Supporting Irish Start-Ups in the Life Science Sector: An assessment of how the support structures provided by Enterprise Ireland are utilised by Irish Life Science Start-ups

Research dissertation presented in partial fulfilment of the requirements for a Masters of Business Administration in International Business

Graduate Business School

Dissertation Supervisor: Dr. John Cashell

Author: Glenn Carroll

Student Number: 2860784

Date: *31st August 2015*

Candidate Declaration:

Candidate Name: Glenn Carroll

I certify that the dissertation entitled "*Supporting Irish Start-Ups in the Life Science Sector: An assessment of how the support structures provided by Enterprise Ireland are utilised by Irish Life Science Start-ups*" submitted for the degree of MBA in International Business Management is the result of the my own work and that where reference is made to the work of others, due acknowledgment is given.

Candidate signature: _____ Date: _____

Glenn Carroll

Supervisor signature: _____ Date: _____

Dr. John Cashell

GRIFFITH COLLEGE DUBLIN

Graduate Business School
Assignment Cover Sheet

Student name **Student number:**	**Glenn Carroll** **2860784**				
Course:	**MBA in International Business**			**Stage/year:**	**Year 2**
Subject:	**MBA Dissertation**				
Study Mode:	Full time			Part-time	**X**
Supervisor Name:	**Dr. John Cashell**				
Assignment Title:	**Supporting Irish Start-Ups in the Life Science Sector: An assessment of how the support structures provided by Enterprise Ireland are utilised by Irish Life Science Start-ups**				
No. of pages:	**95**				
Additional Information:	(ie. number of pieces submitted, size of assignment, A2, A3 etc)				
Date due:	**02Sep2015**				
Date submitted:	**31Aug2015**				

Plagiarism disclaimer:

I understand that plagiarism is a serious offence and have read and understood the college policy on plagiarism. I also understand that I may receive a mark of zero if I have not identified and properly attributed sources which have been used, referred to, or have in any way influenced the preparation of this assignment, or if I have knowingly allowed others to plagiarise my work in this way.

I hereby certify that this assignment is my own work; based on my personal study and/or research, and that I have acknowledged all material and sources used in its preparation. I also certify that the assignment has not previously been submitted for assessment and that I have not copied in part or whole or otherwise plagiarised the work of anyone else, including other students.

Signed & dated:

Please note: Students MUST retain a hard / soft copy of ALL assignments as well as a receipt issued and signed by a member of Faculty as proof of submission.

Acknowledgment & Dedication:

I would like to dedicate this dissertation to my expecting wife for her unwavering support throughout the full two years of my MBA journey.

I would also like to acknowledge and thank my dissertation supervisor, Dr. John Cashell for his support and assistance.

Finally, I would like to take this opportunity to thank the faculty at Griffith College Dublin Graduate Business School and my classmates for the massive part they have played in making the last two years a very enjoyable and rewarding experience.

Table of Contents:

List of Tables:

List of Figures:

List of Abbreviations:

BAC = Biotechnology Advisory Committee

BRI = BioResearch Ireland

CEO = Chief Executive Officer

CMO = Contract Manufacturing Organisation

CSO = Chief Scientific Officer

CTO = Chief Technical Officer

CSDD = Centre for the Study of Drug Development

EI = Enterprise Ireland

FP7 = European Framework 7

HPSU = High Potential Start Up

ILO = Liaison Office

IDA = Industrial Development Authority

MABR = Membrane Aerated Biofilm Reactor

MSD = Merck Sharpe and Dohme

NDP = National Development Plan

PHA = Polyhydroxyalkanoate

PhRMA = Pharmaceutical Research and Manufactures of America

SFI = Science Foundation Ireland

TTO = Technology Transfer Office

TCD = Trinity College Dublin

UCD= University College Dublin

UF = University of Florida

VC = Venture Capital

Abstract:

This study evaluates the supports that Enterprise Ireland is currently providing to start-up companies in the Irish Life Science sector by exploring how seven different Irish start-ups within the sector have utilised the support system.

This study found that the current Life Science support network within Ireland was found to be effective at funnelling potential start-ups into the Enterprise Ireland support system and it was also found companies with reasonable business plans are receiving the required level of funding and support to scope out their business plans. In all seven companies studied, Enterprise Ireland funding and support was sufficient for the business to navigate the difficult first year following formation / spin-out.

At approximately the one year mark the way in which each company interacted with Enterprise Ireland diverged significantly. The companies who were successful in securing revenue from external investors grew quickly and generated a significant level of employment, whereas the companies that could not secure this funding stalled in their development. In two cases there was difference of opinion between Enterprise Ireland and the founders of the companies with respect to the future development of the business, this had a negative impact on how the companies engaged with the support processes.

Overall it was concluded that the current support system provided by Enterprise Ireland is performing well when it comes to the identification of viable candidate companies and is offering the supports needed in the critical early stages of business development.

Two key areas where the current offerings require improvement were identified; firstly, more assistance is needed for companies who are having difficulty securing external sources of funding as this was a significant road block to business development. Secondly, the depth of Enterprise Ireland business mentors within the Life Science sector requires development as a number of companies could not gain access to the required level expertise needed to develop their business plans.

Chapter 1: Introduction

1.1 Overview:

Within Ireland the Life Science industry, in particular the pharmaceutical and biotechnology sectors, accounts for approximately 31% of nominal GDP (€50bn) and this sector has largely outperformed other areas during the recent economic downturn (Mac Coille & Gorman 2012). Ireland possesses a highly skilled workforce and a competitive tax system which has given the country the ability to attract multinational organisations; currently eight of the world's top ten pharmaceutical companies have a manufacturing presence in the country (PharmaChemicalIreland 2014).

However the much publicised "Patent Cliff" hit the industry hard in 2013 as many of the "block buster" drugs produced in Ireland came off patent (for example, Singulair and Lipitor) and this directly contributed to Pharma exports decreasing in August 2013 by €1,420m (17%) in comparison with August 2012 (Ryan 2013). Current estimates show that a drug will lose approximately 80% of its value within the first year after patent loss due to generic substitution, therefore companies who lose patent protection on a drug must then significantly cut their costs in order to remain competitive within the open market (Mac Coille & Gorman 2012). Also the number of generic manufacturers has grown strongly over the last decade, while traditional Big Pharma has been in decline – figure 1 shows how the industry has changed since the early 1990's (Hunt et al. 2011).

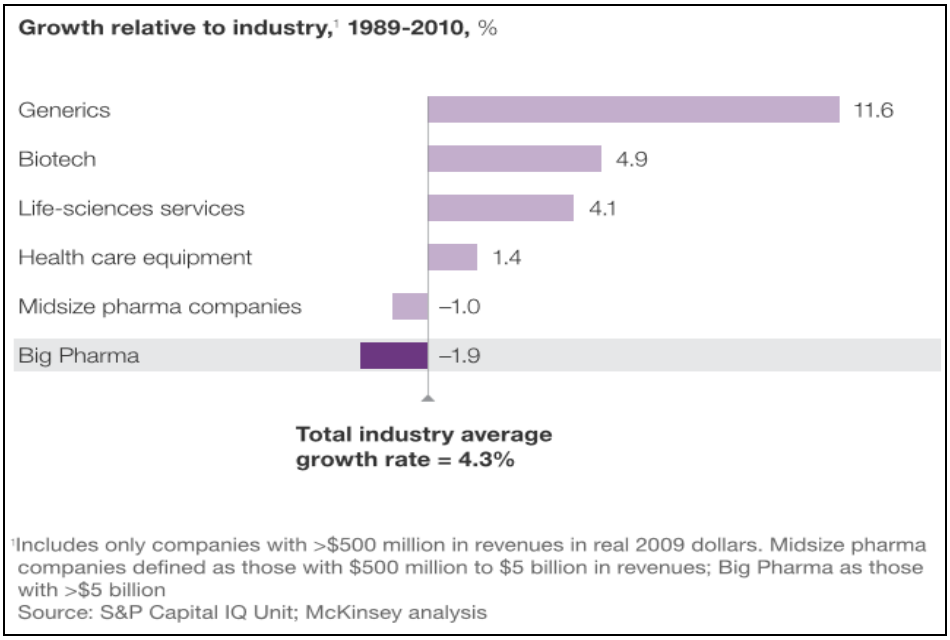

Figure 1: Growth and Composition of the Industry. (Hunt et al. 2011)

Another significant trend within the industry is the merging of large international pharmaceutical corporations which is then inevitably followed by significant "consolidation programs" aimed at reducing costs by cutting the headcount and outsourcing production to lower cost regions of the globe. Some examples of this practice include, Merck Sharpe and Dohme (MSD) acquiring Schering Plough for $41.1 billion in 2009 - this lead to a headcount reduction of 24,000 across the combined company within a four year period and the closure of a number of production facilities, including two in Ireland (Thomas 2013) (Rockoff 2009). Another pharmaceutical giant Pfizer purchased Wyeth Pharmaceuticals in 2009 for $68 billion; at the end of 2008 Pfizer had 81,800 employees and Wyeth had 47,426, which was a combined total of 129,226. By the end of 2013 a total of 51,000 job cuts were made across the combined company which reduced the overall headcount to the same level as Pfizer alone in 2008 (Staton 2014). These two mergers resulted in the loss of over 75,000 jobs within the industry in just five years.

Ireland has not been immune to these trends within the macro industry. Some reports suggest that the patent cliff has directly resulted in a 20% drop in the total pharma workforce within Ireland (O'Riordan 2012). The table below highlights just some of Big Pharma manufacturing facilities that have announced closures or large redundancy programs in the last three years, many of which are the result of mergers and acquisitions that led to an excess of capacity.

Site Name	**Estimated Number of Jobs Lost**
MSD Swords	570 (BusinessEtc 2013)
Pfizer Newbridge	150 (Burke 2013)
MSD Rathdrum	280 (Kennedy 2013)
Pfizer Cork	177 (O'Riordan 2012)
Beckman Coulter Galway	140 (Siggins 2014)
Bristol-Myers Squibb Dublin	160 (RTE 2014)
Arkopharma Waterford	18 (McSorley 2015)
Total Job Losses	**1495**

Table 1: Examples of Recent Job Losses

1.2 Research Purpose and Significance of Research:

Ireland's ability to influence global industry trends within the Life Science sector is relatively limited and one can expect that fluctuations in the macro industry will continue for some time to come; this in turn will lead to volatility within the Irish Life Science sector. A potential solution to this external volatility is to grow the number of smaller indigenous Life Science companies within Ireland which can then complement the current multinational presence and dilute Ireland's overall exposure the global industry trends.

Some groups within Ireland, such as PharmaChemical Ireland, have recognised this opportunity and responded by launching a strategy that aims to divert more investment into development activities which are research intensive and potentially high reward (Moran 2013). This approach is based on an acceptance that the industry is changing and the traditional large scale manufacture of bulk pharmaceutical products is likely to diminish in Ireland. The group argue that the impact of this negative trend could be mitigated by growing on the left side of figure 2 (i.e. increase the focus on R&D and the commercialisation of products developed in Ireland). The PharmaChemical Ireland Director accurately described the current situation when he stated "If the industry in Ireland is to survive and prosper, it needs to remain strategically relevant – this means investment in the development of new technologies" (Moran 2013).

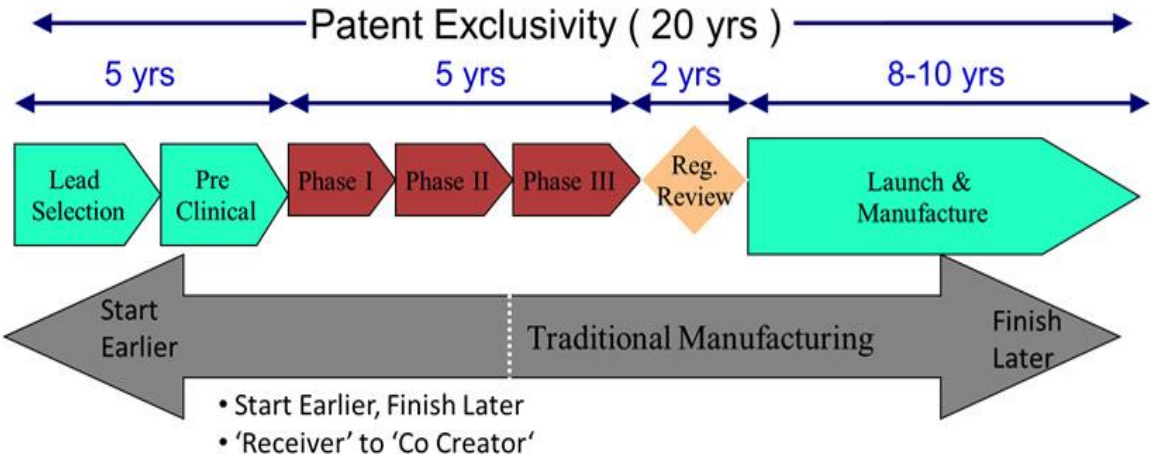

Figure 2: Drug Development Timeline (Moran 2013).

One obvious way to grow the number of small R&D focused Life Science companies in Ireland is to implement a support structure which will identify the best candidate

companies and nurture them from the laboratory bench into the formation of a viable business. Growing the number of Life Science start-ups within Ireland will have a significant multiplier effect within the wider economy as Life Science companies have the ability to create employment across a broad range of skill sets, including academic Professors, PhD graduates, third level graduates and manufacturing staff. A study carried out by the Pharmaceutical Research and Manufacturers of America (PhRMA) which assessed "The Economic Impact of the U.S Bio-pharmaceutical Industry" found that the average compensation of a worker in this area was more than twice the average U.S private sector compensation and the industry is a significant generator of tax intake for the overall economy due to high wages and high value product manufactured (PhRMA 2013). Therefore growing the number of jobs in this space will have a larger impact on the national economy in comparison with growing jobs in other sectors of the economy.

However, starting a Life Science company is extremely challenging as Life Science companies, by their very nature, are high risk ventures that can require a significant amount of funding just to get to the "proof of concept" stage of development. Typically a further ten years of development is required before the company has a product which it can actually sell to end users. A report published by the Tufts Centre for the Study of Drug Development (CSDD) suggested that the cost of developing a new drug now exceeds $2.5 billion and that this is only set to increase over time (Mullin 2014).

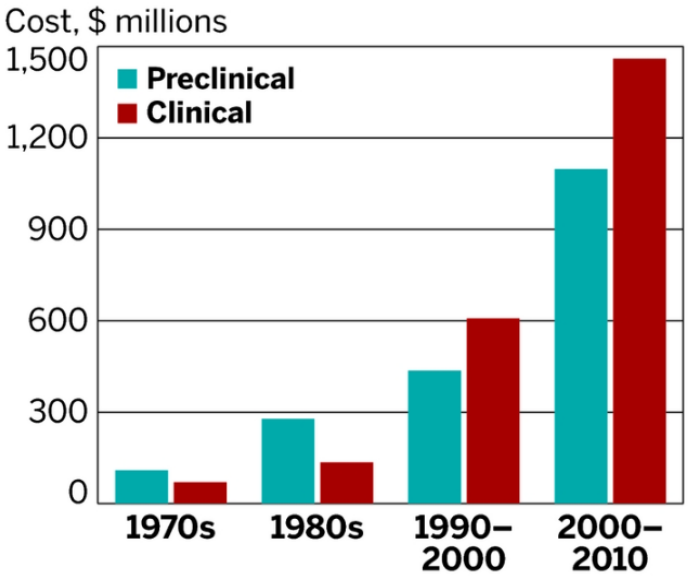

Figure 3: Cost of developing a new drug (Mullin 2014)

The CSDD also found that only 21.5% of drugs that start phase 1 clinical trials actually make it to the market, but just to get a product to phase 1 clinical trials requires millions to be invested (Medical Marketing 2003). Therefore it is clear that creating an environment that will support start-up companies within the Life Science sector is not a simple undertaking.

1.3 Research Objective and Structure:

This study focuses on Irish start-ups within the Life Science industry and aims to evaluate the current supports available from the perspective of companies who have actually used the support mechanisms and from the perspective of the government body (Enterprise Ireland) that is responsible for delivering the supports to the sector. An exploratory sample of seven companies was selected to represent the full range of disciplines within Irish Life Science sector. Each company was profiled, a founding member interviewed and their experiences with the support systems was assessed. The overarching goal was to provide a meaningful evaluation of the indigenous Irish Life Science sector and to identify potential measures which could be taken to improve the overall number and the success rate of start-ups.

1.4 Research Question:

The primary research question which has been addressed by this dissertation is as follows;

“How are Irish Life Science start-up companies using the supports offered by Enterprise Ireland and are these supports meeting the needs of each company?”

Prior to collecting the primary data needed to answer this question, a literature review was completed in order to identify the major academic theories and models in the field of Life Science start-up support. These academic theories and frameworks were then used to construct the primary research methodology, evaluate the primary data collected and to support the findings of this dissertation.

Chapter 2: Literature Review

2.1 Introduction:

A wide range of academic studies have been completed within the field of Life Science start-up support mechanisms. This volume of research has resulted in a large number of varying opinions on how best to nurture young highly technical companies and equip them for a successful future. This literature review identifies the major themes which have been researched within the field and examines the potential uses of this research within the Irish Life Science sector.

2.2 Cluster Model:

Cooke (2002) examined the innovation support systems that have been established in Germany, Cambridge US, Massachusetts and Cambridge UK. His research assessed the capabilities and limitations of public and federal attempts at developing innovation systems which focused on building regional structures based on core technological capabilities which were already in place in the form of Universities (Cooke 2002). In his paper "*Biotechnology Clusters as Regional, Sectorial Innovation Systems*" it is argued that the biotechnology sector, like many other segments of the Life Science sector, is knowledge driven, therefore firms will have a tendency to "cluster" around knowledge sources. This work can be related directly to the current situation in Ireland, which has a number of world class academic research institutes located within a relatively small geographic area, therefore the creation of a cluster support system or governance structure to capitalize on this fundamental asset (the asset being a strong core of technical knowledge based in a small geographic area) could be of significant benefit when it comes to assisting new start-up companies. A system which allows for the free exchange of knowledge while consolidating the resources needed to start a business may suit Ireland, as opposed to providing isolated supports at various universities. Issues relating to Intellectual Property (IP) protection can create significant road blocks when it comes to the creation of a system where knowledge is freely shared and IP risks could result from a lack of engagement from candidate companies and research groups.

Leibovitz (2004) also completed a case study on the use of the "cluster concept" to develop the biotechnology sector within the Scottish cities of Glasgow and Edinburgh; this study is particularly relevant to Ireland as Scotland is quite similar terms of size,

culture and resources (Leibovitz 2004). This research found that the key factors in growing the sector are the size and diversity of the labour market available, the presence of research institutions, and the public provision of infrastructure and supports. The three elements identified through this paper seem obvious at first, however the creation of an environment that contains all three variables is challenging. One could argue that Ireland possesses a diverse labour market within the Life Science sector and the required research institutions, but the provision of public infrastructure and supports may be an area that could be enhanced. An assessment of the infrastructure provided to start-up Life Science companies within Ireland forms part of the primary research for this dissertation as it is a key element in development of the sector.

A significant proportion of the “cluster model” research which has been completed within the Life Science sector has been based on the analysis carried out by Porter (2000). His research forwarded the theory that the establishment of clusters of similar companies within a relatively small geographic area can lead to economic competitive advantages and an environment that will nurture innovation, efficient productivity and strong employment growth (Porter 2000). Although the cluster model approach may support innovation and create an environment in which start up Life Science companies can flourish, it could be viewed as idealistic and in practice it may prove too difficult to create a cluster that contains all the required amenities. Due to the very nature of the Life Science industry there will always be some level of dependence on external relationships, such as suppliers, customer based and regulatory agencies.

