A case study of a university-industry partnership (UIP) in science and technology:

What drives extraordinary performance?

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By

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Abstract

Background

In the 21st century knowledge economies, the creation of knowledge is important for the advancement of society through innovation and economic development. Open innovation has been the knowledge creation and utilisation process whereby universities and industry work in partnership to advance economic means. These university-industry partnerships (UIPs) historically have made the universities more entrepreneurial in their knowledge pursuits and industry more research and development oriented.

Purpose

The purpose of this thesis is to research a single case study involving the University of Liverpool and Unilever Corporation through the interactions within a Centre for Materials Discovery (CMD). The partnership between the parties is notable for its sustained and extraordinary success in the discovery of new chemical entities (NCEs) for new product development. Findings of the empirical research will advance the knowledge for the design, formation and operation of an UIP by innovation professionals.

Methodology

A qualitative research method with ethnography approach to inquiry through access of a single-case study. The study utilised semi-structured, open-ended interviews with past and present UIP participants. The researcher was embedded as a participant-observer within the UIP. The methodology will be used to build a rich understanding of the practices of the CMD UIP.

Findings

The research findings discovered five key categorical themes that drove the sustained extraordinary success of the CMD UIP. Interwoven into these five categorical themes were two cross-cutting global themes that added more synergy and depth to the findings.

Originality

The literature is sparse on sustainability of extraordinary performance within UIPs. The CMD UIP was notable for sustained and extraordinary outputs that make the empirical findings a contribution to the literature regarding UIPs for innovation professionals.

Conclusions

This thesis is a single case study of the University of Liverpool, United Kingdom and Unilever Corporation’s partnership centered on high-throughput chemistry compound discovery for consumer products in the hygiene, personal care and retail markets. This partnership has produced multi-billion dollar revenues for Unilever in new products and advanced the research stature for a major university. Based upon the empirical findings, I have constructed an actionable framework that can be used by innovation professionals when designing, organising and operating UIPs in the knowledge economies of the 21st century.

Acknowledgements

I would like to dedicate this thesis to the people who have mattered most in my life and career. My late parents, Alcee and Marguerite Campbell, who inspired me to live life to the fullness, have complete regard for others and to work hard to make a difference in the world. My wife, Melanie, who without her support for decades and especially in this endeavor, I would never have realized my potential as a husband, father, executive and most dear to my heart- the *scholar-practitioner.* My children: Erin, Shannon and Ryan; who have given me joy since birth and the inspiration to contribute to future generations all I have learnt. Lastly, to my colleagues' over my career who have given inspiration, support and a can-do attitude.

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"It always seems impossible until it's done."

- Nelson Mandela

Declaration

I certify that the thesis I have presented for examination for the DBA degree of the University of Liverpool is solely my own work.

I warrant that this authorisation does not, to the best of my belief, infringe the rights of any third party.

Liverpool, December 2017

Neil J. Campbell

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Glossary

Absorptive Capacity - Absorptive capacity is a firm's ability to identify, assimilate, transform, and apply valuable external knowledge. Absorptive capacity is a limit to the rate or quantity of scientific or technological information that a firm can absorb.

Applied Research - is a form of systematic inquiry involving the practical application of science. It accesses and uses some part of the research communities' (the academia's) accumulated theories, knowledge, methods, and techniques, for a specific, often state-, business-, or client-driven purpose.

Basic Research - also called pure research or fundamental research, is scientific research aimed to improve scientific theories for improved understanding or prediction of natural or other phenomena.

Biotechnology - any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for specific use.

CAPEX or Capital Expenditures - funds used by a company to acquire or upgrade physical assets such as property, industrial buildings or equipment. It is often used to undertake new projects or investments by the firm. These expenditures must be written off over a period.

Centre of Excellence (COE) – is a team, a shared facility or entity that provides leadership, best practices, research, support and training for a focus area. The focus area might be a technology (e.g. computational chemistry), a business concept (e.g. environmentally sustainable products), a skill (e.g. high-throughput screening of chemical compounds) or a broad area of study (e.g. materials science for NCE discovery).

Combinatorial Chemistry - comprises automated instrumental chemical synthetic methods that make it possible to prepare a large number (tens to thousands or even millions) of potential drug compounds in a single process. These potential drug compound libraries can be made as mixtures, sets of individual compounds or chemical structures generated by computational chemistry computer software.

Computational Chemistry - a branch of chemistry that uses computer simulation to assist in solving chemical problems. It uses methods of theoretical chemistry and mathematics incorporated into efficient computer programs, to calculate the structures and properties of molecules and solids.

Drug Discovery - in the fields of medicine, biotechnology and pharmacology, drug discovery is a multi-step process by which new drug candidate medications are discovered.

