international networks and clusters which facilitates the continuous renewal of a firm's knowledge resources. Thus, the capacity for bio-tech firms to dramatically reshape their business logistics and the business design is significantly improved.

Cognitive Distance and Innovative Capabilities

Nelson's and Winter's (1982) evolutionary perspective on innovation stresses heterogeneity or variety as a vital source for innovation. Cognitive distance is the difference between the cognitive foci of firms, with two main dimensions of technological knowledge, competences and moral principles of internal governance (Nooteboom, 2009; and Narayanan *et al.,* 2009). Stuart (1998) contends that the most valuable alliances are those between firms with similar technological foci or those operating in the same markets.

As our interviewee said:

> *"I work with any organisation in clinical development and in that process I gain ideas and knowledge as a result of their varied business processes".*

Tanriverdi and Vankatraman (2005) posit that in alliances where partners have related skills and knowledge their learning is significantly enhanced. Indeed, the level of knowledge transfer and sharing is very high in cross boarder collaborations which assist firms in developing essential innovative capabilities. The increasingly complex nature of technology in the bio-tech sector has led to the emergence of this trend of inter-firm relationships aimed at primarily outsourcing new knowledge from complementary technological sources and absorbing it into the firm's technological portfolio (Agata and Santangelo, 1994). The same view was offered by Nooteboom (2009) who expressed that participants with high betweenness centrality offer bridging of structural holes in ties with distant clusters as a source for new knowledge. Interestingly, our interviews indicate that in the East Midlands region bio-tech firms with knowledge gaps are placed into projects with both indigenous and international specialists or experts in small groups of five to six nodes known as "science projects" monitored by a project manager in a knowledge network centre or a government designated innovation zone or by office representatives from the Euro zone. The idea is to coach, nurture, guide and support firms that have limited resources. At one given time we found that there could be ten to fifteen projects running concurrently. The project manager in *Knowledge Network A* and the office representative in *Knowledge Network C* explained that;

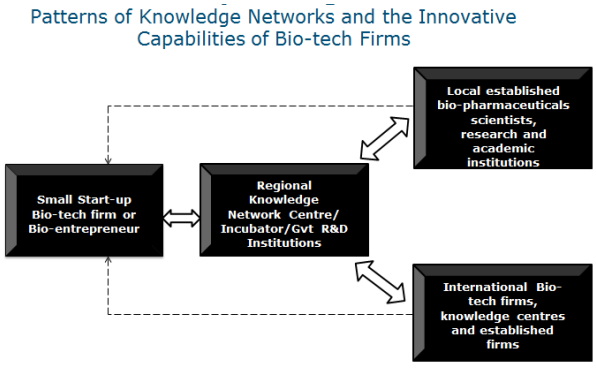
"We facilitate collaborations in the bio-tech industry in the East Midlands region. We are in contact with science experts, research institutions, universities, and various bio-tech firms within the East Midlands and internationally. If a small firm come to us asking for help to develop and grow its operations, we try to match their needs with the portfolio of companies that we have "we call it problem matching". We then facilitate a network which is made up three or four actors/firms and one of them would be an established firm or experienced scientist or academic expert". (Knowledge Network A)

"EEN is part of the bio-tech sector group which brings together numerous business profiles in the bio-sector industry regionally and internationally. The sector group discusses possible partnerships that could be made". (Knowledge Network C)

This indicates a direct link between the knowledge distances and the geographical proximity of actors in a network or cluster with innovation. In particular, the findings show that a firm's ability to generate new knowledge and ideas is directly linked to its ambition to develop alliances with experienced actors in a given geographic area or even beyond in order to supplement its internal research and development (R&D) capacity which is also evident in our secondary literature.

Discussion

The process of capability development in the bio-tech firms within the East Midlands region highlight some striking similarities with well-established networks including Silicon Valley, Cambridge and the Boston biotechnology cluster. Network formation in the East Midlands region exhibits some special and unique characteristics in terms of how firms develop networks within the region which are vital for acquiring essential innovative capabilities. The East Midlands region bio-tech sector which is part of the M1 corridor including Sheffield and Leeds sectors, knowledge network centres create industry *milieu* by linking small start-up firms with the established local and international organisations and academic research institutions. The patterns of knowledge networks diagram neatly illustrates the interplay of the key actors involved in the special networks of biotech firms. Crucial scientific knowledge is shared in those collaborative projects enabling small firms to improve their business logistics and designs and that has proved to be vital for corporate and regional economic growth.



This unique type of networking is designed by knowledge centres with the view to equip firms with the right resources mix in order to respond to changing market conditions and create a strong regional economy which secures the region's long term vitality. The region's strategy for facilitating collaborative projects as a way to solve scientific puzzles has proved to have a positive impact on small firms in their early development stages. These results are similar to those achieved by world renowned clusters including Silicon Valley, Cambridge clusters and Boston bio-tech cluster. All of the firms within their geographical proximity have access to shared resources; innovations are honed and developed in the network.

Concerning the economics of regional development we cannot overlook the fact that the UK government and the EU need to take a leading role by developing effective inter-firm collaboration strategies to boost economic growth. This will help to dispel the stigma sometimes attached with knowledge sharing. During our data collection process potential interviewees turned down our interview requests fearing that they may be making available, to their competitors, vital information about their new innovations. Policy makers should take the initiative to rebuild existing knowledge bases and integrate them with government R&D centres. By facilitating collaborative activities they place themselves in a strong position to monitor the outcomes of R&D projects. This also helps both the policy makers and organisations in regional networks to assess whether their goals of economic growth associated with regional and technological development are achieved.

Conclusion

The paper shows that knowledge networks are the crucial steps for capability development in the knowledge intensive bio-tech sector. Following our analysis of both primary data and secondary literature we found that small bio-tech firms in their early development stages faced with volatile market conditions can supplement their core competences when they engage in collaborative activities with other firms and knowledge network centres. This led us to conclude that knowledge networks have a significant impact on the innovative capabilities of bio-tech firms. Knowledge diversity and cognitive distance are key variables that hugely impact on a bio-tech firm's economic growth. In the East Midlands region, knowledge centres have played an important role in forging the knowledge network of bio-tech start-ups. Small bio-tech firms are given the opportunity to establish, grow and develop which is achieved by creating specialist forums for problem solving, specific help and debate. BioCity the region's most successful incubator use incubation as a means for bio-enterprise and capability development. The technology incubator fosters the growth of new technology based ventures by helping them to close the gaps in the innovation process and correct market failures. In sum the knowledge network centres in the region act as new bio-tech firms' "nurseries", "accelerators" and "greenhouses".

There are limitations with the sample used for data collection. Indeed, as much as the chosen methods are deemed appropriate the authors are aware of the inherent limitations. Access to the target population was a problem faced during the data collection process. The study could have benefited from a larger sample of participants. However, key actors in the East Midlands region were targeted as data sources. In knowledge based industries the main agents such as knowledge centres have significant influence regarding what transpires in their resident network (Breschi and Malebra, 2005).

For future research, we recommend the study of the business incubation process of small bio-tech firms. Business Incubation is an enterprise development strategy which is a unique and highly flexible combination of business development processes, infrastructure, and people, designed to nurture and grow new and small bio-tech firms by supporting them through the early stages of development and change. An incubator can create quality jobs at reasonable net public subsidy cost, widen the tax base and reduce gestation and costs of entering market, while enhancing chances of success. In that context, a follow up study is necessary to explore whether there are any differences or similarities regarding how the East Midlands region's knowledge networks nurture firms in their early development stages within their geographical proximity with world class clusters including Silicon Valley, Cambridge and the Boston biotechnology cluster.

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