Shiri M. Breznitz (2013) examined the sustainability of the Life Science cluster in Israel by asking the question “Can an industry centred on one part of the production cycle become sustainable?”(Breznitz 2013). Based on survey findings and in-depth interviews the author contends that Israel has been successful in gathering the necessary academic expertise and funding from government sources to create a Life Science cluster. The goal of creating such a cluster was to generate a concentration of firms within close geographic proximity which should in theory allow the smaller companies to enjoy the benefits of large-scale industrial production and technical innovations. These innovations would simply be beyond the scope of the individual small firms. However, the author also found that the sector in Israel is stuck in the R&D space and is suffering from a lack of knowledge of later stage Life Science production, limited funding and a fragmented social network – these issues have limited the clusters ability to develop further and contribute to the local economy. The author ultimately concludes that the lack of mature and developed Life Science companies in

Israel has negatively impacted on the ability of the local workforce. As a result, the current Life Science cluster within the country will remain unsustainable until this issue is resolved.

This research is an example of how the cluster approach (while seeming viable on paper) can only be successful if all of the necessary elements are present i.e. Israel has the academic institutions and there is a political desire to create a viable Life Science industry, but has a lack of experience in bringing products to market. By comparing the current Israeli situation to the Irish Life Science industry one can see that Ireland has a distinct advantage due to the presence of a large number of mature multinational pharmaceutical and biotechnological companies; as stated previously, eight of the world's top ten pharmaceutical companies currently have a manufacturing presence in Ireland (PharmaChemicalIreland 2014). Many of these companies have had a presence in Ireland for over 50 years (such as MSD Rathdrum which was founded in to 1960's) and this has resulted the creation of a highly experienced indigenous workforce which is proficient in all elements of the manufacturing process i.e. from R&D through to bulk manufacture and sales. This pool of talent could be used to help the start-up companies within Ireland grow and develop into successful viable businesses.

Although the creation of Life Science "clusters" is not within the scope of this research project, a number of the themes identified as part of the academic research into cluster formation (such as the elements needed to create an environment where Life Science start-ups can grow and the issues faced by other countries when they attempted to implement the cluster model) were used when assessing the role Enterprise Ireland within the Irish support system. These issues were also used to reinforce the recommendations made by this dissertation.

2.3 Comparison Studies:

A number of comparison studies have been completed on the success of the Life Science industries in various regions. One example would be a report which detailed a direct comparison of the Irish and Portuguese innovation systems with respect to biotechnology (Calvert & Senker 2004). The report highlighted that although both counties have a relatively low budget when it comes to investment in R&D, the Irish biotechnology sector largely outperformed its Portuguese counterpart over the period assessed. Ireland, unlike Portugal, developed specific policies directed at biotechnology and the establishment of Enterprise Ireland in 1993 created a system

that was capable of supporting research & development thus creating a mechanism of potentially commercialising the knowledge originating from Universities. Also the establishment of BioResearch Ireland (BRI) programme, under the governance of Enterprise Ireland, further facilitated the commercialisation of R&D. This body was tasked with developing the infrastructure to support the national biotech industry (Calvert & Senker 2004). The BRI eventually lead to the creation of another support structure known as Science Foundation Ireland (SFI), which was developed under the Irish National Development Plan (NDP); the stated remit of the SFI was "*build and strengthen scientific and engineering research and its infrastructure in the areas of greatest strategic value to Ireland's long-term competitiveness and development*"(SFI Ireland 2013).

SFI has employees based within five Universities and the total investment budget allocated to the SFI was in the region of €1.4 billion (UniversityWatchdog 2009). The creation of such supports and an investment in R&D of €12.4 million per million capita, compared to €7.3 million per million capita in Portugal, allowed for the growth of the biotechnology sector within Ireland. This growth can be quantified by comparing the number of biotechnological patent applications between 1995/96 to 1999/00 (Calvert & Senker 2004). Figure 4 clearly shows how Ireland outperformed Portugal over the period in question.

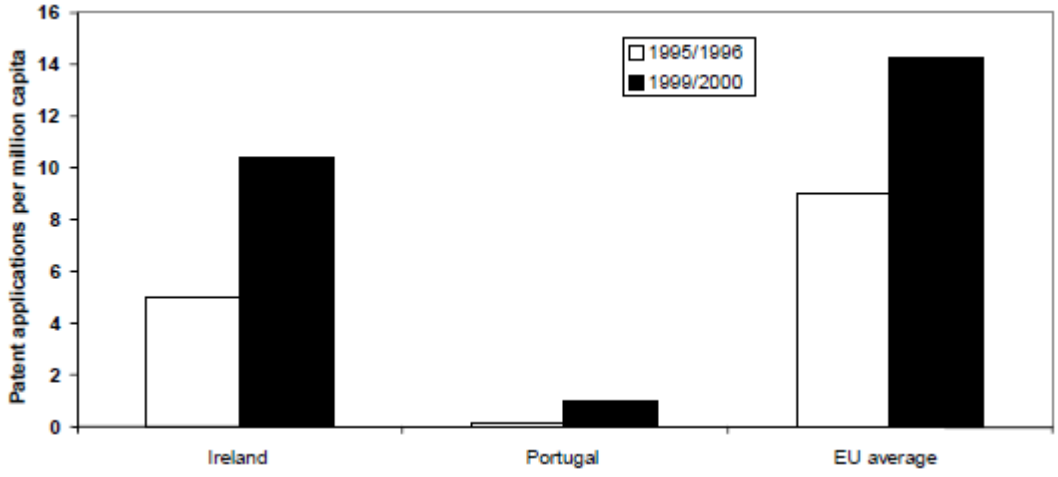

Figure 4: Number of Biotechnology Patent Applications, Ireland vs. Portugal (Calvert & Senker 2004)

It could be argued that the relative success of Ireland in the last number of decades, in comparison with Portugal, was largely based on the fact that the level of funding

provided to the sector in Ireland was almost twice that of Portugal and the impact of the current support structures have been somewhat overstated. With the current economic climate exacting funding pressures on all governments, the ability to generate the levels of funding required to bring a Life Science products to market cannot be provided by the government alone and additional private funding plays a critical role. However, securing private investment in new Life Science products is extremely difficult due to the fears that the product may never make it to market; statistics on the failure rates of new therapeutic products estimate that only one in 5,000 candidate pharmaceutical products ever make it to market and even the drugs that make it through the research & development stage into clinical trials only have a 20% chance of making it to market (Urbig et al. 2013).

Comparison studies are valuable tools when one is seeking to assess the performance different countries support mechanisms relative to each other. During the collection of primary data for this dissertation, the use of comparison studies and benchmarking as a means of measuring Enterprise Irelands performance relative other small open economies was assessed in order to evaluate how Enterprise Ireland support mechanisms are developed and if the learnings from other geographic areas are reviewed when creating policies. Also the issue of securing private investment on the open market was reviewed with all seven companies' studied in this dissertation and was a key point of discussion with Enterprise Ireland.

2.4 Effect of Public Policies:

In general, the majority of the research in the area of supporting Life Science start-ups focuses on the effectiveness of public policies. Enzing et al. 2004 approached this area from a different perspective by asking the question "do dedicated public policies matter?" (Enzing et al. 2004). The authors compared the commercial performance of the biotechnology sectors across fourteen different EU Member States and assessed the impact dedicated public policy had on the growth of the national industry. The public policy instruments implemented in the fourteen countries between 1994 and 2001 were compared using four indicators;

1. Number of Patent Applications in Biotechnology
2. Number of Biotech Companies
3. Amount of Venture Capital Invested in Biotechnology
4. The number of Biotechnology IPO's

In terms of performance in these four areas, the three Nordic countries (Denmark, Sweden and Finland) all performed the strongest. Interestingly none of these countries have dedicated policies. This data set was used to classify each country as “Above Average, Around Average and Below Average”. The authors conclude that dedicated government instruments are not required to deliver a high performing biotechnology sector and that generic policy which is not specifically targeted at one individual sector is just as effective. They attempt to explain why the Nordic counties are outperforming the other fourteen countries by putting forward the following key points;

1. *The Small Country Effect* – Smaller counties have an advantage due to their geographic proximity to open economies and they also have strong internal networks due to the relatively low geographical distance between key stakeholders (similar to the “cluster” model discussed in section 2.2). This proposal is supported by peer research.
2. *Quality of the “Generic” Instruments* – The authors propose that the level of support offered from the generic instruments in the Nordic countries in many cases outperformed the “dedicated supports” used in other countries. However there is an acknowledgment that there isn’t sufficient public data available to draw any definitive conclusions.
3. *Systematic Approach to Innovation* – Adopting a systematic approach to supporting innovation by offering support to all areas of the innovation pathway is far more important than having dedicated policies targeted at specific areas and neglecting others (Reiss et al. 2004). The Nordic countries have adopted a systematic approach to great effect.

One clear counter argument to these finding is that only three countries with no specific policy (Denmark, Sweden and Finland) scored “Above Average” and the only countries to score “Below Average” also had no dedicated public policy at the time of the study. No countries with dedicated policies scored “Below Average”. One could conclude that Denmark, Sweden and Finland are outliers or that their generic public policies are well developed and this is why they are outperforming other countries as opposed to coming to the conclusion that “Dedicated public policies do not matter.” Due to the importance of public policy in supporting start-ups, an assessment of the EI policies and how they are formed was included as part of the primary research in this dissertation.

This research completed by *Enzing et al* also highlights the importance of using appropriate measures when seeking to gauge the effectiveness of a support

mechanism. Although this dissertation does not specifically evaluate the "need" for Irish support policies, the importance of using the appropriate indicators was considered when assessing how EI measures its success on an annual basis. Also, indicators such as job creation and EI supports utilised were used in the findings section of this report when comparing the "success" of each of the seven start-ups.

2.5 Commercialisation of Academic Research:

The "commercialisation of academic research" is another common theme observed when one reviews methods of growing the number of successful indigenous companies in the Life Science sector. Uctu and Jafa (2013) considered the emerging biotechnology industry in South Africa and assessed the "first structured attempts to equip scientists to build a bridge between the science of biotechnology and the commercialisation of knowledge in the field" (Uctu & Jafta 2013). The authors introduced the term "bio-entrepreneurship", which they describe as wealth creation that comes from Life Science discoveries in the laboratory that are applied in a commercial market. They discuss the differences between traditional entrepreneurs and bio-entrepreneurship (see figure 5) and put forward "three pillars" (Managerial Skills, Sufficient Capital, Access to new technology leading to products) that underpin the success of a start-up biotech company (Hine & Kapeleris 2006)(Uctu & Jafta 2013).

	Traditional entrepreneurs	Bio-entrepreneurs
Background	Business	Scientific
Education	MBA	Life science (Masters, PhDs) and/or MBA
Age	Younger	Relatively older
Objectives	Involved only with development and marketing of product	Also have in-depth knowledge of product itself

Figure 5: Traditional entrepreneur's vs. Bio-entrepreneurs(Uctu & Jafta 2013)

The authors found that the initial policies implemented in South Africa were largely effective based on feedback from participants and made a number of interesting recommendations, such as; the incorporation of bio-entrepreneurship teaching into undergraduate qualifications, improving networking abilities of aspiring bio-

entrepreneurs and the creation of a dedicated agency to "champion bio-entrepreneurship". Although the Life Science industry in Ireland can be considered more developed, the issues identified in this study of South Africa are still relevant and applicable to an Irish setting as it can be difficult to find an individual who possesses the business and management acumen to complement their scientific capabilities. The creation of effective leadership teams, as opposed to relying on one individual to deliver on all fronts, can be a potent method of forming a successfully start-up business. This topic was assessed as part of the primary research section of this dissertation; the ability of Irish Life Science start-ups to implement effective management structures and EI's role in that process was reviewed. The "three pillars" discussed by the authors were also identified in the more successful companies studied as part of this dissertation, this further supports that the work compared by Uctu & Jafta is applicable to the Irish sector.

Penin & Wolff (2010) completed a body of work analysing what is needed to for a successful start-up in the biotechnology sector by analysing four different start-ups in the Upper Rhine Biovalley (Peinin & Wolff 2010). The four companies were selected on the basis that they were young (all started between 1999 and 2001), were hosted by an incubator in Strasbourg and all operated in the human health area. Each company was profiled using qualitative interviews with the founders, queries in multiple data bases and questionnaires. The overall plight of each company is detailed in the figure 6.

	Year of foundation	Spin-off	Patent	Initial organisation	Domain	Incubator	Situation in 2008
Firm A	1999	Academic	Yes	CSO + CEO	Human health	Yes	Bankrupt (in 2005)
Firm B	2000	Mixed	Yes	CSO + CEO	Human health	Yes	Bankrupt (in 2006)
Firm C	2001	Corporate	Yes	Single employee	Human health	Yes	Bankrupt (in 2003)
Firm D	2001	Mixed	Yes	CSO + CEO	Human health	Yes	Alive

Figure 6: Overview of each company studies (Penin and Wolff, 2010)

Firm A was described as the "Success story…..without the happy ending". It originated from an academic spin-off and secured €30 million from two rounds of VC investment. It then grew to 46 employees by 2003 and had planned to get

to 160 by 2006. Unfortunately the firm went bankrupt in 2005 as it failed to raise sufficient funding to sustain its high growth. “Quick growth without turnover” was identified as the key to the company’s failure.

Firm B grew to 40 employees by 2005 and secured over €55 million in private funding. The company showed significant promise but closed in 2006 due to poor performance in clinical trials which resulted in loss of investor confidence.

Firm C never really got off the ground. It is a very good example of how a lack of finance in the early stages can effectively kill off any chance of creating a thriving biotech company.

Firm D was the only company studied which managed to generate a turnover and survive. It grew to 20 employees, turned over €750,000 in 2003 and €797,000 in 2004. In comparison to the other three companies, this firm had the most focused business plan and had a cash flow strategy that sustained the company as it grew. This example highlights the importance of implementing a strong business model to complement scientific research and also emphasises the importance of effective leadership within a start-up venture.

The “lessons learned” from each of the companies experiences highlighted three key areas where start-up biotech company’s need to perform;

1. *Human Capital* – the entrepreneur needs the have aspirations linked to their culture and the ability to grasp opportunities. Entrepreneurs with previous managerial experience or start-ups that had a dual team of scientific manager and executive manager stood the best chance of success.
2. *Social Capital* – recognition that biotech companies do not grow in isolation and having a strong network is critical. Building and leveraging this network will have a profoundly positive impact on the business.
3. *Physical Capital* – the ability to patent and protect your technology is a central aspect of the businesses success. The authors argue that in the biotech sector, firms rely on patents much more than in other sectors.

The stories of the four companies described by Penin and Wolff bore a striking resemblance to the seven Irish companies studied during this dissertation and the “lessons learned” that were identified by the authors were used when evaluating the success or failure of the Irish companies. Common links between the plights of each company were examined as potential areas for improvement. A similar approach to the one used by Penin and Wolff was also taken when collecting the primary data and

presenting the findings of this study. Collecting data using this method allowed to the comparison of a number of very different companies and it also allowed for the identification of common issues faced by all companies.

2.6 Incubators:

As previously stated, Life Science companies can be notoriously difficult to grow due to their need for seed capital, R&D support, overcoming regulatory hurdles and the identification of appropriate business partners. An "incubator" support structure (such as the one used in Strasbourg discussed in section 2.5) can address the key early needs of the start-up company and can be an effective method of building a strong foundation for the business. Smilor and Gill (1986) stated that the most effective "incubator seeks to effectively link talent, technology, capital and know-how in order to leverage entrepreneurial talent and to accelerate the development of new companies" (Smilor & Gill 1986). Incubators can also offer intangible benefits to young companies such as credibility, networking opportunities, access to suppliers, access to potential customers and access to potential employees – all of which makes it easier for the entrepreneur to secure additional investment and grow the business (Smilor 1997)(Totterman & Sten 2005).

One example of a successful Life Science incubator is the award winning University of Florida (UF) Sid Martin Biotechnology Incubator (Breedlove 2014). This incubator was opened in 1995 and accommodates academic spinouts developing therapeutic, diagnostic, drug delivery, ag-bio and bio-energy products. To date, forty seven companies have used the facility and these companies have raised in excess of $1 billion in funding from investors. The facility has also had a number of extremely successful graduates in the recent past, such as;

> *Nanotherapeutics*: Won a $358 million contract with the U.S Department of Defence and has begun the construction of a 165,000 sq. ft drug development and manufacturing facility which will create 150 jobs at an expected average salary of $90,000.
>
> *Pasteuria Bioscience:* A gene therapy company was acquired by Syngenta for €113 million.
>
> *Applied Genetic Technologies:* Launched a $50 million IPO.
>
> *AxoGen:* Listed on the NASDAQ for $18 million.

These four success stores occurred over a two year period and the facility was selected from 1,900 members in 60 countries for the 2013 *Randall M. Whaley Incubator of the award*, for overall excellence. The Director of the UF incubator highlighted five key areas as the *"Ingredients of Success";*

1. *Highly Specialized Physical Infrastructure:*

   As Life Science start-ups require significant capital investment in laboratory space to perform their work, they can seldom afford to purchase their own in order to start the business. The incubator adopted a "Lean Start-up" approach by sharing office space and almost $1 million of core scientific equipment. This method allowed the UF incubator to maximise the return on capital investment by ensuring all facilities are used efficiently.

2. *Vigorous Research Ecosystem:*

   A robust pipeline of Life Science research is fundamental to the success of any incubator program and the UF incubator director states that the "build it and they will come" approach simply does not work. Therefore a successful incubator needs to actively seek new opportunities and partner with institutions that have strong technology licencing operations that understand how to commercialize research. Well-funded Universities often provide the ideal knowledge and talent pipeline required to establish the climate necessary to create a successful incubator space.

3. *Collaborative Culture and Responsive Management:*

   The managers of the incubator must strive to create an environment that is lively, welcoming and prioritises the interactions between peers, mentors and the service providers. Adopting this approach creates a collaborative culture within the incubator and creates a "mini cluster" of businesses who can feed off each other to the benefit of the overall program.

4. *Effective Talent Screening:*

   The selectivity in accepting clients is a critical element to success. The UF incubator uses a *Biotechnology Advisory Committee* (BAC), which is a team of venture capitalists, bio-entrepreneurs, regulatory specialists and other experts to review company applications and make recommendations on admissions. Companies entering the incubator are given one-year renewal terms and are reviewed each year by the BAC. Underperforming companies are moved out of

the incubator to make space for other more promising ventures. This rigorous screening approach ensures that the resources are used to support the best possible portfolio of companies at any point in time. It avoids the situation where poor performing companies are allowed to languish for years and drain resources, which is an issue commonly faced by other incubator programs. Also, UF incubator tries to keep at least one lab available at all times, this allows the program to accommodate a promising company at short notice and minimises the risk of turning down a promising opportunity. To date the incubator has not turned down a company that was a "good fit" and is averaging a 90 percent occupancy rate.

5. *Comprehensive Goal Measurement:*

   Picking the right metrics to measure the performance of the incubator is critical and the Director states that measures such as sales per incubator are often poor indicators. The UF tracks metrics such as companies admitted, number graduated, survival rates (to date only 12 of the 47 companies admitted have failed), total funding, regulatory progress, patents, corporate partnerships, acquisitions, IPO's and number of products to market. Local jobs created is also another key measure of success; between 2004 – 2010 graduate companies created 1,467 local jobs and generate $100 million per year to the local economy.