Economic Development - from a policy perspective, economic development can be defined as efforts that seek to improve the economic well-being and quality of life for a community by creating and retaining jobs and supporting or growing incomes and the tax base. Innovation policy and programmes focus on economic development as one key strategy for growth.

Entrepreneurial or Entrepreneurship - a process/action or person who organises and manages any enterprise, especially a business, usually with considerable initiative and risk.

Environment Sustainability - a state in which the demands placed on the environment can be met without reducing its capacity to allow all people to live well, now and in the future. The notion behind environmental sustainability is the resources are renewable when used and not in jeopardy of being depleted permanently.

First Industrial Revolution (1750 to 1850) – The first industrial revolution began in Britain in the late 18th century, with the mechanisation through automation of the textile industry. Tasks previously done laboriously by hand in hundreds of weavers' cottages were brought together in a single cotton mill, and the factory was born. This first spontaneous industrial growth was first starting in Great Britain and extending to other parts of the world, especially the newly formed the United States of America allowed many inventions to be made. Inventors became sought after to address the very standard forms of labour that existed. This first revolution has been noted to have occurred without strong government assistance or push which has been characteristic of most succeeding industrial revolutions.

Gross Domestic Product (GDP) - the gross domestic product is the best way to measure a country's economy. GDP is the total value of everything produced by all the people and companies in the country. It doesn't matter if they are citizens or foreign-owned companies. If they are located within the country's boundaries, the government counts their production as GDP.

High-Throughput Screening (HTS) - is a method for scientific experimentation especially used in drug discovery and relevant to the fields of biology and chemistry. Using robotics, data processing and control software, liquid handling devices, and sensitive detectors, High-throughput screening allows a researcher to quickly conduct millions of chemical, genetic, or pharmacological tests. Through this process, one can rapidly identify active compounds, antibodies, or genes that modulate a particular biomolecular pathway. The results of these experiments provide starting points for drug design and for understanding the interaction or role of a particular biochemical process in biology.

High-Performance (as a construct) - is a concept within organisation development referring to teams, organisations, or individuals that are highly focused on their goals and that achieve superior results. High performance is a measurement for comparison. To be high-performing, the entity must be succeeding above and beyond standard norms (measurements agreed upon by the majority of a known group as being the normative metric) over the long-term.

HPI or High Potential Employee - is an employee who has been identified as having the potential, ability, and aspiration for successive leadership positions within the company. According to Corporate Executive Board (CEB), high potential employees have three key characteristics in common: aspiration, ability, and engagement.

HPT or High-Performance Team - A high-performance team can be defined as a group of people with specific roles and complementary talents and skills, aligned with and committed to a common purpose, who consistently show high levels of collaboration and innovation, that produce superior results.

Industrial Research Complex – a coined term after the Second World War (WWII) to signify the growth and interactions between industry and government for research of new science and technology. This rise of industrialised research was more with military organisations during and immediately after WWII. This shift from academic to industrially-driven basic research started during the latter part of the second industrial revolution. The end of WWII and the Cold War led to a strong interest in industry driving a new form of applied research that industry started. The knowledge transfer processes during this time were still heavily predicated on partnerships and interactions between academe and industry. The term was first used in the farewell address of U.S. President Dwight D. Eisenhower on January 17, 1961.

Industrial Research & Development - a term used to signify the departmental research efforts (both basic and applied) and commercial development processes used to create new products and services from companies to the marketplace.

Intellectual Property or (IP) – refers to creations of the mind, such as inventions; literary and artistic works; designs; and symbols, names and images used in commerce.

Intellectual Property Rights or (IPR) - Intellectual property rights are like any other property right. They allow creators, or owners, of patents, trademarks or copyrighted works to benefit from their work or investment in creation.

Ivory Tower Mentality - an impractical often escapist attitude or secluded place marked by aloof lack of concern with or interest in practical matters or urgent problems. Can be used in a general sense, but usually attributed to universities.

Knowledge Economy - an economy in which growth is dependent on the quantity, quality, and accessibility of the information available, rather than on the means of production. The knowledge economy is a system of consumption and production that is based on intellectual capital. The knowledge economy commonly makes up a large share of all economic activity in developed countries.

Massachusetts Institute of Technology or (MIT) - originally M.I.T., the abbreviation of Massachusetts Institute of Technology, attested from 1892. Considered by many to be the first formally organised entrepreneurial university in the United States with the main intention of commercially-oriented research with industry.

Materials Science – the scientific study of the properties and applications of materials of construction or manufacture (such as ceramics, metals, polymers, and composites). Materials science is a syncretic discipline hybridising metallurgy, ceramics, solid-state physics, and chemistry. It is the first example of a new academic discipline. Materials scientists emphasise understanding how the history of a material (its processing) influences its structure, and thus the material's properties and performance. Many of the most pressing scientific problems humans currently face are due to the limits of the materials that are available and how they are used. Thus, breakthroughs in materials science are likely to affect the future of technology significantly.