Another interesting step taken by this incubator was the elimination of professor-led companies. This decision followed a review of the program structure which found that professor-led companies were a "fundamental flaw" in the incubator strategy and that the recruitment of experienced bio-management coupled with aggressive courting of venture capitalists yielded more successes. The incubator is adamant that helping start-ups with the early recruitment of experienced bio-business management adds credibility to the venture and gives confidence to potential investors – similar to the "bio-entrepreneur" effect discussed in section 2.5. This strategy has developed to a point where the University of Florida will not licence its technology to a company unless it is led by an "investible CEO"; it is believed that this practice has been part of the formula for improved success. This system is significantly different to the current Irish approach as the majority of Irish Life Science start-ups are led (at least in part) by the professor who developed the technology – this was the case with almost every start-up

interviewed during the course of this dissertation. These findings also seem to indicate that the installation of an effective leadership or “investible CEO” could be a vital key to success. Enterprise Ireland’s role in identifying experienced business partners for Irish Life Science start-up was explored as part of this study.

Salvador and Rolfo (2011) completed a study on the effectiveness of incubators and science parks for the creation of spin off companies using Italy as the subject of the case study (Salvador & Rolfo 2001). The authors describe the development of the public policy initiatives aimed at supporting research spin-off over the last number of decades. They found that in the 1970s and 1980s the primary focus was centred on the creation of science and technology parks, described as “a property-based initiative that has formal and working links with a University or other higher education institution or research centre”.

But more recently the attention of public policy makers has focused on the role of the University in the development of localised spinouts. This can be seen globally through the creation of internal structures within Universities focused on technology transfer (such as liaison offices and incubators) and the increase in the number of new firms created from academic research. Italy followed this trend of public policy development by supporting science parks throughout the 1980s (by the end of the 1990s there was a science park in almost every region in Italy) and then through the implementation of regulations regarding the creation of technology transfer offices (TTO’s) and Liaison Offices (ILOs) in the 2000’s (Nosella & Grimaldi 2009). This evolution in policy is very similar to the path taken by Ireland. The authors began their research into the effectiveness of these policies by identifying spin-offs in all of Italy’s 20 regions and then mapping the number of science parks and incubators in each of these regions. They identified over 400 research spin-offs and found that there were no significant differences between the “on-park” and “off-park” firms i.e. the on-park firms were not outperforming the off-park firms, however they did conclude that “positive judgement of the hospitality and the key importance of geographic proximity to the host structures to the university as well as the international attitude of the on-park spin-offs are important proofs of the soundness of the current Italian policies”.

The authors then constructed a statistical regression model which confirmed the hypothesis that research spin-off firms are growing in number within Italy, “particularly in areas where there is a higher number of science parks and incubators”. They found that most of the public policy energy is focused on increasing the number of spin-offs as opposed to increasing the probability that the companies will survive – their

empirical research identified that the majority spin-offs in Italy are classified as “micro-firms” as opposed to SME’s according to the European Union classification.

The findings from this study are particularly relevant to the current situation in Ireland and it suggests that although incubators do have a positive effect on the number of spin-offs created, they should be very selective when choosing companies to support i.e. do not just focus on creating another spin-off, focus on creating a company that may have the potential to develop and grow into an SME’ or multinational business. Salvador and Rolfo (2011) made reference to a body of work completed by Bearse (1998) which asked the question “do Harvard students (the incubates) succeed because of what Harvard (the incubator) did for them or because of the selection criteria undertaken by Harvard that selected only successful students, regardless of what Harvard did to them” - this quote sums up the attitude successful incubators should take when selecting potential candidate companies. This is also a highly relevant finding when it comes to assessing the goals of Enterprise Ireland (EI), who have set targets to grow the number of start-ups significantly and use the number of High Potential Start-Ups (HPSU) created as one of their measures of success – this point is discussed further in a section dedicated to an assessment of EI. Ireland may potentially be falling into the same trap as the Italian model by simply focusing on growing the number of start-ups as opposed to focusing on increasing the success rate of start-ups. This is an area which was scrutinised when interviewing a representative from EI during the course of this dissertation.

Although the majority of research carried out on incubators focuses on the positive effect they have on business development, there are a number of potential issues when it comes to starting a business in an incubator. *McAdam and Marlow (2007)*, completed a study of a business incubator unit in the Republic of Ireland located on a Science and Technology Park linked to a university (McAdam & Marlow 2007). The aim of this particular incubator studied was to support new Irish start-ups that had significant growth potential. Following an in depth analysis of 12 firms who used the incubator, the authors found that although the incubator offered a number of benefits to the firm in the early years (such are the benefits discussed above), tensions began to emerge as firms grew within the incubator space and concerns over privacy, protection of intellectual property and competiveness strategies became genuine issues for the firms. Also as new firms joined the incubator space they may not be welcomed by mature companies who viewed them as potential threats. The study identified that most firms remain within the incubator for three years before they move to an alternative site, however a number of firms were ready to move before the three year

time frame. It is recommended that the relocation of firms should be encouraged as it ensures that the mature company is not constrained in its development and that newer firms can gain access to the supports. The authors also recommended that the role of management within the incubator should be examined to ensure it is not inadvertently creating barriers to greater entrepreneurial independence.

While the use of incubators is outside the scope of this dissertation (primarily because the Enterprise Ireland support system does directly oversee Irish incubators such as NovaUCD), a number of themes which are discussed in the research of Life Science incubators were used when assessing the current Irish support system. The "ingredients of success" discussed in this section were also used to frame the issues various companies were facing and were used when forming recommendations.

2.7 Enterprise Ireland Support Structures for Life Science Start-ups:

As previously stated, Enterprise Ireland (EI) is the primary support structure for Irish Life Science start-ups and the vast majority of start-ups will have some interaction with this government funded body during their development. The mission statement of EI is "To accelerate the development of world-class Irish companies to achieve strong positions in global markets, resulting in increased national and regional prosperity"(Enterprise Ireland 2015). The body employs 800 people within 10 specific Irish offices and across 32 international offices spanning all continents and sits under the Department of Enterprise, Trade and Innovation. EI works in tandem with other government supports bodies such as Science Foundation Ireland (SFI), Forfas and IDA Ireland to support and grow the Life Science space within Ireland, as depicted in the figure 7.

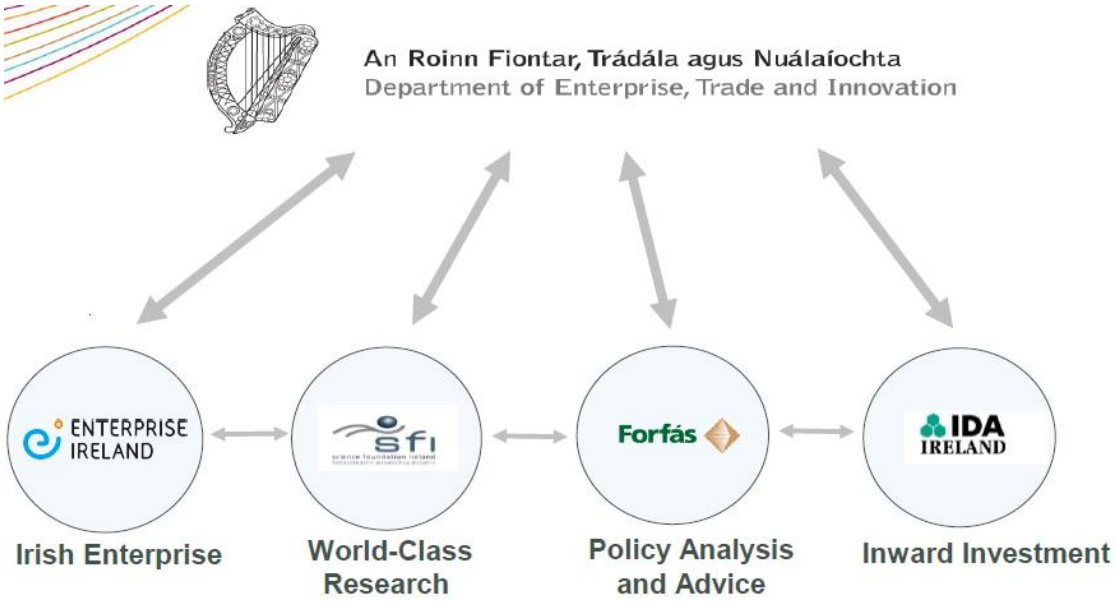

Figure 7: Enterprise Ireland relationship with other government bodies (O'Neill 2011)

The EI support mechanism aims to provide the necessary supports across the full lifecycle of a start-up business, from idea generation to technology development, licencing the technology and ultimately to the formation of a spin out company. The support structure which primarily focuses on the commercialisation of viable academic research in the Life Science sector is the *National Technology Transfer System,* which seeks to transfer the research outputs into industry. The term Technology Transfer refers "the process of moving the commercial outputs of a research project out of a higher education institute and into a company". Technology Transfer Offices (TTO) have been set up in all of the major academic institutions and these offices act as the initial point of contact between the potential entrepreneur and the EI supports (O'Neill 2011). This model is very similar to the Italian model presented by Salvador *and Rolfo (2011)* which was discussed in section 2.6.

The Technology Transfer System was launched under the "National Strategy for Science, Technology and Innovation" and since its introduction in 2007 there has been a marked increase in the "Commercialisation Performance" of Irish start-ups in the Life Science sector. Figure 8 shows the impact of the program on the level of start-up activity within the Irish sector since its introduction (this data was presented in 2011 by Brian O'Neil, the HPSU manager for Life Science within EI) (O'Neill 2011).

Commercialisation Performance

Introduction of Technology Transfer Strengthening Initiative

	2005	2006	2007	2008	2009
Licence/ Option/ Assign	12	28	56	67	95
Spin-outs	5	8	13	7	35
Invention Disclosures	135	193	271	407	421
Patents Applications	83	107	124	202	136

Figure 8: Impact of the introduction of the TTS Initiative (O'Neill 2011)

Once a start-up becomes a "client company" of EI and engages with the support structures, the system is designed to offer holistic service which covers all areas of business development and attempts to get the start-up thinking globally from a very early stage in their development, as depicted in figure 9.

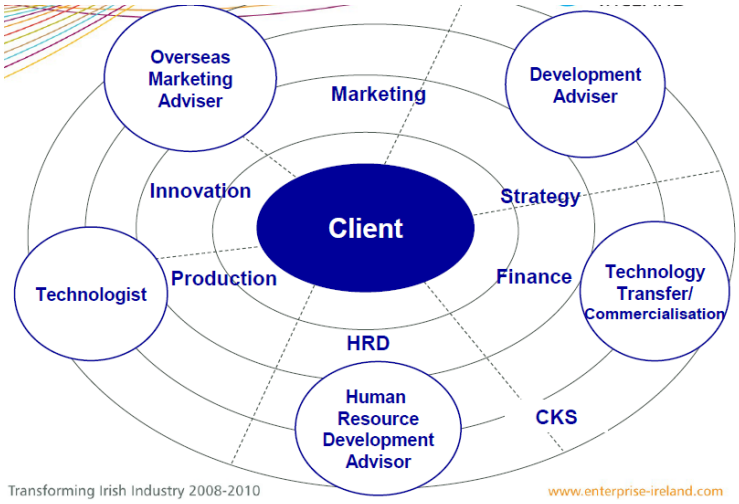

Figure 9: Supports offered to client companies (O'Neill 2011)

Although the supports on offer by EI are clearly defined, seem comprehensive and are being utilised by an increasing number of start-up companies, there is a relatively limited amount of data available on how start-ups are actually using the EI supports and if they are realising any benefits. This dissertation aims to bridge that knowledge gap by identifying how target companies are interacting with the support system, and highlighting the issues they are facing.

2.8 Literature Review Conclusions and Conceptual Framework:

As previously stated, the primary research question addressed by this dissertation is *"How are Irish Life Science start-up companies using the supports offered by Enterprise Ireland and are these supports meeting the needs of each company?"* This literature review has identified that there is wide range of opinions and approaches available when attempting put a system in place that will nurture and support start-up companies in the Life Science sector. The peer reviewed research themes and best practices identified during this literature review, coupled with the assessment of the current Enterprise Ireland offerings was used frame an assessment of the Irish support system and to form recommendations on how the current Irish system could be improved.

The research methodologies used by some of the authors discussed in this literature review (particularly authors such as Peinn & Wolff) were also used when constructing the research methodology & methods for this dissertation (discussed further in Chapter 3), as these methods have been sown to yield the primary data required to draw meaningful conclusions.

Chapter 3: Research Methodology and Methods

3.1 Introduction and Research Paradigm:

As identified by the studies discussed in Chapter 2, there is a broad variety of methods and strategies which can be utilised when researching support structures for the Life Science industry. These strategies can range from large quantitative experimental surveys completed over a long periods of time designed to track the overall performance of an entire sector, to detailed case studies of specific companies designed to assess the plight of a single business.

In order to answer the primary research question posed by this dissertation, the *research paradigm* (which can be described as a belief system that will guide the way in which we do things) of the author was evaluated prior to developing the research design (ERM 2014). This research takes a *Post Positivism* view of the Irish Life Science sector as it aims to take into account the context of the situation when making judgements and the primary data was collected with the understanding that previously held theories or human knowledge are often based on conjecture and opinion (Robinson 2002). This dissertation aimed to challenge "opinions" about the Irish Life Science Sector and remove bias by using sound research methods that were free from feelings. The collection of primary data from subject matter experts representing all areas of the Irish Life Science landscape was identified as a means of removing bias and could also be used to form a rounded view on the current status of the industry. This method also allowed for the identification of the challenges that Life Science companies are facing and the issues that need to be addressed in order to create an environment where indigenous companies can grow. One potential issue with adopting this research philosophy was the ability to gain access to the relevant individuals who could provide the insight necessary to generate meaningful findings on the industry. The identification of targets for interview was a fundamental to the quality of the research findings.

3.2 Research Philosophy and Approach:

In order to generate the high quality primary data needed for this dissertation a number of research strategies were assessed. It was concluded that a qualitative interview based research strategy was the best method for the collection of primary data as this method provided the flexibility needed to understand the very different development pathways used by each of the companies studied. It also allowed for the data to be processed in a way that facilitated the identification of common issues across all the

companies. A quantitative survey / questionnaire approach was also assessed but it was concluded that this method would not have provided the flexibility needed, as generic surveys could not capture the large variation between the companies targeted by this study.

Once the research philosophy was identified, a set of criteria was developed to aid the selection of interview candidates. The following criterion was applied when selecting candidate companies and individuals for interview;

1. The company must be of Irish origin.
2. The company must operate within the Life Science sector.
3. The company must be based on a novel concept, technology or service i.e. no "copycat" companies who were attempting to mimic an existing business were within scope.
4. The company must have engaged with Enterprise Ireland at some point in their development.
5. The company must have set out with the goal of bringing a product or service to market which had the potential to create employment within Ireland.
6. The interviewee must be a founding member of the company or the current CEO.
7. The companies interviewed must represent the full spectrum of the Life Science sector and all candidates must not operate within the same space e.g. not all Biotech based.

3.3 Research Strategy:

A total of seven companies were selected based on the criteria listed in section 3.2; reference Table 2 for the name of each company and the representative interviewed. These seven companies offered a comprehensive analysis of the full indigenous Irish Life Science sector as they covered virtually all disciplines – including, pharmaceuticals, biotechnology, medical diagnostic, waste water treatment, biodegradable production and contract service provision. The purpose of selecting companies from each of these areas was to get an exploratory sample of the full breath of the sector and to eliminate the issue of bias toward one sub group. The interview candidates identified were also high quality as they were founding members of each organisation; this was a critical element in the collection of meaningful primary data.

After a review of the Enterprise Ireland senior management team, Mr. Brian O'Neill was identified and the most appropriate candidate for interview. He is the current EI

manager for High Potential Start-ups in the Industrial and Life Science Industry and was ideally placed to provide the EI perspective on supporting the Irish Life Science sector.

Interviewee:	Company:	Position:	Life Science Field:
Prof. Kevin O'Connor	Bioplastech Ltd	Founder and CEO	Biodegradables
Prof. Eoin Casey	OxyMem Ltd	Co-Founder	Water Treatment
Prof. William Gallagher	Oncomark Ltd	Co-Founder and Chief Scientific Officer	Diagnostics
Dr. Mark Barrett	APC Ltd	Co-Founder	Pharmaceutical and Biotech
Prof. Kingston Mills	TriMod Therapeutics Ltd	Co-Founder	Biotech (Oncology)
Prof. Kingston Mills	Opsona Therapeutics Ltd	Co-Founder	Biotech
Prof. John Gilmer	Solvotrin Therapeutics Ltd	Co-Founder, Chief Technical Officer and Director of Research	Pharmaceutical
Mr. Brian O'Neill	Enterprise Ireland	Manager of High Potential Start-Ups in the Industrial and Life Science Industry	Enterprise Ireland

Table 2: Interviews carried out as part of primary research

3.4 Research Design and Collection of Primary Data:

Each company was then profiled and a founding member / current CEO was asked a series of standard questions which set out to address the following topics (reference Appendix for an example interview transcript);

- During the initial stages of development did the Start-up approach EI or did EI make the first contact?
- What supports were offered and how were they used?
- Were additional supports (outside the ones offered by EI) used by the company?
- How did the company interact with EI?

- What were the most significant issues the company faced during its formation and did EI provide the necessary assistance?
- Could the company have started without EI support?
- Are EI still involved today?
- Were there any specific strengths or weaknesses with the overall process?
- Based on the companies experience, what changes would they like to see made to the EI offerings?

The findings from the interviews with the start-up companies were used to guide the line of questions put to the EI representative in order to gain the EI view on the major themes identified (reference Appendix for transcript of this interview).

3.5 Approach to Data Analysis:

The company profiles and interviews findings were collated and a number of common issues were identified. A similar analysis method to the one used by Penin & Wolff (2010) was utilised and a table was constructed which compared the development of each company. The findings were reviewed against the themes identified during the literature review section prior to the formation of recommendations. This method of data analysis ensured that the resulting recommendations were supported by facts and peer reviewed research, as opposed to just giving the authors “opinion” on the Irish Life Science Sector.

Chapter 4: Research Findings

4.1 Introduction:

The following is an overview of each company assessed during the course of this research and the findings from the interviews carried out with the founding members / current CEO's. The findings from the interview with the Enterprise Ireland Manager for HPSC are also documented in this section

4.2 OxyMem Limited:

Figure 10: Oxymem Official Company Logo

Oxymem Limited originated from the University College Dublin (UCD) School of Chemical and Bioprocess Engineering and spun out from the college in 2013 following ten years of product development (Oxymem 2015). The company has developed a novel, patented biofilm control system which is used in the treatment of waste water. The Oxymem "Membrane Aerated Biofilm Reactor" (MABR) is considered a breakthrough technology in waste water treatment and the product can be retrofitted to existing waste water system or can be installed in new treatment plants (Oxymem 2015). Since it spun out in 2013 Oxymem has received a number of prestigious awards including the 2015 Enterprise Ireland Knowledge Transfer Ireland Impact Award for Best Spin-out and it was named the 2014 Start-up of the year at the Bank of Ireland Start-up awards (Oxymem 2015).

Oxymem is a client company of Enterprise Ireland and raised €250,000 in seed funding from EI which it used to open its manufacturing facility in Athlone and employ six direct staff (McAleer 2014). The company successfully secured a further €2 million in a funding round in 2014 and grew its employment to twelve people (UCD 2014). Currently the company employs 30 people (figure quoted by Prof. Eoin Casey) and the stated goal is to grow turnover to €50 million within the next five years.

Professor Eoin Casey, who was a founding member of the company and current company Chairman, was interviewed about the origin of the company and how it interacted with Enterprise Ireland. When asked what supports the company leveraged from EI in the early stages of development Prof. Casey stated "mainly just the money,

but they (EI) would have put us in touch with commercial partners through a business partner program which is something they don't always do but they did with us. Basically they bring together the start-ups and entrepreneurs who are interested in setting up a business based on University research". Through this process, Oxymem then found a business partner. Prof. Casey stated, "We decided to go down the route of forming a business based on this partnership and formed an alliance between us, UCD and this entrepreneur who was looking for a new opportunity". "Over at least a year prior to spinout, we had engagements in the form of weekly meetings between us, UCD and the investor. That was us working through the business plan, financial calculations, and technical specifications. The outcome was a business plan". During this period no additional funding from outside sources was required as the business partner provided the necessary funds (on top of the initial EI investment) to develop the business prior to spin-out. Also, as the business partner had significant previous experience in the business world and brought a "been there – done that" level of knowledge to the company. The company did not need to seek additional assistance in the form of a business mentor from a support function. When asked, would it have been possible to find this business partner without the assistance of EI and if the EI are still involved in the company today, Prof. Casey stated "It wouldn't have been possible without EI"; EI no longer take an active role in the company and "they don't have a director appointed, but they would have set some certain milestones as part of their conditions for investment that we are required to meet as part of that agreement".

EI gave key support to Oxymem in the early stages of the business development and Prof. Casey stated "they (EI) are not in the business of going into major rounds of investment; that is not what they do. The next rounds of investment will be larger international players who specialise in the kind of business we are in". In terms of the vision and strategy for the company, Prof. Casey stated "Oxymem was always based on high volume sales to international markets from the very beginning and never had any intention to focus on the Irish market and then expand. The vision was always thinking very big, so the early stages were to prove the product at an industrial scale, develop partnerships and to come up with a manufacturing process that was scalable to meet a major global demand for the product." This vision matched the EI criteria for a HPSU as the company was focused on internationalisation and quickly employed in excess of 10 people within Ireland. When asked about the company's overall experience with EI, Prof. Casey stated "EI have been great, very professional and very supportive. You couldn't ask for better support"; "because of what we were offering from the very beginning (an export business) and because it was going to deliver jobs

in Ireland EI were very, very supportive. Their level of interest and support is probably proportional to the vision of the company in terms of what it wants to do".

In summary, Oxymem Limited can be considered an Irish innovation success story, it was founded on novel scientific innovation which was developed within an Irish academic institution and has created a product offering that is considered as best in class within its industry. One of the keys to Oxymem's success was the identification of an experienced business partner at an early stage of the company development – this partnership was facilitated by EI. This added management and business acumen complemented the innovative scientific technology. Also, focusing on a single product and developing a strong business plan (under the guidance of an experienced business partner) prior to spinning out from UCD allowed the company to grow quickly and made it easier for them to present the value proposition of Oxymem to potential investors. This in turn allowed the company to secure the necessary funding from external investors to grow the business. The Oxymem story emphasises the importance of the right management team when it comes to the success of a start-up venture. The EI supports offered to Oxymem met all of the companies needs and helped the organisation to mature to a point where it is now self-sufficient.

Oxymem is a real world example of "bio-entrepreneurship" (which was described earlier in section 2.5 as "wealth creation that comes from Life Science discoveries in the laboratory that are applied in a commercial market") happening in Ireland with the support of EI (Uctu & Jafta 2013). Oxymem have implemented the "three pillars" which were described by Uctu & Jafta 2013 as "Managerial Skills, Sufficient Capital and Access to new technology leading to products" and as a result the company continues to go from strength to strength.

4.3 Bioplastech Limited:

Figure 11: Bioplastech Official Company Logo

Bioplastech Limited is a company focused on green technologies which offer alternatives to petrochemical polymers and their derivatives (Bioplastech 2015). The company originated in University College Dublin and spun-out in 2009. Bioplastech produces a range of biodegradable polymers made by bacteria which were developed in the research laboratories of UCD. The primary polymer produced is Polyhydroxyalkanoate (PHA) which belongs to a group of polymers with diverse physical properties and can be used to manufacture a range of products including biodegradable plastics, elastics, rubbers and glues. The company uses waste materials from other industries, such as agricultural and petrochemical waste, to feed the bacteria who then produce the biodegradable PHA's – therefore the technology developed by Bioplastech addresses the full life cycle of waste materials (Bioplastech 2015).

The company has had some involvement from Enterprise Ireland and received proof of concept funding to further develop a method of converting PHA into biodegradable plastics and to investigate the scalability of the process. The company also won the 2008 NovaUCD start-up of the year award and secured additional VC funding from two angel investors (CSCB 2008). It used these funds to employ a team of scientists, rent laboratory space in UCD and begin working on their product range. Bioplastech currently employs four people and is still based on the UCD campus; it is yet to bring a product to market.

Professor Kevin O' Connor, co-founder and current CEO of Bioplastech, was interviewed about the process of starting the company and his interactions with the Irish support structures. Following a number of years of research within the UCD microbiology department, Prof.O'Connor approached the NovaUCD incubator with his invention disclosures and began the process of filing a patent. Representatives from NovaUCD then suggested that he should spin out a company based on the technology he developed and Bioplastech entered the NovaUCD campus company development program, coming third. When asked about his experience in dealing with NovaUCD; Prof. O'Connor stated "It was very good, but frustrating in many ways because you are operating in a space where you have no real clue. People you are working with do not understand your technology and you don't understand the business world. They are

telling you to do certain things and you are saying to yourself *"that will never work"* and then you are telling them certain things and they are saying *"that will never work*." I found it a very intensive process although it was beneficial to the business as we learned a lot from it" - "It is a very different mind-set going from the academic world into a business mind-set."

When asked about Bioplastech's involvement with EI Prof.O'Connor stated "We were reluctant to engage fully with EI. We have engaged a lot in some ways, they were very good in pushing us to understand the market, what are the real commercial opportunities, where are your weaknesses – that has been very good. However we have been reluctant to be a client company of EI because we knew from day one that the goals didn't match and that our timeline was slower than theirs and that if we got involved with them then we would be on a road to failure. I think EI recognised that as well. EI wanted to push us to do certain things, but we knew there was a downturn in the economy and that there was no money out there and we were going to have to do things in other ways. Having said that, I still report into EI to keep them updated as I think it is important to keep that relationship. But we are not a full client company of EI – I would say that we are in-between".

The company "pivoted" a number of times during its development and has changed its business model from a biodegradable production company, to a technology development company which seeks to develop products using the biodegradable polymers it produces. Prof. O'Connor noted that the company may have spun out too early, "however by spinning out early we learned a lot and actually probably moved in the right direction because we were immediately faced with the commercial questions from other people" such as EI representatives. The financial investment received from the angel investors has been consumed by product development and the company has branched out into contract work in order to generate a cash flow for the business.

When queried about Bioplastech's overall view of the EI supports, Prof. O'Connor stated "EI were really good because they really helped by challenging what is your business plan? Who are you targeting? What is your offering? When are you going to target them? What do your financials look like? All of these different questions were all very good". "One thing I think that is lacking is highly qualified knowledgeable advisors. EI have a series of advisors who are consultants but to me they do not know about the tech space. So I would definitely say that that is a gap that these guys are suddenly thrown into biotech and don't have the expertise". "I'm not sure if it can be addressed because it is too specialised. I did recognise it as a gap when I talked to a few advisors

that EI put me in contact with and it was just a waste of time". "Another weakness is cash – cash is a major weakness for everybody. The VC community in Ireland is small and does not have a lot of cash. Therefore they are looking for everything – big returns, short turnarounds etc. The reality is that companies in our space in other countries such as the USA and China are having millions spent on them". When asked if there is a possibility of locating the right advisors for companies such as Bioplastech Limited within Ireland Prof. O'Connor stated "the Kerry Group have some activity in developing biotech and I have another technology which I might spin out into a new company which the likes of Kerry and others would be useful as they will have an understanding of that technology. It is a balance between telling them about your technology and telling too much and it is gone."

When asked about the future plans for the business Prof O'Connor stated, "We want to go to pilot scale and to start to validate the scaling to product which will allow us to develop further products. In seven years' time we will hope to be in a partnership with someone who will actually be producing the polymer for the market. To get to that next level we need a third party to come in and work with us - we have one company that already have a pilot plant so we are hoping to use them and put our technology into their pilot. This way there is no capital expenditure only some slight modifications. This would possibly cost €100k as opposed to multiple millions to start from scratch".

Bioplastech can be classified as a company founded on a promising technology but is yet to realise its full commercial potential. Enterprise Ireland have made attempts at guiding the company by injecting some initial seed funding and providing mentors, however a lack of technical understanding within EI about Bioplastech's potential product offerings coupled with the availability of sufficient funding to grow the company to the next level seems to be stunting the company's progress. Another issue identified was the fundamental misalignment between EI and the Bioplastech CEO on the vision for the future of the company and its potential to grow rapidly – this is in contrast to Oxymem who shared the EI vision of rapid internationalisation. The Bioplastech development story highlights the potential pit falls of spinning out too early. When the company spun out in 2009 it did not have a clear vision of the final product, target markets or a definitive business plan – this then created a lag period following spin-out where the company put a lot of energy into addressing these areas. The advice and guidance of a suitably qualified and experienced mentor may have addressed these issues at a far early stage and allowed the company to grow, however EI did not seem to have such a mentor within its support system therefore the company had to work through its issues alone.

It could be said that Enterprise Ireland was not sufficiently equipped with the internal expertise or the finances to address some of the key issues which were facing Bioplastech and the company is not a good fit for the current EI system.

4.4 APC limited:

Figure 12: APC Official Company Logo

APC limited is a chemical engineering solutions company which services pharmaceutical, biopharmaceutical and contract manufacturing operations (CMO) to ensure the delivery of robust and scale-independent production processes. The company spun-out in 2011 from the School of Chemical and Bioprocess Engineering in UCD and is still located on campus. APC currently works at a global scale with companies in R&D, commercialization, manufacturing and technology development. Its staff of 60 consists of chemical engineers, process chemists and analytical chemists with PhD, Post Doc and industrial pharma experience (APC 2015). The company's mission statement is "From lab bench to manufacturing, we bring innovation to process design and development" and its aim is to deliver unique solutions to its clients which reduce the risk, cost and time to market for new and existing pharmaceutical products. Since its formation, APC has added many of the world's top 10 multinational pharmaceutical companies to its client list (NovaUCD 2011). The company won the NovaUCD 2011 Start-up of the year Award and was the overall winner of the 2011 NovaUCD Campus Company Development Program, which is a program supported by Enterprise Ireland (NovaUCD 2011).

The current CEO and co-founder, Dr Mark Barrett, was interviewed about the spin-out of the company and how it interacted with the Irish supports. Dr. Barrett stated, "APC was started by myself and my co-founder Professor Brian Glennon out of the school of chemical and bioprocessing in UCD. We essentially were doing a lot of applied chemical engineering with a lot of the multinationals within Ireland. As a result, there was a large research consortium called the solid state pharmaceutical cluster which brought together all of the leading academics and pharmaceutical companies within Ireland. I was doing a lot of research within that consortium and it allowed us to engage with the pharmaceutical community which we had previously not been able to engage with. Under that umbrella we began to develop a lot of activity and realized that some of the technology we were developing and the research capabilities were incredibly useful to the industry so that validated the value of what we were delivering and it

created the early momentum required to establish the company. This happened in late 2011 and APC was formed. We hired our first two employees and by year end 2015 we will be up to approximately 60 employees, which are about 50% PhD qualified chemical engineers and about 50% PhD qualified scientists so it's a very large research and R&D focused team. One of the attributes that is very interesting is that we are the largest employer of PhD qualified chemical engineers in Ireland so there is a lot of really skilled scientists and engineers and we have developed a company and eco system that is catering towards high end R&D. Sometimes you just don't get that within the manufacturing community in Ireland and it is an alternative for people who are seeking a technical driven career progression."

In terms of supports used, he stated "The one thing that you are aware of when you start a company is everything costs money, so there are just overheads associated with everything – from lab rental to advertising jobs, hiring people, pension contributions, equipment depreciation. One of the first things we looked at was ways to kick off our revenue cycle. We identified two ways, one was we kick started our engagements with two companies who put a lot of faith in myself and Brian, there was no real organizational structure or equipment base but they gave us a chance and those two companies would still be our biggest partners. In parallel to that we started to engage with Enterprise Ireland and they have been fantastic in terms of supporting us. It probably took about a year to get the tangible support but it has been tremendous. Even now we are working with them (EI) on another grant. They initially supported us with a large R&D grant, I think we were one of the first start-ups under the HPSU to obtain a large R&D grant, which is a grant more often provided to medium and large enterprises. That really helped initiate our research strategy in both small and large molecules."

When describing the company's initial dealings with EI, Dr. Barrett stated "it took a bit of time working with EI for them to obtain clarity on our vision, what our purpose was and how we were going to achieve our business plan. We were essentially claiming that we were going to do big things quite quickly and I think that there is a lot of history of companies telling that to EI and not delivering. We on the other hand were in an environment where we were delivering so they were extremely supportive of us. We are still working with them on grants, training and employment expansion." "They had a number of representatives within their Life Science division that were very supportive. They see a very broad application within the Life Science sector and the origins of APC was almost a niche within a niche so it took a bit of time to talk through things and I guess they are coming from an environment where there are a lot of people under

delivering where as we are very confident of our ability to deliver. Once they saw that they prioritized their time with us and in turn prioritized the assignment of the R&D grant". In addition to finance, APC were also supplied with an EI mentor; "we were assigned a HPSU representative and he was great. He visited us a lot and was really keen on understanding how we were progressing. We have now developed beyond the HPSU space and we are classed as a medium sized established company so we have different representatives. It's going really well and I was delighted with the process because it was during the recession in Ireland and they were more than accommodating. They were never trying to personalize the revenue or the income of the company. They were always looking at the best interests of the tax payer and I think that went really well – I have nothing but respect for how they helped us."

From his dealings with EI it was very apparent to Dr. Barrett that "a real key element to EI is jobs and jobs creation. We graduated from the HPSU and met our new representative, at the time we committed to having 34 jobs by now but we have 50 so they are really focused on the jobs. Also the fact that the jobs we have created are PhD and research focused has meant that EI have tried to come up with support in any way possible. They would come up with milestones and advise you on what to put in based on your revenue cycle and job cycle to date which is a very informative process and very helpful."

Unlike many other companies who start-up within the Life Science industry, APC had a service that was immediately available to customers, therefore the challenges faced when setting up the business were very different to traditional Life Science startups. Dr. Barrett stated "not having any operational systems to run the company from business development, pipelines, internal systems, revenue systems, financial planning and modeling systems to HR systems, consumable purchasing, and space utilization systems. The company now is really being driven by all of this information which has allowed us to develop these systems and it feels very much like an operations business. You take for granted all of these systems that allow you to do your job, at the start we didn't have anything like that, therefore we were trying to grow the company by a few hundred percent every year whilst trying to establish those systems – so I would say that was the biggest challenge. However, we were extremely fortunate that we were not relying on venture capital to grow, therefore we were allowed to focus on building a company as opposed to building a business plan and trying to sell that to a VC organization."

One area where APC has encountered difficulties is in the cross over between EI and the IDA. Dr Barrett stated “we work with all of the Pharma companies within Ireland – who are all FDI investments managed by the IDA very closely, obviously we are an Irish company so we work with EI very closely.” – “it is quite difficult to engage across the IDA because we are not a multinational so the responsibility lies with EI, but we are helping the IDA based companies.”, “EI look after the Irish companies and the IDA look after the foreign companies, and that is brutally how they play it. I just think that an environment that is more conducive to enabling APC or companies like us to really drive research initiatives into these foreign multinationals, because the work that we are doing is so transformational in its impact, if it could be facilitated it would be a fantastic outcome for all.” A more collaborative approach to business supports where information is shared freely is in alignment with the “cluster model” discussed earlier (in Section 2.2) and would help in the development of companies such as APC Limited.

APC has successfully found a niche within the Irish Life Science industry and is quickly becoming a significant employer within the sector. The main benefit to EI when supporting companies such as APC, who are offering a service to the industry as opposed to a specific medicinal product, is that they do not need regulatory approval to sell their service, they are labor intensive, they require highly educated personnel and can scale very quickly. EI identified the potential within APC at a very early stage and offered every support possible to the company – this support allowed the company to grow without the need for VC funding which in turn allowed the founders to keep control of the organization. This was crucial because the company founders retained full control of the business and were allowed to grow into other areas, therefore the business developed rapidly and new opportunities emerged. The EI supports provided to APC limited addressed the companies needed in its first year which gave the company time to secure service contracts from a number of key customers and this has given the company the cash flow needed to grow the business from within.

4.5 Opsona Therapeutics Limited:

Figure 13: Opsona Official Company Logo

Opsona Therapeutics Limited was spun-out from Trinity College Dublin in 2004. It has developed a series of new candidate pharmaceutical products and strategies which treat and prevent autoimmune, inflammatory diseases as well as cancers and other infectious diseases (Opsona 2015). The companies mission statement is “We discover and develop therapeutics to restore balance to the immune system and to improve the quality of life of patients - this is achieved by the development of new compounds through the dedication and commitment of all our people.” (Opsona 2015)

Since its formation, Opsona has had a very impressve track record when it comes to raising funds for prooduct development. Initially it was funded by Enterprise Ireland and its co-founders, the company then completed a financing round in 2004 where it raised €6.25 million from a number of external sources (Enterprise Ireland 2004). This round of investment was facilitated by Enterprise Ireland who introduced Opsona to the main third party investor (Genentech) through the BioLink USA-Ireland program, a networking body facilitated by Enterprise Ireland (Enterprise Ireland 2004). The company went on to secure an agreement with the multinational pharmaceutical company Wyeth to collaborate on the development of a new treatments for chronic inflammatory diseases in 2006, for which it received a number of “milestone payments” (Opsona 2015). In 2009 a further €18 million in funding was raised from a round which enabled it to expand both at an operational and clinical level. In that same year, the company opened a new facility in Switzerland to complement the Dublin operations and is further developing its portfolio of candidate compounds. Also in 2009 the company raised a further €3.3 million from the Roche Venture Fund and Enterprise Ireland, which brought the total money raised in 2009 to €21.3 million and put the company on a strong financial footing. In 2011, the company was awarded €5.9 million from the European Commission “to lead a European framework 7 (FP7) consortium of research and clinical groups (termed MABSOT) in the advancement of clinical trials for its lead drug candidate OPN-305 in solid organ transplantation” (Opsona 2015). In 2013, the company raised another €36 million from existing investors and new investors (Opsona 2015).

A co-founder of the company, Professor Kingston Mills was interviewed about Opsona's journey. When asked how the company began, Prof. Mills stated "It started in 2004 when I, Luke O'Neill and Dermot Kelleher had intellectual property which we filed with the University and were really not doing much with it. Then Mark Heffernan came along, he went around the Irish University system looking at various IP portfolios and came to meet us individually first and then collectively, having previously reviewed our IP. He then said there was a case to set up a start-up company around our IP. We agreed and within a matter of weeks the company was setup. That was the beginning of it." Mark Heffernan became the CEO of the company and had significant previous experience due to his involvement in two Biotech start-ups in Australia. The newly formed company then approached EI for funding in the first year, when asked about their interactions with EI Prof. Mills stated "we needed to pay a salary to Mark who became the full time CEO. Therefore we needed funding to cover his salary. We also needed money for completing pitches and traveling, so we approached EI for some seed funding and they were very helpful in that initial year. Then we went out to raise an A round and we got funding from a local venture fund, Seroba, from Genentech in California, and from Inventages who are a Nestle VC fund in Switzerland." The three investment funds "were just a fraction of the funds we pitched to as there were not many options in Ireland – there never has been and there still isn't local VC's that the Biotech sector will get funding from so you have to go outside the country. Certainly for bigger rounds which involve more money you won't get it in Ireland – there just isn't the funding or the appetite for risk in Ireland that there is in Europe for the United States."