Mutuality of Interests or (MOI) - The legal principle that provides that unless both parties to a contract are bound to perform, neither party is bound.

Nanotechnology - the branch of technology that deals with dimensions and tolerances of less than 100 nanometers, especially the manipulation of individual atoms and molecules. Nanotechnology is the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering.

New Chemical Entities or (NCE) - a drug or chemical that is without precedent among government regulated and approved drug products. The NCE designation indicates that a drug in development is not a version or derivative of an existing and previously investigated, trialled and approved substance. Being labelled as entirely 'new' or first-in-class molecule dictates that certain types of clinical trials must be run, and that particular attention must be paid to proving a drug's safety. An NCE is also open to having new intellectual property such as a patent written and filed to protect the discovery of a new chemical entity.

New Product Development or (NPD) - is the complete process of bringing a new product to market through identification of market opportunities into a product available for sale. Products can be tangible (that is, something physical you can touch) or intangible (like a service, experience, or belief).

Research & Development or (R&D) - refers to the investigative activities a business conducts to improve existing products and procedures or to lead to the development of new products and procedures.

Second Industrial Revolution (~1870 to ~1920) – also known as the Technological Revolution, came in the early 20th century when Henry Ford mastered the moving assembly line and ushered in the age of mass production. The factory automation technologies combined with new inventions in communications and electricity spawned a larger phase of growth and continuation of the larger Industrial Revolution corresponding to the latter half of the 19th century until World War I. It is considered to have begun with Bessemer steel in the 1860s and culminated in mass production, the production line and the physical sciences like chemistry, biology and physics.

Small-to-Mid-Size-Enterprises or (SME) - The abbreviation "SME" is used in the European Union and by international organisations such as the World Bank, the United Nations and the World Trade Organization (WTO). Small enterprises outnumber large companies by a wide margin and also employ many more people. SMEs are also said to be responsible for driving innovation and competition in many economic sectors.

Sustainability (as in duration of time) - is the ability to continue a defined behaviour indefinitely. This behaviour is one that is consistent over time and operates on its momentum.

Third Industrial Revolution (1940 to 1990) - The first two industrial revolutions made people richer and urbaner. The third revolution began with the mind is what makes things not hands like the first two industrial revolutions. During this period industry became more digital than analogue and many industries benefited from this digitalisation such as computers, electronics, automotive, communications. The rapid rise of digital has largely been attributed to the Second World War and the Industrial Complex that arose from the advancements.

The Triple Helix Model - The bond and inter-relationships amongst three impactful stakeholders: 1) Universities, 2) Industry and 3) Governments. The term originates from seminal work of Henry Etzkowitz and colleagues around the notion of knowledge transfer that does exist between the three parties. The goal is to leverage the importance and contributions of each party as they relate to the knowledge diffusion and innovation that can occur for original research (Universities), applied research and commercial focus (industry) and instituting a framework for which these innovations can be delivered and validated for society (government).

Chapter 1: Introduction

1.1 Research Objectives

Historically, Universities have contributed to the processes of knowledge creation and diffusion within society (White, 1964; McClellan and Dorn, 2006). Universities have served as an important venue for original research and studies of the world around us (Pacey, 1992). The original research by universities was motivated by investigating observations made by researchers and inventors who were exploring voids of knowledge or understanding that existed within the community (Pacey, 1991; Mays, 1999; McClellan and Dorn, 2006; Etzkowitz, 2008). As the university institution evolved and formalised, it began to foster group collaborations with other universities and societal organisations (White, 1964; Etzkowitz, 2008). The importance of universities to society has always been appreciated. The important element of the university entity has been the ability to evolve in various forms for hundreds' of years as the needs of society changed. This evolutionary shape-changing was primarily driven by knowledge gaps in understanding and the pursuit of intellectual knowledge to provide insights into the gaps that existed. (White, 1964; McClellan and Dorn, 2006).