Prof. Mills stated that EI "were very much involved in the first couple of years in terms of helping us and we actually managed to secure funding from a number of EI mechanisms when starting the business. EI are very good at the inception of the company; I've had this experience with two companies, but they are not so good at following on so they tend to help the company in the very early stage. Once they have invested an amount of money they are very reluctant to follow through. I suppose you might say that that is their job, just get things going. But there is a valley where some companies get stuck. Opsona was lucky enough to be able to go out and rise substantial funding by the end of the first year of the company."

When asked about Opsona's current presence within Ireland Prof. Mills stated "Opsona does not have a product or sell a product because it doesn't have a licenced product. To get a licenced product you need to complete phase 3 clinical studies, Opsona was founded eleven years ago and is only in phase 2 now, so it is a long way off having a product. Therefore manufacture is irrelevant. What Opsona does, like every other small

biotech, is outsource the production of the material for clinical trials to CMO's. That's what every small biotech company actually does – no one makes it in-house, it is always outsourced. Most of that outsourcing is not in Ireland, and generally they are sprinkled around the world as far a China – who do a service for a fee such as product development, manufacture, production and even clinical trials which are outsourced a lot of the time. Opsona did have 23 people at one stage which was the peak of where we were in terms of employment but the numbers now are much smaller than that because of the way we operate. Like every start-up biotech when it gets to phase 1 they will in some ways downsize because they have done their research and now they are just trying to get their drug through clinical trials to go for either a trade sale or if they were lucky enough to get to phase 3 clinical trials – but to get through phase 3 would be in excess of another €100 million, so most of the small biotech's can take it to phase 3 and are acquired if they are luck enough."

Opsona Therapeutics can be describe as a successful start-up Biotech company as it has managed to secure significant amounts of funding and is progressing a drug through clinical trials. Enterprise Ireland did play a crucial role in the early start-up phase of the business, however Opsona's overall impact on employment within the Irish Life Science sector is relatively small as the company has chosen to outsource virtually all elements manufacturing, development and clinical trials to contract company's based outside Ireland. Although EI have invested a significant amount of time and finances in Opsona, the reality is that it will generate minimal employment within Ireland.

One other key element highlighted by the Opsona story is the importance of having a CEO and management structure that has the business knowledge required to pitch for additional funding and navigate the company to a point where the product is marketable. By putting an "investible CEO" at the head of the company who was not a professor that founded the technology, Opsona effectively followed the University of Florida (UF) Sid Martin Biotechnology Incubator model which was discussed section 2.6 (Breedlove 2014). Opsona removed the so called "fundamental flaw in strategy" by recruiting an experienced bio-manager and coupling that with "aggressive courting of venture capitalist" and this lead to the company becoming an attractive prospect for potential investors, this in turn meant the company was able to become financially secure in a relatively short period of time.

4.6 TriMod Therapeutics Limited:

Figure 14: TriMod Therapeutics Official Company Logo

TriMod Therapeutics Limited is a start-up biopharmaceutical company founded in 2010 based on a novel cancer treatment developed in Trinity College Dublin (TCD). The company's sole product, "TriMoVac", aimed to improve a patient's immune repose and promote the destruction of viable cancer cell within the human body thus eradicating tumours. The idea to create TriMod Therapeutics originated when the two co-founders (Dr Jeremy Skillington and Professor Kingston Mills) were working for Opsona Limited.

The company was supported by the Enterprise Ireland High Potential Start-up (HPSU) programme and successfully raised €750,000 in seed capital from the HPSU programme (Connolly 2012). This money was added to finance which was raised from an Angel investor to start the company.

The founding member, Prof. Kingston Mills (who was also a founding member of Opsona Therapeutics) was interviewed about the creation of TriMod Therapeutics. Prof. Mills stated "the company has been mothballed at the moment", "In the end it was funding. But we were trying to do something that was very complicated – it was a cancer therapy and we had two drugs that we were using in combination. A lot of the investors found it hard to get their head around the fact that we needed to have two drugs working together, it was too complicated for them. This was even compounded by the fact that we didn't actually own either of the two drugs, we owned IP around the combination of the two drugs. Even though we had licencing deals in place to bring in the two drugs and use them, investors were nervous about the use of combinations. Also, we were at a very bad time during the middle of the recession and the investor appetite for risk was the lowest it had been for ten years. Therefore people were just not willing to put money into risky businesses." "The Biotech sector is much more high risk-high return than the likes of IT or medical devices. Therefore a lot of the VC's in Ireland at the time were going for lower risk low return investments because of the shaky nature of everything at the time. So, timing was not on our side as well."

When asked about TriMod's involvement with EI Prof. Mills stated "The one issue with EI I have is that they give you some money in the first year or two and then they leave you. The effectively drop you and say "*right get on with it guys*". They need to follow

through and assist assistance with fund raising and the development of the company until it is actually going. We needed a relatively small amount of money to keep TriMod going until we could get to a proper A round, but EI, once they had given us the first lot of money that was it, they would not entertain anything else. I suppose they have their rules and their way of doing things, but we felt that they hadn't followed through on their initial investment. That initial investment wasn't insignificant and if they had given a bit more we might have been able to keep going."

When asked if he would consider revisiting TriMod in the future, Prof. Mills stated "Yes, we continue to push out IP. Universities have a very poor record of licencing IP and a lot of it sits in the University portfolios with nothing ever happening to it. The patent costs start to mount and in fact days ago I had a conversation with one of our in-house patent people asking me if I would drop a patent because even though the patent was granted they couldn't see the potential for licencing it for big pharma. The avenue which is slightly easier or at least more doable is the start-up where you do it yourself and get it to a further stage. Large pharma won't take on anything unless it has been through phase 1, so to get it through phase 1 you will not do that in academia so you have to do it through the start-up mechanism. That is why going the start-up route is almost the preferred round than trying to licence it to pharma from university."

TriMod is an example of a start-up that was founded on a promising technology but could not secure sufficient funding to make it to the next stage of development. EI did provide €750,000 of funding to the company but would not exceed that figure, even though this resulted in the company winding up operations. This is a potential area that needs to be addressed within the overall support mechanism, i.e. potentially companies could be reassessed and given additional funding (above the current EI limits) if it is deemed that they can successfully move on with the business.

Having dealt with EI during the start-up of two separate companies, one a success (Opsona Limited) and one which has stalled in its development (TriMod Therapeutics), Prof. Mills is ideally placed to comment on the system as a whole and the role EI are playing. He stated "If another Mark Heffernan was to walk in the door, I would be very tempted to restart TriMod because Mark was the catalyst for Opsona's foundation. It would never have happened if it was not for him. He brought energy; he had the enthusiasm, ability and the experience to do it. Academics don't have the time to do this unless they decide to do the very risky thing such as taking a leave of absence or cashing in your day job. To try and do this and keep your academic job going is very hard. Both Luke O'Neill and myself spent a lot of time with Opsona and it is time

consuming – if you want to do it properly you need someone there doing it full time. That is why you need someone like Mark. He was fulltime CEO of the company from the very start and devoted all of his energy to the company. He brought fantastic experience and it just wouldn't have happen without him."

One issue he identified is that there is a "very limited number of Mark Heffernan type people operating within the Biotech sector within Ireland – you could count on one hand the amount of people who have the wherewithal, the ability and the interest to go into something that is quite risky. The salary for a start-up CEO is pretty poor, and it is only when the company gets going will the CEO get properly paid. Therefore the CEO will have to give up a year or two of their life in terms of a salary. So there are very few people like that around. How do you entice them here – I just don't know, it's not easy. The US is full of people like that, if you go to California or the Boston area and look at the amount of start-ups there is far more. Obviously it is a much bigger country, but there just seems to be a different mentality in terms of risk taking and entrepreneurship. I think what Ireland needs to do is build its entrepreneurs – it is putting some things in place to help that, but by and large it has been poor. Using Mark as an example, he has a science PhD, has done an MBA and worked in business so he had the absolute perfect range of skills that were needed for a small biotech CEO. He understood the science, he understood money and he understood management. He also understood the business world and the language of how the talk to a VC. The language used when talking to a VC is not the same as the language I use when talking to my lab – that is something I learned very quickly and Mark brought that to the company immediately. That is what you need, people who understand the business side and understand the academic side."

This point raised by Prof. Mills again highlights the importance of having the correct management structure in place within a start-up Life Science company and reinforces the "lessons learned" that were identified during Penin & Wolff's (2010) study of the elements needed for a successful start-up in the biotechnology sector. It could be argued that TriMod did possess two of the three key elements for a successful start-up as it had "*Social Capital*" due to the fact that it was within an ecosystem of other start-ups and it did have "*Physical Capital*" in terms of a technology that was licenced and patient protected. But the company did not have the necessary "*Human Capital*" in the form of an entrepreneur with previous experience or a dual team of a scientific manager couples with an executive manager (Penin and Wolff, 2010). This ultimately made the company a less attractive investment proposition and was a primary cause for its inability to secure funding on the open market.

4.7 Solvotrin Therapeutics Limited:

Figure 15: Solvotrin Therapeutics Official Company Logo

Solvotrin Therapeutics Limited is a pharmaceutical drug development company that originated in Trinity College Dublin and focuses on the chemical modification of existing well established pharmaceutical products to generate novel, patent protected chemical entities which offer improved efficacy and safety when compared to the existing drugs on the market (Solvotrin 2015). The company has three main products in development which include a modified form of aspirin, a potent anti-cancer drug and a unique iron compound which has increased absorption capabilities.

The company has setup its headquarters in Cork and also has offices in the Dublin school of pharmacy and pharmaceutical sciences in TCD. The co-founder and current Chief Technical Officer of Solvotrin Therapeutics, Professor John Gilmer, was interviewed about the company's development and interactions with Enterprise Ireland. Prof. Gilmer stated, "the company started initially with EI funding and was then asked to participate in the business partners program, which was a program designed to match projects with commercial potential to experienced entrepreneurs. The experienced entrepreneurs were supposed to help to write a business plan, but my experienced entrepreneur decided to put his hand in his pocket and support the company himself", this kick started the company. "The entrepreneur put in a substantial amount of money, EI also took a stake in the company and we were classified as a HPSU. We were also supported with an innovation partnership grant from EI". Solvotrin were awarded the spinout of the year in 2010, they were given the use of the EI New York offices and introduced to a number of overseas contacts by EI.

The company went onto meet with a large number of VC funds in an attempt to secure the finances needed to develop their primary Aspirin product and bring it to phase 1 clinical trials. One large multinational pharmaceutical company, who were developing and trialing a drug with a similar therapeutic effect did show interest however due to issues outside Solvotrin's control, the development of the product did not progress further. The company has now focused its efforts on developing its Iron product which they hope to launch in mid-2016. At the moment the company employs a total of eight people.

One issue the company did see with the EI support system was that EI seemed to have a limit of €750,000 when it came to investing in a new company – which for a biotechnology company trying to develop a product to phase 1 studies is not a sufficient amount of capital. This is a similar issue which was faced by TriMod Therapeutics in its development. One recommendation made by Prof. Gilmer was “if a company can demonstrate that it has made a credible effort to deliver on a business plan, but ran into issues caused by circumstances beyond the company’s control, they should be eligible for additional finances if they can justify how they will be used.’’

The story of TriMod and Solvotrin are quite similar in that they were both founded on novel scientific discoveries but could not secure the funding necessary to bring the product into clinical trials. If these companies were successful in getting their products to clinical trials they would most probably have gone down a similar road to Opsona, i.e. outsourcing many of the functions, as this is much more cost effective way of developing a product. If the product is successful in trials the likely next step would be acquisition of the technology by an existing multinational pharmaceutical company and the product would leave the country. Therefore one must question how much the Irish economy would gain in this process. Possibly EI were correct when they decided to limit the amount of funding in Solvotrin and TriMod, as a significant investment of Irish taxpayers money into a company which may not have a long-term future in the country could be deemed as an inappropriate use of public finances – this topic will be discussed further.

4.8 Oncomark Limited:

Figure 16: Oncomark Official Company Logo

Oncomark limited is a diagnostic company which is centered on the development and application of biomarker panels, particularly supporting oncology clinical decisions and drug development (Oncomark 2015) – the companies mission statement is "to use R&D collaboration as the driving force behind how we discover, develop and validate cancer diagnostic tests for our market facing partners." The company was spun-out of UCD in 2007 and currently occupies space in the NovaUCD Belfield Innovation Park. The number of direct employees within the company has fluctuated between 10 – 20 over the life of the business to date.

One of the founding members of the company and current Chief Scientific officer, Prof. William Gallagher was interviewed about the formation of the business and the supports it leveraged. Prof. Gallagher stated, "Oncomark Ltd is a spin out company which I established with co-founder Steve Penny back in 2007 and really only got going 2 years after that. Our strategy at the time was to put in some of our own seed money and we got some EI core support - a small amount of money to check out the market opportunity of the company. The company is focused in the area of medical diagnostics with a particular focus in the oncology sector and we were looking at a couple of different technologies from my academic lab as initial product opportunities. One of them did not pan out; it was originally a product from an EI proof of concept grant which didn't really work as we couldn't validate it. The second technology we successfully got a US and EU patent issued. It is an image analysis technology and we licenced that into Oncomark Ltd as a first product opportunity. In contrast to a lot of other companies, from an academic point of view, I have a good track record in availing of EU funds. Because the EU was quite supportive of small companies we decided to target EU funds directly instead of VC funding to really grow the company. For the first year and a half after incorporation we targeted a number of grants from the EU which kicked off in the middle of 2009. Since then we have gotten 8 grants from the EU totalling close to €5 million which would directly fund R&D activities within the company. We are an R&D heavy company which is a high risk area and a lot of the discoveries we find we cannot subsequently validate so there is a lot of failure within the system. We are involved in a

risky area for people to invest. We were fortunate to have that source of EU funding to do that activity."

When asked about the company's interactions with EI, Prof. Gallagher stated "For the initial EI core grant, we participated in a campus company development program for about a year previous to the grant. It was a nine month program where they take 10 – 12 new venture ideas and go through the process of trying to mature out the concept and so Steve and I participated in that. Steve was a mature student and had come from an investment funding background for about 15 years in London and Japan so he had lot of experience in business acumen. I obviously had a scientific background and so he went back and studied biotechnology in DCU and then he spent some time in my lab. Together we decided to push forward with the campus company development program to form a company in the oncology diagnostics space. As part of that process we became aware of the supports available from EI and we then applied for the core grant."

Apart from funding, Oncomark Ltd is not using any additional supports from EI, Prof. Gallagher stated "the initial support was for scoping out a market area for the technology and we subsequently have not gotten any EI support since then. We were teeing up some investment about two years ago, we were pushing forward an investment round and we had secured in principal EI funding of €250,000 but were not able to match that at that time from external investors. So you could say that we had good support in principal from EI but we haven't subsequently gotten support or any direct funding as a company from EI to this point."

When asked about the next development stage for the company, Prof. Gallagher stated, "We need to go to the next step and get external investment from non-grant funded sources. That is the reason we have targeted a new CEO who has successfully commercialised two companies previously to the point of sale and so we needed someone who has that experience within the diagnostic industry. We have some experience but wouldn't have a lot of industry experience. We needed someone with that experience who can drive the business forward and secure external investment. We will also pursue a grant funded strategy as well because that lessens the risk for external investors.

At the moment EI are not directly involved in the company, "We would be at the fringes. In principal we fulfil the objectives of EI in terms of number of people and being a high performing start-up but we were kind of a different breed than what they are looking at. They had a six year timeframe for participating in the HP company programme but the

nature of Life Science takes a lot longer so we have slightly fallen out of that space. Every now and again we have been in contact with our point of contact within EI but no real concrete support at the moment." "There is no real need for us to go to EI at the moment. Certainly if we go back and pursue another round of investment we would consider EI but they have a limited amount of money they can provide anyway so we may or may not decide if we are going to bring them on board."

One potential weakness identified with the EI supports was "they didn't really suit our type of company; they're probably used to dealing with IT companies who are quick turnaround with low potential overheads. Whereas Life Science companies are more of a slow burner and can take a while to mature." The company had difficulties explaining the business concept to EI, "a business concept within biotech can be somewhat nebulous because you can be talking about something that is quite abstract so it is not like a piece of software. It was a potential promise of a new diagnostic but there is a long way to the validation of that technology. In the drug development space there can be 15 years from the proof of concept to actually delivering a product. So diagnostics can have a similar timeframe due to the validation of the product so it's hard for people to grasp that."

In general the company had very good initial support from EI "On an indirect level, from an academic level, we have received a lot of support from EI. The two technologies that we did licence into the company were from EI funded sources so they were two tech development grants which allowed us to successfully bring the technology forward to a point of issuing patents and licencing the technology in the first and in the second we are still pending the patent. But from a company support point of view from EI there isn't a huge amount. On the academic side when I was bidding for the EU grants we always sought very good support from EI for coordination support grants. These are small pots of money which help you bid for large EU grants which we were never turned down for and we were quite successful, above 50% for these programs. So from an academic point of view we got excellent support from EI. Once you step over into the company side we found that the supports, at least from our perspective, are quite a lot less or at least we haven't availed of them or actively pushed on them."

The Oncomark development path is quite similar to that of Bioplastec in that they were founded on novel technology but the overall trajectory and time horizon on the company did not fit with the EI template for a start-up company.

4.9 Enterprise Ireland:

Figure 17: Enterprise Ireland Official Logo

In order to gain the EI perspective on the effectiveness of the supports they offer and to assess EI's future vision for the area, an interview was completed with Brian O'Neill who is the current EI Manager of High Potential Start-Ups in the Industrial and Life Science Industry. When asked about EI's current role when it comes to supporting start-up Irish Life Science companies, Mr O'Neill stated "We play a key role in the Irish Life Science industry really from a grass roots level, we are the largest investor in Europe and we take equity in just under 200 businesses per year, of which approximately 10 – 15% would be Life Science orientated. We would be the first port of call for any entrepreneur and we look to support any entrepreneur right the way through pre commercial activities. We apply a very significant amount of a financial budget into applied research with the specific purpose of seeding and funding technology which can either be licenced by existing industry or in terms of start-ups, IP and technology platforms that can be bundled together and spun out as start-up businesses."

"In addition to being a direct investor into businesses at an early stage we would probably be the friendliest investor (for want of a better word) that you would find and we review every proposition. We have a very specific technical and commercial due diligence system before we make any decision. We would really be the definite first port of call for many entrepreneurs and founders, in fact a lot of the work that we do is what an early stage founder would have to do but they would just not have thought about it. We have very significant expertise in terms of just the sheer volume and scale of start-ups that we are involved in and we have a keen interest in backing and developing technology companies that can have a differentiated platform on an international stage."

When asked about the types of companies that EI are looking for, Mr O'Neill stated, "Really we are interested in businesses which we refer to as High Potential, have international potential, have the ability to employ at least 10 people and have international market opportunity. We also fund the local enterprise offices throughout the country which gives us a reach right down to the grass roots of the early stage entrepreneurial activity within Ireland."

“I would describe our role in the process as critical and without us there would be 200 business that would not be funded each year and really I think that in addition to being a direct investor in businesses we are also a fund of funds – as we are a limited partner in all of the seed investment programs throughout the entire country and at this point in time we have put in just short of €700 million in a seed investment scheme which is leveraged in about €1.3 billion in external finance. We have worked very closely with the private investment community to ensure that there are appropriate levels of capital available at all stages of development of business. We realise that different businesses are on different trajectories and will require different types of capital. More traditional businesses require traditional banking type facilities where as technology based and high risk companies need seed and venture types of funding. We would work closely with them to ensure that the private venture and our contributions ensue that there is sufficient capital available to support and follow on the investments that we make directly in our businesses at an early stage.”

When asked about how EI identifies potential start-ups and interacts with them Mr O’Neill stated “I think that any entrepreneur within the system will come to EI at some point”, “we get about 1000 enquiries a year, of which we finance about 450, of which 200 are equity based investments, of which approximately 100 are considered the *crème de la crème* high potential start-ups as we call them. We get a lot of people coming in our doors and we try to provide as much support to them as possible. We equally go looking for opportunities throughout the country as we have a regional spread with offices throughout Ireland. We fund the local enterprise offices which have an even wider reach then we do to the more grass route level opportunities and we want businesses to come in our doors.” One of the key roles of EI is to identify opportunities “which really have international potential and ensure that there is the right team, the right financing structure that can support a viable business proposition that can be funded by the private market – that is something that is essential, we need to see somebody that can obtain other financial supports other than us.”

Securing the finance required to kick-start the business was a key EI support utilised by all of the start-ups interviewed during the course of this study. When asked about this element of the EI supports system, Mr O’Neill stated “we do about 100 competitive start funds per year and that’s where we literally go to people who have opportunities in a specific field, maybe graduates, female entrepreneurs, overseas entrepreneurs, opportunities in aviation and manufacturing which we did last year. Also we would have general calls which we would run maybe 6 – 7 times per year. Literally we would do about 8 calls with a mix of both targeted and open calls looking for entrepreneurs with

ideas to come in the door and if successful they put in €5000 and we will put in €50,000 so the business can be funded quickly and cheaply so that they can prove their business model in as lean a manor as possible."

When asked about how EI manage the initial interactions with a potential start – up company Mr' O Neill stated "Our first port of call is to discuss the business idea, give them a mentor, give them €15,000 feasibility funding just to build an investor ready proposition, a business plan and scope out their opportunity. They may get competitive start funding, they may go to the accelerator program such as the new frontiers program where we put €15,000 tax free for six months". The company may then "apply for our competitive start fund, which would give them €50,000 and then they would come back for our HPSU money which is in the €100's of thousands."

Another issue identified when interviewing companies who started with EI support was the fact that there was a lack of experienced mentors within their specific field. When asked how this mentor pool is created Mr O'Neill stated "We are always approached and are always looking for high quality experienced mentors across all sectors and people are always willing to give back. We are always approached by people who are looking for potential opportunities as well as looking to give back to other entrepreneurs and relay their experience to others. We have built a very significant panel of mentors that we vet and we will pull mentors from all areas including finance, product development, overseas development etc. to give their expertise. We will cross reference our database and let companies pick who they want."

"We also run a business partners program that aims to help technology spin outs from third level institutions. We would get people with a very significant track record, financial wherewithal and good experience and bring technology with commercial potential to their interest so that they can bundle it together and form a start-up themselves. Not alone do we bring mentors to existing businesses but we bring people to form new businesses."

Mentoring is an area that EI are currently seeking to develop "given the sheer volume of businesses we work with now, we are undergoing a significant change program where we are putting together an accelerate program so that we wrap around all of the business we are investing in and we will provide founders networks, group coaching, facilitative group coaching, business masterclasses, overseas sales and marketing support, market access support and we will regularly meet with our clients who understand the challenges they are facing and to ensure they are getting the supports they need when they are required. We have 33 overseas offices at the moment and

they are key to ensuring that companies are identifying appropriate partners in appropriate geographic areas so they can get to markets faster, quicker and gain market traction. We hope to have this accelerator program up and running in October."

Once the start-up company has made it through the initial development stages and proven that they have a potentially viable business, many then struggle to get the necessary finance either from traditional financing mechanisms, VC funds, angel investors or government bodies required to bring the business to the next level – TriMod Therapeutics and Solvotrin Therapeutics are examples of this situation. This may be linked to the fact that the time-to-market for biotech/pharmaceutical products is very long and very risky in comparison to other sectors where EI are actively investing e.g. IT. When asked about the process of allocating additional finance to Life Science start-ups and helping them to find other sources of external finance on the open market Mr O'Neill stated "the overriding determinant to how much we invest in the business is the job creation potential for the business. Typically while biotech or Life Science businesses employ less people, the economic multiplier of those businesses operating in the economy is very substantial, they spend a lot in the economy, they employ very high value added people, they are typically employing very highly educated graduates, their average salaries are higher, their spend is higher, their research intensive, they use a lot of ancillary service providers. So while they may not have a very significant number of direct employees, it balances out in the overall context. The biggest challenge businesses face is being able to raise sufficient private sector capital to drive forward opportunities and that's why we have invested so significantly in our seed venture programs."

During the course of the interviews with companies who used EI funding, a number mentioned "milestones" which EI set as part of the funding deal. When asked about these milestones Mr O'Neill stated "we are not that different than most investors but we are interested in the development of the business for different reasons, we are not so much interested in commercial return on the business, we are more interested in the economic return on the business so we often transfer money along pre-determined milestones – either technical or commercial which are case specific and case dependent as it should be because every business is different and every business requires different interventions at different times. For example, we may release €200,000 right now and not release another €100,000 depending on the next technical or commercial milestone which is imperative to the longer term growth of that particular business."

One of the metrics EI uses to measure its performance within a given sector is the number of companies it supports and funds within a given year, this was identified as a possible issue with the Irish system when interviewing founders of companies who were successful in securing some initial investment from EI but could not obtain any follow up investment. One potential solution to this issue would be to reduce the number of companies funded by EI and give more money to companies who have a higher probability of delivering a successful business. When asked if the EI goal is to increase the overall number of start-ups or if it is to stick to a finite number and try to increase the quality of the companies Mr O'Neill stated "five years ago we were doing 65 businesses a year, now we are doing over 100 HPSU's and 100 competitive start funds - so we have gone from 65 to 200 in the space of five years. Our three year target is to do 550 start-ups, 300 of which are high potential and 250 of which are competitive start funds so certainly for this year and next year the run rate will be 100 HPSU's per year. That number is a real challenge because we are doing twice what some of our competitor economies are doing - this represents a resource challenge as our business development officers are being asked to do a lot more with less people."

"In the Life Science space we have a portfolio of approximately 350 businesses and our economic data on them have shown that our job creation and exports from these companies have been growing year on year. We have more value added business, in that they have moved up the value chain from being commodity suppliers to own brand developers to product development companies to therapeutic businesses, to diagnostic businesses to point of care business. We have really seen an explosion in terms of the Life Science start up community because when there was a wider down turn, a lot of investors started looking closely for the returns that were available and the quality of the businesses that are being set up in Ireland. So certainly our indigenous Life Science company base is highly innovative, highly dynamic, highly globalised and actually a great place to work. We have some fantastic businesses operating in the country that are global leaders."

When asked about how the EI policy and future strategy is set and if they assess what is happening in other geographic areas of the world when setting the Irish policy Mr O'Neill stated "in terms of benchmarking we always look at comparable size economies that are high tech – so we look to Finland, Denmark etcetera. In terms of our output we are twice the output of these economies. Denmark does about 49 start-ups per year, whereas we are doing over 100 high potential ones per year and up to 200 which we have put equity in. We know already that we are the largest investor in Europe from a deals basis. But we very much keep a close eye on what's going on in individual

geographies and pick the best interventions that we see. I have to say that it's typically the other way around; I spend a lot of my time working with other countries." "We are at this as a country for about 35 years, so we have actually have a very well developed industrial development system but certainly we are always looking for ways to improve and to ensure that we remain relevant to businesses and business sectors as they develop and evolve."

As EI have interacted with 100's of Irish start-ups within the Life Science sector Mr O'Neill was asked if there are any common issues identified within this sector; "Each company typically has its own specific set of challenges, but if you want to be general, I think we have a lot of learnings – we run a program specifically tailored to a subset of HPSU with the highest potential which focuses on building a team and management capabilities. You can have a mediocre idea with a fantastic leadership and management team that will go a long way further than a brilliant idea with poor execution. Leadership and management will make a bit of a difference."

Also "sales & marketing is a big challenge for companies as they really need to think about internalising from the get go because of the very fact that we are an island. Product market fit is something that is a challenge to a lot of businesses to ensure that they are investing and building a product or service that is actually required or wanted by the market and that the market is willing to pay for, and it is in a format that the market is willing to pay for. That is particularly true in the Life Science sector as we are seeing large companies becoming less willing to invest in early stages and more likely to wait until they're less risky and pay more for them. This means that there is an awful lot of impact on the type of capital and the length of time that investors have to carry investments before they can actually gain significant traction in a particular market." Most companies "that went through our accelerated growth program (approximately 60 – 70%) have pivoted which is a fancy way of saying they have tweaked or trailed or changed slightly their proposition. Initially they may have thought they would get traction in market A but they have found that if you go after A, B and C it is a more powerful proposition for the company. That is just the nature of business and I think the quicker we can provide a market feedback system to people the better, so in that regard we do a lot of work such as act for silicon valley in the US and in the UK, we do the same throughout all of our key geographic areas for our start-ups and we ensure that they are familiar with the local market, local processes and any issues that may arise. The businesses can be faced with significant technical, regulatory, financial and market specific challenges, so we work to ensure that they understand these challenges."

In terms of future goals and challenges for EI in the Life Science sector, Mr O'Neill stated that the first goal "will be ensuring that there are sufficient types of capital available, which there are right now, but really bringing business to scale is the next frontier for us. We also see very exciting businesses that have true global potential selling before they really need to sell; this is possibly due to risk aversion or more specific issues." "My focus is scale; also there are market opportunities that are going to open up in Asia. These are markets that are different to do business in but really with the explosion in the number of middle income consumer spending, we expect to see very significant opportunity and that is why we are increasingly opening offices in China and in the Middle East and Asian economies."

As a closing comment about the current state of the Irish Life Science sector Mr O'Neill stated "Life Science businesses have to be global from the get go, global systems and the macroeconomic environment drivers also impact indigenous businesses. While most talk about consolidation of the larger MNE's, the flip side to that is that there is an insatiable desire amongst the global multinational community for next generation technology and opportunity. That really creates an opportunity for economies who are investing in the early stage high potential businesses which provide the next generation technology who then become international beacons for innovation. It actually creates great opportunity, so I actually think that there has never been a better time to set up an early stage Life Science business because you have more interest from the global market than you've ever had before". "No one country, no one company, no one economy can have a monopoly on the Life Science space because it is so complex, is multi-disciplinary, involves more stake holders than it has ever before and it involves more disciplines than ever before. That puts economies like Ireland and those that invest in, and continue to invest in, the research that underpins these businesses and follow it up with early stage seed funding, incubation and venturing of businesses in a very strong position as global MNE's and the general global community are increasingly looking for new products and services to meet medical and clinical needs of society."

Based on the information publically available on EI and the findings of the interview with Mr. Brian O'Neill it is clear that EI are aware of the challenges and opportunities which exist in the Irish Life Science sector. They are actively seeking to address the key areas of funding, business development & mentoring and the internationalisation of Irish Life Science companies through the implementation of a number of mechanisms. The impact of these initiatives remains to be seen.

4.10 Summary of Research Findings:

The key measure of “success” for the companies which were assessed during this research is the level of employment generated by the business; this success indicator was selected because it is the primary goal of the Enterprise Ireland support mechanisms. One of the key EI criteria for a High Potential Start-up Company is that it must be capable of creating at least 10 jobs in Ireland - therefore for the purposes of this dissertation, any company which created 10 or more new jobs in the Irish Life Science sector was deemed a “successful start-up”.

Table 3 gives an overview of the research findings by presenting the primary EI supports used by each company, the number of jobs created and a current status of the business.

Four of the seven companies researched were classified as “successful start-ups” and a total of 145 new jobs in the Irish Life Science sector were created across all seven businesses. The over-all EI funding provided to these companies was in the region of €3 million (this is an estimated figure as some companies did not wish to disclose financial details); which translates to approximately €21,000 per job created (excluding the cost of providing non-financial EI supports). This is a strong return on the EI investment when one considers that the current average salary in the Life Science sector is far in excess of the average industrial wage of €32,500 (Brightwater 2015).

The data collected during the course of this dissertation generated the information needed to address the primary research question that was discussed in Section 1.4 as the EI supports utilised by each company were identified and the effectiveness of the supports from the perspective of the company founders was determined. The interview with the EI HPSU Manager also generated the data required to gain an understanding of the support bodies’ primary objectives, its strategy for the Life Science sector and what actions it is taking to address the problems the sector is facing.

The implications of these findings are discussed further in Chapters 5 and 6.

Company:	Year Formed:	EI Supports Used:	Jobs Created:	Successful Start-Up:	Current Status:
OxyMem Ltd	2013	- Seed Funding of €250,000. - Commercial contacts and business partner identification.	30	Yes	External finance secured and company growing strongly. Projected to develop its presence in Ireland and grow employment.
Bioplastech Ltd	2009	- Business plan creation and advice. - Proof of concept funding.	4	No	Development stunted due to lack of finance. Currently working on a number of products which could lead to future business development.
APC Ltd	2011	- R&D grant at early stage. - Business plan development.	60	Yes	Large customer base created and company growing strongly. Projected to be a significant employer within the Irish Life Science Sector.
Opsona Therapeutics Ltd	2004	- Seed funding during early stage of the business. - Additional funding in a later round. - Assistance in identifying external investors.	23	Yes	Currently progressing products through phase 2 clinical trials; although the employment presence has diminished as much of the R&D activities in Ireland have been completed.
TriMod Therapeutics Ltd	2010	- HPSU seed capital of €750,000.	0	No	Development stunted due to lack of finance. Currently no plans to develop the company further.
Solvotrin Therapeutics Ltd	2010	- HPSU seed capital of €750,000. - Use of the EI office in NYC and introduction to contacts.	8	No	Projected to launch Iron product to market in 2016. A successful launch will potentially increase its manufacturing presence in Ireland and increase employment.
Oncomark Ltd	2007	- EI core grant of €250,000.	20	Yes	Currently installing a new CEO and actively seeking additional external investment to grow its product portfolio and commercialese patented technologies.

Table 3: Summary of Primary Research Findings.

Chapter 5: Discussion

5.1 Introduction:

Although all seven companies researched as part of this study operate in very different areas of the Irish Life Science sector, a number of similarities were identified with respect to their interactions with Enterprise Ireland and how the companies used the EI supports offered to them. In all cases the company founders were very positive about their initial interactions with EI; all accepted seed funding to explore the potential of their business, all were provided with business mentors and all were put in contact with experienced business partners. In some cases these business contacts became large investors and fundamental parts of the management structure within the company. In most circumstances the company founders acknowledged that they would not have been able to make it through the early development stages without the supports provided by EI.

5.2 Interactions with Enterprise Ireland:

Although the initial interactions with EI were similar for all seven companies, their development stories began to diverge at approximately the one year mark and they can be classified into three distinct groups based on their experience and interactions with Enterprise Ireland;

1. *Financially Self Sufficient*:

   APC, Oxymem and Opsona quickly became financially self-sufficient by either generating cash flow through growing their customer base or by raising significant investment from VC funds and angel investors. This allowed EI to effectively take a back seat in the company's development and focus its energy on the identification of new opportunities. In terms of the number of jobs created relative to the amount of EI funding and support required these companies are excellent examples of how an effective and well-managed support function can have a significant economic impact. Between the three companies they have created over 100 new jobs (the majority of which are highly skilled) and in the case of APC and Oxymem, these companies look set to have a presence within Ireland for many years to come. This is the space where the current EI support mechanisms are most effective i.e. they give a promising young company some seed funding and mentoring in the early stages which then allows the company

to develop to a point where it can support itself. This is the true value of EI to the Irish economy and these are types of companies EI are actively seeking. The progress of these companies also highlights just how critical external finances are to the development of the business.

2. *Conflicting Vision for the Business :*

   In the case of Bioplastec and Oncomark, there was a fundamental misalignment between the EI vision for company's development and the founder's vision. The source of this misalignment was the length of time it would take to develop the companies to a point where they saleable products. This is particularly true for Bioplastec and led to its founder being reluctant to engage fully with the EI. The development (or lack thereof) of these two companies does not necessarily reflect entirely negatively on the EI support process as the same supports were made available to both companies in their early development stages and these were utilised to grow the businesses to a point. Also, these supports are still available to the companies and both CEO's regularly "check-in" with EI in order to maintain an active working relationship. These two cases highlight the importance of "fit" between the start-up and the support systems in terms of vision for the business and development time lines. EI have a clear vision and criteria for what defines a HPSU; although both of these companies were classified as HPSU's initially, they are yet to achieve their full potential. Both companies expressed an interest in reengaging with EI at some point in the future if required.

3. *Promising Company, Insufficient Funding:*

   TriMod and to some extent Solvotrin can be classified as companies who have very promising medicinal products but to date have not secured the funds required to bring the projects to the next level – this is a direct contrast to the three companies that became financially self-sufficient within the first year. One issue which was raised by the founders of both companies was that EI seemed to have strict internal rules on the level of funding provided to each company (capped at €750,000 based on the experience of the two companies). Both companies recommended that the EI rules should be made more flexible and companies who have a potentially viable product should be eligible for additional funding. However whether or not EI should invest large sums of money into start-ups is debatable - in order to address this issue one must go to

the core of what EI is looking to achieve within the Irish economy (this issue will be discussed further in section 5.3).

5.3 The Role of Enterprise Ireland:

Some company founders who were interviewed during the course of this study were of the opinion that the role of EI should be to identify potentially high value Life Science innovations and support these innovations to the point where the technology is saleable; they accepted that this strategy is high risk but there would be potentially high financial returns for EI if successful. However, the findings of this study clearly show that EI are not in the business of making high risk investments with taxpayer's money in order to make a financial return. In the interview with Mr O'Neill he stated that EI's primary focus is not on a commercial return on their investment, rather they are looking for an economic return in the form of job creation.

When one looks at the EI investment strategy in this light it makes perfect sense for the support body to distribute their budget across as many start-up companies as possible and to grow the level of R&D activity which in turn creates high value jobs. The one caveat to this strategy is that the potential start-up companies must pass the due diligence processes which EI have in place – this is a prudent and effective way of managing EI's resources. Also measuring EI's annual performance based on the overall number of companies started is an appropriate metric for gauging their success as it keeps the organisation focused on this key area. However EI could benefit from the introduction of additional more sophisticated measures, such as the ones used by the University of Florida Incubator (discussed in section 2.6) which included metrics on company survival rates, total funding, regulatory progress, patents, corporate partnerships, acquisitions, IPO's, number of products to market and number of local jobs created (Breedlove 2014).

5.4 EI Strategy:

An assessment of the "types" of Life Science companies supported by EI was completed based on the findings of this study in order to guage the effectiveness of the support mechanism. The majority of EI supported companies studied (with the exception of Oxymem and APC Ltd, who have products that do not require the same level of regulatory approval) are active in the Lead Selection, Pre-Clinical, Phase I and Phase II stages of product development. Therefore this study has confirmed that the

current EI supports are delivering on their objective of growing the level start-ups based on indigenous R&D and that EI strategy is attempting provide an effective system where companies can develop their technology to a “proof of concept” stage. This is a strategy supported by PharmaChemical Ireland who (as stated previously) are adamant that “If the industry in Ireland is to survive and prosper, it needs to remain strategically relevant – this means investment in the development of new technologies such as biotechnology”, refer to figure 2 for an overview of the process (Moran 2013).

Once EI have helped the company reach a stage where it is ready to pitch for additional third party funding the supports reduce and it is expected that the company should then start to become self-sufficient. If the business is genuinely viable and there is a market for what it is offering then it will more than likely be successful in obtaining the required funding on the open market – as was the case with Opsona Therapeutics and Oxymem Limited. The VC funds and angel investors who are active in the global Life Science sector are extremely experienced when it comes to investing in start-ups and have a wealth of expertise which is used to assess the feasibility of each business. Arguably they are far better placed then EI when it comes to assessing the potential financial return on a business investment.

If a start-up company is not successful in securing VC funding on the open market to develop their product further, then one could conclude that EI are correct to not allocate additional funds to that business. Instead these funds should be diverted to a new start-up which at a minimum will create new R&D employment opportunities within the local Irish sector.

5.5 Importance of Leadership:

Another key element which was identified during this study was the importance of installing an effective management and leadership structure within the company. Ideally this management structure should be put in place early (prior to spinning out the business) as it provides a platform upon which the company can grow. All of the successful companies reviewed in this study had a strong CEO who drove a clear vision for the company that was communicated effectively to potential investors – Oxymem Ltd is a prime example as they had a long term vision for the business from its very inception. Having this strong base in place from an early stage was a key enabler for the growth of the business and was critical when it came to securing additional funding outside the EI support process.

EI can play a vital role in the creation of strong leadership teams within Irish Life Science start-ups through the provision of appropriately experienced business mentors who can guide the business in the early stages and even become part of the management team – this was effective in the case of Oxymem Ltd. However, this study has highlighted that EI need to do more work on their offerings in this area and it needs to grow the level of expertise within its mentor pool. This is a point EI did acknowledge during the interview and the support group is seeking to address this issue.

Chapter 6: Conclusions

6.1 Introduction:

This study set out to assess a range of Irish start-up companies in the Life Science sector, determine how they are using the Enterprise Ireland supports available and if these support structures are meeting the needs of each company. The development paths taken by each of the seven companies' studied was very different and each company used the EI supports to varying degrees depending on their business model. All companies studied, received the same initial supports from EI in the form of seed funding and coaching / mentoring which facilitated the initial growth within the business. One theme that was identified in all cases was that the current Irish system is effective at funnelling Life Science start-ups into the EI support system; this indicates that the current EI network throughout the country is an appropriate model for identifying high potential companies. Based on the findings from the interviews it was clear that all company founders were aware of the supports available from Enterprise Ireland and engaged with the support system at a very early stage in their business development.

6.2 Implications and Recommendations:

A critical finding from this study was that the companies supported by EI did generate new employment within the Life Science sector which met the core objectives of Enterprise Ireland. Approximately 145 highly skilled Life Science jobs were created across the development lifecycles of the seven companies studied; this is equivalent to a medium size "Big Pharma" manufacturing facility and supports the hypothesis that a vibrant indigenous Life Science sector can create enough employment within Ireland to reduce the sectors dependence on foreign multinationals. Job creation in this area also has a significant multiplier effect for the broader economy as it has been shown to stimulate jobs in support services – a study completed by the University of Massachusetts estimated that between 3.6 - 5 additional jobs are generated from the creation of every 1 direct Life Sciences job (Deval L 2008).

The findings of this study did identify two key areas where the current system is in need of development and the following recommendations have been made;

1. *Support for Securing External Finances:*

   Additional support is required when it comes to helping Irish companies secure funding on the open market to further develop their businesses. The majority of companies interviewed stated that the VC funds currently operating within

Ireland are not meeting their needs and they had to seek finance outside the country. EI may not have the ability to improve the local EI funds in Ireland, but the support body could use its extensive global network to link Irish companies with appropriate funds that would be more likely to invest in Life Science start-ups. This may improve the success rates of Irish start-ups.

2. *Mentoring System Development:*

   The provision of business mentors with the necessary experience and capabilities required to guide relatively inexperienced academic entrepreneurs in the business world is another area where EI needs to develop its offering. The study completed by Shiri M. Breznitz (2013) (discussed in section 2.2) on why the Israeli Life Science cluster remains unsustainable identified that the Israeli sector "is suffering from a lack of knowledge of later stage Life Science production" (Breznitz 2013). Ireland has developed an extensive amount of expertise within this area due to the presence of multinational pharmaceutical companies in the country for over 50 years. Because of this, Ireland possesses a significant pool of business experts in all areas of Life Science company development. EI should look to this pool of people when attempting to strengthen the mentor program.

EI have recognised these two areas as opportunities to develop their current offerings and are currently addressing them through the implementation of a number of initiatives. The impact of these initiatives may form the basis of further research within the area of Life Science start-ups.

Another area where the Irish system could grow is in the creation of links between indigenous companies which may lead to advantages such as collaborations, economies of scale and the formation of clusters of companies who can support each other as opposed to relying on EI. Although this topic of cluster formation was outside the scope of this dissertation and was not specifically discussed during the collection of primary research, the cluster model of Life Science development has been researched heavily (as described in section 2.2) and the creation of Life Science clusters within Ireland could also be an area for further research in the future. At the moment one could see it as somewhat of a missed opportunity.

6.3 Contributions and Limitations of this Research:

This research achieved its primary objective and identified a number of areas where the current support system is meeting the needs of start-up Life Science companies and areas where the system requires further development. The level of employment created from the seven companies profiled in this study supports the hypothesis that development within the indigenous Irish Life Science sector has the ability to generate significant levels of high value employment and can reduce the sectors dependency on foreign multinational companies. This study also found that Enterprise Ireland are aware of these issues facing Irish Life Science start-ups and are actively seeking to address them through the introduction of new support mechanisms and initiatives.

This dissertation could be described as “exploratory research” within the area of Life Science start-up development, therefore one expected limitation of this report is that the sample size of companies studied is relatively small when compared to the number of companies that EI support within the Life Science sector. The findings of this exploratory research could be used to develop further studies that target a larger sample size of companies – these additional studies could then verify (or challenge) the findings of this dissertation. This verification would be required in order to support the recommendations made prior to the implementation of any actions.

6.4 Final Conclusions and Reflections:

In conclusion, the ecosystem within the Irish Life Science sector created by the Enterprise Ireland is conducive to the formation of new businesses and as a result has the potential to create a sizeable level of high skilled new employment. This indigenous employment will never eliminate Ireland’s dependence on foreign multinational Life Science corporations, but it may prove to be an effective protection against global market fluctuations such as large scale mergers & acquisitions and the movement of bulk production to geographic areas which have a lower cost base. EI’s strategy of focusing on increasing the number of start-ups year-on-year is an effective way of generating as much economic activity from their resources as possible and improvements in the provision of funding and mentoring can only make for a stronger sector in the future.

Chapter 7: Bibliography

APC, 2015. APC: Official Company Website. Available at: http://www.approcess.com/.

Bioplastech, 2015. Bioplastech: Official Company Website. Available at: http://www.bioplastech.eu/.

Breedlove, P., 2014. Overcoming the odds: How to incubate fledging bioscience companies. *Nanotechnology Law & Business*, 101, pp.101–106.

Breznitz, S.M., 2013. Cluster Sustainability: The Israeli Life Sciences Industry. *Economic Development Quarterly*, 27(1), pp.29–39.

Brightwater, 2015. Brightwater Salary Survey 2015. Available at: http://www.brightwater.ie/docs/default-source/salary-surveys/salary-survey-2015.pdf?sfvrsn=2.

Burke, El., 2013. Pfizer seeking 150 redundancies in Newbridge plant. *SIliconRepublic*. Available at: http://www.siliconrepublic.com/business/item/35058-pfizer-seeking-150/.

BusinessEtc, 2013. 570 job losses at pharmaceutical company in Dublin. Available at: http://businessetc.thejournal.ie/job-losses-msd-dublin-1196799-Nov2013/.

Calvert, J. & Senker, J., 2004. Biotechnology innovation systems in two small countries: a comparison of Portugal and Ireland. *Science & Public Policy (SPP)*, 31(5), pp.359–370.

Connolly, P., 2012. HPSU startup of the day: TriMod Therapeutics. *The Daily Business Post*. Available at: http://www.businesspost.ie/#!story/Home/News/HPSU+startup+of+the+day%3A+TriMod+Therapeutics/id/19410615-5218-4f8d-774f-9baf50201850.

Cooke, P., 2002. Biotechnology Clusters as Regional, Sectoral Innovation Systems. *International Regional Science Review*, 25(1), pp.8–37.

CSCB, 2008. Dr Kevin O'Connor wins NovaUCD Start-up award. Available at: http://www.ucd.ie/cscb/main_pages/news/news211108.html.

Deval L, P., 2008. FY2010 House 1 Budget Recommendation: Policy Brief. Available at: http://www.mass.gov/bb/h1/fy10h1/prnt10/exec10/pbudbrief23.htm.

Enterprise Ireland, 2004. Enterprise Ireland Annual Report and Accounts 2004: Opsona Therapeutics Ltd. Available at: http://www.enterprise-ireland.com/annualreport2004/opsona.html.

Enterprise Ireland, 2015. Enterprise Ireland: Research Commercialisation. Available at: http://www.enterprise-ireland.com/en/Researchers/Research-Commercialisation-Supports/.

Enterprize Ireland, 2015. Enterprise Ireland:Technology Transfer Supports. Available at: http://www.enterprise-ireland.com/en/Researchers/Technology-Transfer-Support-System/.

Enzing, C., van der Giessen, A. & Kern, S., 2004. Commercialisation of biotechnology: do dedicated public policies matter? *Science and Public Policy*, 31(5), pp.371–383.

ERM, 2014. What is your paradigm. Available at: http://www.erm.ecs.soton.ac.uk/theme2/what_is_your_paradigm.html.

Hine, D. & Kapeleris, J., 2006. Innovation and Entrepreneurship in Biotechnology, an International Perspective, Concepts, Theories and Cases. *Cheltenham, UK: Edward Elgar*.

Hunt, V., Manson, N. & Morgan, P., 2011. A wake-up call for Big Pharma, Lower profit margins suggest a need for new business models. Available at: http://www.mckinsey.com/insights/health_systems_and_services/a_wake-up_call_for_big_pharma.

Kennedy, J., 2013. 280 pharmaceutical jobs to go at MSD plant in Wicklow. *SIliconRepublic*. Available at: http://www.siliconrepublic.com/business/item/31782-280-pharmaceutical-jobs-to/.

Mac Coille, C. & Gorman, J., 2012. Ireland and the Pharma Patent Cliff. Available at: http://www.davy.ie/content/pubarticles/patentcliff20121128.pdf.

McAdam, M. & Marlow, S., 2007. Building Futures or Stealing Secrtes?: Entrepreneurial Cooperation and COnflict within Business Incubators. *International Small Business Journal*, 25(4), pp.361 – 382.

McAleer, M., 2014. Taoiseach lauds entrepreneurs at “Irish Times” Innovation Awards. *Irish Times*. Available at: http://www.irishtimes.com/business/taoiseach-lauds-entrepreneurs-at-irish-times-innovation-awards-1.1759304.

McSorley, A., 2015. 18 job losses at Waterford pharmaceutical site. Available at: http://utv.ie/News/2015/01/09/18-job-losses-at-Waterford-pharmaceutical-site-25941.

Medical Marketing, 2003. R&D Costs are on the rise. Available at: http://www.highbeam.com/doc/1G1-102908512.html.

Moran, M., 2013. Irish pharmachem industry fights to maintain its global position. Available at: http://www.engineersjournal.ie/irish-pharmachem-industry-fights-to-maintain-its-global-position/.

Mullin, R., 2014. Cost to Develop New Pharmaceutical Drug Now Exceeds $2.5B. *Scientific American*. Available at: http://www.scientificamerican.com/article/cost-to-develop-new-pharmaceutical-drug-now-exceeds-2-5b/.

Nosella, A. & Grimaldi, R., 2009. University-level mechanisms supporting the creation of new companies : an analysis of Italian academic spin-iffs. *Technology Analysis & Strategic Management*, 21(6), pp.679 – 698.

NovaUCD, 2011. APC, A New Pharmaceutical Research and Technologies Company, Wins the NovaUCD 2011 Start-Up Award. Available at: http://www.ucd.ie/nova/mediacentre/2011pressreleases/novanewstitle,109725,en.html.

Oncomark, 2015. Oncomark: Official Company Website. Available at: http://www.oncomark.com.

O'Neill, B., 2011. Enterprise Ireland: Helping Irish companies achieve global success. Available at: http://www.dkit.ie/system/files/DKIT%20Pharma%20Presentation-brian%20o%20neill.ppt.pdf.

Opsona, 2015. Opsona Therapeutics: Official COmpany Website. Available at: http://www.opsona.com.

O'Riordan, S., 2012. More job losses likely at pharma giant Pfizer. *Irish Examiner*. Available at: http://www.irishexaminer.com/ireland/more-job-losses-likely-at-pharma-giant-pfizer-196477.html.

Oxymem, 2015. Qxymem: History. Available at: http://www.oxymem.com/history/.

Peinin, J. & Wolff, S., 2010. Start-up Creation in Biotechnology: Lessons from the case of four new ventures in the upper Rhine Biovalley. *Internation Journal of Innovation Management*, 14(2), pp.253–283.

PharmaChemicalIreland, 2014. Pharmaceutical Industry Profile in Ireland. Available at: http://www.pharmachemicalireland.ie/Sectors/PCI/PCI.nsf/vPages/About_us~industry-profile?OpenDocument.

PhRMA, 2013. The Economic Impact of the U.S. Biopharmaceutical Industry. Available at: http://www.phrma.org/sites/default/files/pdf/The-Economic-Impact-of-the-US-Biopharmaceutical-Industry.pdf.

Porter, M., 2000. Location, competition and economic development: local clusters in a global economy. *Economic Development Quarterly*, 14, pp.15–34.

Reiss, T., Hinze, S. & Lacasa, I.D., 2004. Performance of European Member States in biotechnology. *Science & Public Policy (SPP)*, 31(5), pp.344–358.

Robinson, C., 2002. *Real World Research. A Resource for Social Scientists and Practitioner-Researchers*, (Second Edition). Malden: Blackwell.

Rockoff, J.D., 2009. Merck to Buy Rival for $41 Billion. *Wall Street Journal*. Available at: http://www.wsj.com/articles/SB123659326420569463.

RTE, 2014. 160 jobs to go at Bristol-Myers Squibb. Available at: http://www.rte.ie/news/2014/0306/600602-bristol-myers-squibb/.

Ryan, V., 2013. Pharma patent cliff continues to eat into country's export performance. *The Irish Examiner*. Available at: http://www.irishexaminer.com/business/pharma-patent-cliff-continues-to-eat-into-countrys-export-performance-246367.html [Accessed November 5, 2013].

Salvador, E. & Rolfo, S., 2001. Are Incubators and Science parks effective for research spin-offs? Evidance from Italy. *Science and Public Policy*, 38(3), pp.170–184.

SFI Ireland, 2013. SFI Mission Statement. Available at: http://www.sfi.ie/about/vision-mission-statement.html.

Siggins, L., 2014. Beckman Coulter to close Galway plant with 140 job losses. *Irish Times*. Available at: http://www.irishtimes.com/business/health-pharma/beckman-coulter-to-close-galway-plant-with-140-job-losses-1.1949341.

Smilor, R.., 1997. Entrepreneurship: Reflections on a Subcersive Activity. *Journl of Business Venturing*, 12(3), pp.314 – 346.

Smilor, R.. & Gill, M.., 1986. *The New Business Incubator: Linking Talent, Technology, Capital and Know-How*,

Solvotrin, 2015. Solvotrin Therapeutics: Official Company Website. Available at: http://www.solvotrin.com/.

Staton, T., 2014. Pfizer's post-megamerger cost-cutting record? 51,500 jobs in 7 years. *Fierce Pharma*. Available at: http://www.fiercepharma.com/story/pfizers-post-megamerger-cost-cutting-record-51500-jobs-7-years/2014-04-29.

Thomas, K., 2013. Merck Plans to Lay Off Another 8,500 Workers. *New York Times*. Available at: http://www.nytimes.com/2013/10/02/business/merck-plans-to-lay-off-8500-workers.html?_r=1.

Totterman, H. & Sten, J., 2005. Start-ups: Business Incubation and Social Capital. *International Small Business Journal*, 23(5), pp.487 – 511.

UCD, 2014. UCD spin-out, OxyMem announced overall winner at the 2014 Irish Times InterTradeIreland Innovation Awards. Available at: http://www.ucd.ie/news/2014/04APR14/100414-UCD-spin-out-OxyMem-announced-overall-winner-at-the-2014-Irish-Times-InterTradeIreland-Innovation-Awards.html.

Uctu, R. & Jafta, R.C.., 2013. Bio-entrepreneurship as a bridge between science and business in a regional cluster: South Africa's first attempts. *Science & Public Policy (SPP)*, 41, pp.219–233.

UniversityWatchdog, 2009. The Capitulation of Science Foundation Ireland. Available at: http://universitywatchdog.wordpress.com/category/science-foundation-ireland/.

Urbig, D. et al., 2013. Investor Reactions to New Product Development Failures The Moderating Role of Product Development Stage. *Journal of Management*, 39(4), pp.985–1015.

Chapter 8: Appendix

Appendix 1: Interview transcript from Enterprise Ireland interview.

Appendix 2: Example of interview with a start-up company and CEO.

Appendix 1: Interview transcript from Enterprise Ireland interview.

Brian O'Neill - Enterprise Ireland Manager of Life Sciences:

Q: Can you give an overview of the role EI plays in supporting Irish Life Science Companies?

"We play a key role in the Irish life science industry really from a grass roots level, we are the largest investor in Europe and we take equity in just under 200 businesses per year, of which approximately 10 – 15% would be life science orientated. Really we would be the first port of call for any entrepreneur and we look to support any entrepreneur right the way through pre commercial activities. We apply a very significant amount of our financial budget into applied research with the specific purpose of seeding and funding technology which can be either licenced by existing industry or in terms of start-ups IP and technology platforms that can be bundled together and spun out as start-up businesses."

"In addition to being a direct investor into businesses at an early stage we would probably be the friendliest investor (for want of a better word) that you would find and we review every proposition. We have to a very specific technical and commercial due diligence system before we make any decision. We would really be the definite first port of call for many entrepreneurs and founders, in fact a lot of the work that we do is what an early stage founder would have to do but they would just not have thought about it. We have very significant expertise in terms of just the sheer volume and scale of start-up that we are involved in and we have a keen interest in backing and developing technology companies that can have a differentiated platform on an international stage."

Q: What types of companies are EI looking for?

"We are interested in businesses which we refer to as High Potential, have international potential, have the ability to employ at least 10 people and have international market opportunity. We also fund the local enterprise offices throughout the country which gives us a reach right down to the grass roots of the early stage entrepreneurial activity within Ireland."

"I would describe our role in the process as critical and without us there would be 200 business that would not be funded each year and really I think that in addition to being

a direct investor in businesses we are also a fund of funds – as we are a limited partner in all of the seed investment programs throughout the entire country and at this point in time we have just put in short of €700 million in seed investment scheme which is leveraged in about €1.3 billion in external finance. We have worked very closely with the private investment community to ensure that there appropriate levels of capital available at all stages of development of business. We realise that different businesses are on different trajectories and will require different types of capital. More traditional businesses require traditional banking type facilities where as technology based and high risk companies need seed and venture types of funding. We would work closely with them to ensure that the private venture and our contributions ensue that there is sufficient capital available to support and follow on the investments that we make directly in our businesses at an early stage."

Q: Do businesses typically approach EI or does EI actively seek new opportunities?

"It's a mix of both; I think that any entrepreneur within the system will come to EI at some point. Secondly I think that we get about 1000 enquiries a year of which we finance about 450 of which 200 are equity based investments of which approximately 100 are considered the cram-de-la cram high potential start-ups as we call them. We get a lot of people coming in our doors and we try to provide as much support to them as possible. We equally go looking for opportunities throughout the country as we have a regional spread with offices throughout Ireland. We fund the local enterprise offices which even have a wider reach to the more grass route level opportunities and we want businesses to come in our doors. And we want people with ideas and really the trick is identifying the opportunities which really have international potential and ensure that there is the right team, the right financing structure that can support a viable business proposition that can be funded by the private market – that is something that is essential, we need to see somebody that can obtain other financial supports other than us."

"We have a variety of programs at different stages, New Frontiers which is held out of our institutes through the country where you would have early stage entrepreneurs who are put on accelerator programs to help them build and develop their proposition. Similarly we work closely with the BIC (business innovation centres), Dublin BIC, Cork BIC, West BIC in terms of helping the system build propositions on our behalf and with us. We would be very closely integrated into a wide range of directive and support

mechanisms. Certainly we do directly go to the markets. For an example, we do about 100 competitive start funds per year and that's where we literally go to people who have opportunities in a specific field, maybe graduates, female entrepreneurs, overseas entrepreneurs or opportunities in aviation and manufacturing which we did last year. Also we would have general calls which we would run maybe 6 – 7 times per year so literally we would do about 8 calls with a mix of both targeted and open looking for entrepreneurs with ideas to come in the door and if successful they put in €5000 and we will put in €50,000 so the business can be funded quickly and cheaply so that they can prove their business model in as lean a manor as possible."

Q: Would that be stage one of the interaction, looking at the business concept?

"No, the first stage of interaction (we get about 1000 enquiries a year), someone would ring up or come to us with a business idea and we take it from there. Our first port of call is to discuss the business idea, give them a mentor and give them €15,000 feasibility funding just to build an investor ready proposition, a business plan, and scope out their opportunity. They may get competitive start funding or they may go on to the accelerator program such as the new frontiers program where we put €15,000 tax free for six months."

"We have a variety of different inventions and they may apply for our competitive start fund, which would give them €50,000 and then they would come back for HPSU money which is in the €100's of thousands. There is a gambit of ways in which entrepreneurs and early stage businesses can work with us and we have tools and instruments which reflect the makeup of the industry that is out there so that business that have different trajectories and business which are in different sectors have supports which are appropriate to their needs."

Q: How do you build the network of mentors and assign them to various companies?

"We are always approached and are always looking for high quality experienced mentors across all sectors and people are always willing to give back. We are always approached by people who are looking for potential opportunities as well as looking to give back to other entrepreneurs and relay their experience to others. We have built a very significant panel of mentors that we vet and we will pull mentors from all areas including finance, product development, overseas development etc. to give their

expertise. We will cross reference our database and let companies pick who they want."

"We also run a business partners program to help technology spin outs from third level institutions where we would bring people with very significant track record, financial wherewithal and good experience and take technology with commercial potential to their interest so that they can bundle it together and form a start-up themselves. Not alone do we bring mentors to existing businesses but we bring people to form new businesses."

Q: Who mentors the business?

"When the businesses come in the door they will be assigned a senior business development advisor to work with them. Given the sheer volume of businesses we work with now we are undergoing a significant change program where we are putting together a accelerate program so that we wrap around all of the business we are investing in and we will provide founders networks, group coaching, facilitative group coaching, business masterclasses, overseas sales and marketing support and market access support. We will regularly meet with our clients who understand the challenges they are facing and to ensure they are getting the supports they need when they are required. We have 33 overseas offices at the moment and they are key in ensuring that companies are identifying appropriate partners in appropriate geographies so they can get to markets faster, quicker, earlier and gain market traction earlier. We hope to have this accelerator program up and running in October. So, that is just an addition to our work."

Q: The time to market for the product can be quite lengthy and you don't see a return in the short term – is this issue when allocating funding to companies?

"No, the overriding determinant to how much we invest in the business is the job creation potential for the business. Typically while biotech or life science businesses employ less people, the economic multiplier of those businesses operating in the economy is very substantial. They spend a lot in the economy, they employ very high value added people, they are typically employing very highly educated graduates, there average salaries are higher, their spend is higher, their research intensive and they use a lot of ancillary service providers. So while they may not have a very significant number of direct employees, it balances out in the overall context. The biggest

challenge business face is being able to raise sufficient private sector capital to drive forward opportunities and that's why we have invested so significantly in our seed venture programs."

Q: When you do identify a HPSU and make a significant investment, do you set out milestones for the company to achieve?

Yes, we are not that different than most investors but we are interested in the development of the business for different reasons, we are not so much interested in commercial return on the business, we are more interested in the economic return on the business so we often transfer money along pre-determined milestones – either technical or commercial which are case specific and case dependent as it should be because every business is different and every business requires different interventions at different times. For example, we may release €200,000 right now and not release another €100,000 depending on the next technical or commercial milestone which is imperative to the longer term growth of that particular business."

Q: How do you set the EI policy and strategy, do you look at what other geographic areas are doing?

"Absolutely, in terms of benchmarking we always look at comparable size economies that are high tech – so we look to Finland, Denmark excreta. In terms of our output, we have twice the output of these economies. Denmark does about 49 start-ups per year, whereas we are doing over 100 high potential ones per year and up to 200 which we have put equity in. We know already that we are the largest investor in Europe from a deals basis. But we very much keep a close eye on what's going on in individual geographies and pick the best interventions that we see. I have to say that it's typically the other way around; I spend a lot of my time working with other countries. Just yesterday a colleague of mine was doing some work with the Belgian government because they wanted to benchmark what we do in Ireland. We are at this as a country for about 35 years, so we actually have a very well developed industrial development system; but certainly we are always looking for ways to improve and to ensure that we remain relevant to businesses and business sectors as they develop and evolve."

Q: When supporting HPSU's are there any common difficulties you face in supporting different companies, or is it company specific?

"Each company typically has its own specific set of challenges, but if you want to be general, I think we have a lot of learnings. We run a program specifically tailored to a subset of HPSU with the highest potential which focuses on building a team and management capabilities. You can have a mediocre idea with a fantastic leadership and management team that will go a long way further than a brilliant idea with poor execution. So, leadership and management will make a bit difference."

"Also, sales & marketing is a big challenge for companies and they really need to think about internalising from the get go because of the very fact that we are an island. Product market fit is something that is a challenge to a lot of businesses; to ensure that they are investing and building a product or service that is actually required or wanted by the market and that the market is willing to pay for, and in a format that the market is willing to pay for. That is particularly true in the life science sector as you're seeing large multinationals less willing to invest in early stages and more likely to wait until their less risky and pay more for them. This means that there is an awful lot of impact on the type of capital and the length of time that investors have to carry investments before they can actually gain significant traction in a particular market."

Q: Do you typically find that you have to make modifications to the product offerings from the start-up companies?

"Most do, of the companies that went through our accelerated growth program, approximately 60 – 70%, have pivoted which is a fancy way of saying they have tweaked or trailed or changed slightly their proposition. Initially they may have thought they would get traction in market A but they have found that if you go after A, B and C it is a more powerful proposition for the company. That is just the nature of business and it think the quicker we can provide a market feedback system to people the better; so in that regard we do a lot of work such as act for silicon valley in the US and in the UK, we do the same throughout all of our key geographies for our start-ups and we ensure that they are familiar with the local market, processes and any issues. The businesses can be faced with significant technical, regulatory, financial and market specific challenges so we work to ensure they understand these challenges."

"We start at the same point as VC's and that is where our interests diverge, VC's are interested in getting a financial return on their investment, our interest is on ensuing

that the companies we invest in have sufficient capital. VC's want an exit, so they are either going to be bought up by an existing firm to bring in additional capital or private equity. We need to ensure that if the early VC fund is looking to exit that there is somebody there that can take the place of these funds in that business such that the business does not have to be flipped or sold – the goal is to maximise the potential of the business."

Q: What are the biggest challenges you see in the life science sector in the medium to long term?

"The first will be ensuring that there are sufficient types of capital available, which there are right now, but really bringing business to scale is the next frontier for us. We see very exciting business that really have true global potential selling before they really need to sell, possible due to risk aversion or more specific issues."

"We also need to have an open and proactive health system so that our companies can test, trial and develop their products and services before they internationalise; as the first question asked when they go into new areas is "how did you get on in your own system?" So we are working closely with the HSC and the department of health in that regard because it is hard enough the raise capital without having to navigate complex regulatory structures in addition to ensuring that you are building your team and your business. That is a challenge that we need to ensure is addressed."

"My focus is scale; also there are market opportunities that are going to open up in Asia. These are markets that are different to do business in but really with the explosion in the number of middle income consumer spending we expect to see very significant opportunity and that is why we are increasingly opening offices in China, the middle east and the Asian economies."

Q: Are your goals to grow the number of HPSU's or stick to a finite number and increase the quality?

"Five years ago we were doing 65 businesses a year now we are doing over 100 HPSU's and 100 competitive start funds so we have gone from 65 to 200 in the space of five years. Our three year target is to do 550 start-ups, 300 of which are high potential and 250 of which are competitive start funds so certainly for this year and next year the run rate will be 100 HPSU's per year. That number is a real challenge

because we are doing twice what some of our competitor economies are doing - this represents a resource challenge as our business development officers are being asked to do a lot more with less people."

"In the life science space we have a portfolio of approximately 350 businesses and our economic data on them has shown that our job creation and exports from these companies have been growing year on year. We have more value added business, in that they have moved up the value chain from being commodity suppliers to own brand developers to product development companies, to therapeutic businesses, to diagnostic businesses to point of care business. We have really seen an explosion in terms of the life science start up community because when there was a wider down turn a lot of investors started looking closely for the returns that were available and the quality of the businesses that were being set up in Ireland. So certainly our indigenous life science company base is highly innovative, highly dynamic, highly globalised and actually a great place to work. We have some fantastic businesses operating in the country that are global leaders."

Q: Do you see much interaction between the companies?

"On a sectoral basis we would hold client forums such as CEO forums, CFO, COO and founders typically know each other and we bring together leaders of businesses within the same area and cross sectorial too."

Q: Do you have anything else you would like to add?

"Life Science businesses have to be global from the get go, global systems and the macroeconomic environment drivers also impact indigenous businesses. While most talk about consolidation of the larger MNE's, the flip side to that is that there is an insatiable desire amongst the global multinational community for next generation technology and opportunity. That really creates an opportunity for economies who are investing in the early stage high potential businesses which provide the next generation technology which then become international beacons for innovation. It actually creates great opportunity, so I think that there has never been a better time to set up an early stage life science business because you have more interest from the global market now than you've ever had before. No one country, no one company, no one economy can have a monopoly on the life science space because it is so complex, is multi-disciplinary, involves more stake holders than it has ever before and it involves more

disciplines than ever before. That puts economies like Ireland and those that invest in and continue to invest in the research that underpins these businesses and following it with early stage seed and venturing funds, incubation and businesses development has put us in a very strong position as those global MNE and the general global community are increasingly looking for new products and services to meet medical and clinical needs of society. As it was put to me once upon a time, if you are fat or fit you are going to need some type of medical intervention. So it is a case of what economies can build businesses that actually provide facilities to promote businesses on a global stage."

Appendix 2: Example of interview from a start-up company.

William Gallagher – Co-Founder and CSO of Oncomark Ltd:

Q: Can you please give an overview of your company and how you developed to where you are today?

"The limited company is Oncomark Ltd, is a spin out company which I established with co-founder Steve Penny back in 2007 and really only got going 2 years after that. Our strategy at the time was to put in some of our own seed money and we got some EI core support. It was a small amount of money to check out the market opportunity of the company. The company is focused in the area of medical diagnostics with a particular focus in the oncology sector and we were looking at a couple of different technologies from my academic lab as initial product opportunities. One of them did not pan out, it was originally a product from an EI proof of concept grant which didn't really pan out as we couldn't validate out diagnostic. The second technology we successfully got a US and EU patient issued, it is an image analysis technology and we licenced that into Oncomark Ltd as a first product opportunity. In contrast to a lot of other companies, from an academic point of give I have a good track record in availing of a lot of EU funds. Because the EU was quite supportive of small companies we decided to target EU funds directly initially instead of VC funding to really grow the company. So the first eighteen months after incorporation we targeted a number of grants from the EU which kicked off in the middle of 2009. Since then we have gotten 8 grants from the EU totalling close to €5 million which directly fund R&D activities within the company."

"We are an R&D heavy company – which is a high risk areas and a lot of the discoveries we find we cannot subsequently validate so there is a lot of failure within the system, so we are involved in a quite risky area for people to invest in. We were fortunate to have that source of funding to do that activity. Our leading product we are trying to develop at the moment is an assay for early stage breast cancer where we are trying to product if women should get chemotherapy for not. We have recently licenced a technology from TCD where we have a potentially alterative solution technology that needs to be validated. But it seems to outperform the market leaders in the space so we are probably going to focus a lot of attention within the company on this particular product. We are in the process of hiring in a new CEO into the company who has a lot of commercial diagnostic to bring that product forward."

Q: Did you approach EI of did EI find you?

“We approached EI.”

Q: How did you find that process?

“For the initial EI core grant we participated in a campus company development program for about a year previous to the grant. It was a nine month program where they take 10 – 12 new venture ideas and go through the process of trying to mature out the concept and so Steve and I participated in that. Steve was a mature student and had come from an investment funding background for about 15 years in London and Japan so he had lot of experience and business acumen. I obviously had a scientific background and so he went back and studied biotechnology in DCU and then he spent some time in my lab. Together we decided to push forward with the campus company development program to really pursue an idea of trying to form a company in the oncology diagnostics space. As part of that process we became aware of the supports available at EI and we then applied for the core grant.”

Q: Was it mainly the grant you availed of in the early stages, or was there any guidance proved such as assistance in developing a business plan?

“Not really at that stage, the initial support was for scoping out a market area for the technology and we subsequently have not gotten any EI support since then. We were teeing up some investment about two years ago, we were pushing forward an investment round and we had secured in principal EI funding of €250k but were not able to match that at that time from external investors. So you could say that we had good support in principal from EI but we haven’t subsequently gotten support or any direct funding as a company from EI to this point.”

Q: When you went to the EU for funding, did you use your own contacts or did you use an EI contacts?

“We pretty much used our own contacts; I would have a lot of experience in that area so I would have been involved in securing funding from the EU for the last 20 years so I knew the ropes there.”

Q: Have you used any other supports to date, such as NovaUCD or any other body?

“Nova provided indirect support. As a campus company you didn’t get direct support from Nova per say – for example there is no support in terms of IPe that’s reserved for the academia. But you get indirect support in the sense that they may organise some seminar events and obviously we are hosted in NovaUCD where we do have labs and office space there but we pay for those as if you would in any other commercial entity. There is general support which you pay for.”

Q: In terms of the next stages of the business, how do you see yourself growing the company?

“I think we have been good at getting EU funding but that is insufficient for us. We need to go to the next step and get external investment from non-grant funded sources. That is the reason we have targeted this new CEO who has successfully commercialised two companies previously to the point of sale and so we needed someone who had that experience within the diagnostic industry. We have some experience but wouldn’t have a lot of industry experience. We needed someone with that experience who could drive the business forward and secure external investment. We will also pursue a grant funded strategy as well because that lessons the risk for external investors if there is some research activity that can be supported by grant funding sources then it reduces the amount of money required for the company and lessons their risk.”

“One of the big targets for us is the SME instrument under Horizon 2020 which is a program that funds single SME’s up to €5 million 100% funding plus overhead so it is a very good funding model and in particular program which are directly linked to what we do.”

Q: In terms of finding your CEO, did you locate him yourself or did you leverage contact / advice from a support body such as EI?

“He was looking at particular technologies coming from Irish institutions and NOVA UCD linked me with him and we struck up a friendly conversation. It was a timely moment for the two of us as he had just finished with an executive position in his most recent company which was sold so he was looking for a new opportunity.”

Q: What is the structure of the company at the moment?

"We have fluctuated between 10 -15 sometimes 20 people within the company which would be directly funded and most are research active, some are project management and support and there is a layer of executive support around that."

Q: What are the future plans of the company?

"We would hope to grow the foot print and employment within Ireland. We have projected out if we get some of the external investment and this SME instrument we will grow quite rapidly and we will probably not grow beyond a critical size which would be maximum around 30-40 people if we are successful."

Q: At the moment you have no direct EI involvement with the company?

"No direct involvement at the moment. We would be at the fringes, in principal we fulfil the objectives of EI in terms of numbers of people and being a high performing start-up but we were kind of a different breed then what they are looking at. They had a six year timeframe for participating in the HP company programme but the nature of life science takes a lot longer so we have slightly fallen out of that space. Every now and again we have been in contact with our point of contact within EI but no real concrete support at the moment."

Q: Is that a decision made by EI or is it a decision that you made as a company – i.e. you know that the current EI offerings are not a good fit at the moment?

"There is no real need for us to go to EI at the moment. Certainly if we go back and pursue another round of investment we would consider EI but they have a limited amount of money they can provide anyway so we may or may not decide if we are going to bring them on board."

Q: looking back on the development of the company, would you do anything differently if you were to start again?

"There are a few things I would do differently with the benefit of hindsight; certainly finding the right person to lead the company is key. We had an interim CEO for about

two years who was quite good for moving from a broadly academic setting into a more commercial environment but didn't have the full experience in the diagnostics industry. They had previously been involved in spin-outs and were good at converting companies into a formal structure in that sense but didn't have the wherewithal within the investment arena and diagnostics area. If I was to start again I would really hold back to find that person to really drive the business forward."

Q: What were the strengths / weaknesses with regard to your dealing with EI in the early stages of your company development?

"As a weakness, they didn't really suit our type of company, they probably used to dealing with IT companies who are quick turnaround with low potential overheads. Whereas life science companies are more of a slow burner and can take a while to mature."

Q: Did you have any difficulties explaining the business concept to EI?

"Yes, a business concept within biotech can be somewhat nebulous because you can be talking about something that is quite abstract so it is not a piece of software. It was a potential promise of a new diagnostic but there is a long way to the validation of that technology. The drug development space can be 15 years from the proof of concept to actually delivering a product. So diagnostics can have a similar timeframe due to the validation of the product so it's hard for people to grasp that."

Q: Would you have any additional comments on the overall process of starting a life science company out of University in Ireland? Areas for development etc.?

"One of the issues for spinning out is the funding for developing a portfolio of patents is not there - what then typically tends to happen is that you come up with a particular type of technology you submit a patent and then you have a year of chasing around people to try and get the limelight on the technology because there isn't funds available to move it to the more expensive stage of development. Therefore most of the academic institutions try to offload the technology or terminate the IP before its gets too expensive that then does not allow you to build up a portfolio of IP which is what you need for a robust company – i.e. not just having one patent, but having a suite of patents in a specific area. A good example would be Stokes Bio Limited, which is a

successful spinout from Limerick and was one of the early success within the biotech sector in Ireland. They were able to build up a favourable portfolio of IP which is really where the value of a life science company is. That is a weakness, probably because of the funding models, most of the technology transfer institutions within Ireland don't have the financial wherewithal of the foresight to really build up a portfolio."

Q: During your development did you approach any established diagnostic or biotech companies with a view to forming partnerships?

"We had some initial interactions but didn't really do it in great depth because I suppose we were trying to formulate and fix our own ideas before we really went out there."

Q: Do you have any additional comments on EI?

"On an indirect level, from an academic level, we have received a lot of support from EI. The two technologies that we did licence into the company were from EI funded sources so they were two tech development grants which allowed us to successfully bring the technology forward to a point of issuing patents and licencing the technology in the first and in the second we are still pending the patent. But from a company support point of view, EI have not provided a huge amount. On the academic side when I was bidding for the EU grants we always sought very good support from EI for coordination support grants. These are small pots of money which help you bid for large EU grants which we were never turned down and we were quite successful, above 50% for these programs."

"So from an academic point of view we got excellent support from EI. Once you step over into the company side we found that the supports, at least from our perspective, are quite a lot less or at least we haven't availed of them or actively pushed on them."