The structure of the university system did positively impact the development of knowledge. The diffusion, spill-over and knock-on effects of new knowledge that inventors and discoverers generated provided the antecedents in which to conduct basic research**.** These antecedents provided practical definition and a starting point of interest for universities to conduct research. The eventual off-shoots from this basic research provided pre-cursors of new knowledge that others in society (chiefly, industry-oriented enterprises) would take and conduct more applied research**.** The translation of the basic research outputs would be the starting points in applied research for the development of commercially-viable products and services to society (White, 1964; Pacey, 1991; Pacey, 1992; Wesser, 2003a). Academic inquiry and the growing institutional nature of the university evolved into a major component and contributor of economic development of society. Economic development became a way for advancement in society and the motivations behind governmental policies that would later develop (Pacey, 1991; Chesbrough, 2003; Shane, 2005; McClellan and Dorn, 2006; Etzkowitz, 2008; Todaro and Smith, 2009). During this academic evolution, Universities began to partner with other organisations to further the purpose of knowledge creation, diffusion and translation into practical applications within society (Latour, 1987; Etzkowitz and Leydesdorff, 1995; Etzkowitz, 2002; Fazackerley, Smith and Massey, 2009; Fagerberg and Mowery, 2015).

By the early 17th century, Universities had become a proactive partner within society (Evans, 2004). The contributions to industrial development became more pronounced through the need to automate many facets of daily work life (White, 1964; Pacey, 1992; Munson, 2005; Todaro and Smith, 2009). With the arrival of the First Industrial Revolution in the late 18th century and followed by the Second Industrial Revolution in the latter part of the 19th century, the academic researcher would become a more formal collaborator with other members of society (Etzkowitz, 2003; Gelb and Cadicott, 2007). These more formal collaboration models would eventually become known as university-industry (society) partnerships or (UIPs) (Etzkowitz, 2002).

UIPs have a long history of contribution to the knowledge economy and society (Alder, Shani and Styhre, 2003; Balconi and Laboranti, 2006; Etzkowitz, 2002; Glynn, 1996; Gould, 2012;

Rieu, 2014; Wills, 2009). In my more than thirty years of professional practice, I found it to be common to have successful UIPs. In my experience though, it is not so common to encounter, an individual UIP that demonstrates the extraordinary success of outputs over a long periodof time. The high-performance success of partnership output is one key motivator and desired objective when forming a UIP (Wesser, 1999; Weisberg, 2003; Wesser, 2003a; Wesser, 2003b; Gould, 2012; Haeussler and Higgins, 2014).

My thesis research is a single case study of a partnership notable for the sustained, extraordinary output. The outputs from this UIP are in a field of computational chemistry and materials science that historically has been difficult to produce new chemical entities (NCE). The partnership between the University of Liverpool and Unilever in materials science is notable and unique. From the findings of this research, I will provide a key deliverable in the form of an actionable framework for innovation professionals in UIPs. This innovation framework will allow practitioners in their professional practice the ability to develop strategies in design and execution for sustained extraordinary performance regarding their UIPs.

1.1.1 Purpose

The purpose of this thesis research was to elucidate factors of UIP success, high performance and sustainability of the University of Liverpool (UoL) and the Unilever Corporation's (Unilever) partnership involving high-throughput screening for chemical compound discovery. High-throughput chemistry discovery is also known as high-throughput screening (HTS). The chemical compound discovery activity and the main venue for this UIP occur through the University of Liverpool's Centre for Materials Discovery (CMD). This partnership will be referred to as the CMD UIP in this thesis. The CMD is an on-campus; separate physical set of laboratories that contain highly sophisticated instrumentation, software and computerisation providing an ability for the discovery of NCEs. Both academic and industrial scientists involved in the UIP conduct all their discovery work within the CMD. The Output of the CMD UIP is distinct and independent for each partner. The UoL objective was to discover publishable and patented new process methods of chemical discovery, new chemical compounds and recognition of its contribution as a major global research university (EPSRC: CMD Proposal, 2005; History of UoL, 2007; Barr, *et al.,* 2013; Business Department, 2013). The university used the CMD UIP outputs for publishing in peer-reviewed scientific journals and for licensing to outside parties for potential commercialisation. Additional objectives for the UoL were to increase its global ranking amongst research universities, attract new faculty talent, receive more extramural grant funding from government and royalty funding from industry (EPSRC: CMD Proposal, 2005; Barr, *et al.,* 2013; Business Department, 2013).

Unilever's goal was to discover NCEs that could be incorporated into new products (EPSRC: CMD Proposal, 2005). The new products that Unilever would eventually market would be to developed and emerging markets. The NCEs used in products for the developed countries would be added to a premium line of products. The main goal of the CMD UIP NCE work was around expanding Unilever market share and revenues in the emerging/developing markets through new products. These new products would address the needs of communities in developing countries by the strategy of environmental sustainability (HRMD, 2009; Smith, 2009; Strategic Direction, 2009; Barr, *et al.,* 2013; Bell, 2013a; Bell, 2013b). Unilever's strategy of using environmental sustainability focused on the reduction in the use of natural resources (Bell, 2013b). One example of a Unilever programme in the CMD UIP of this environmental sustainability strategy was finding new chemical surfactants that could be incorporated in cleaning products that would not use heat or hot water to clean (Smith, 2009; Strategic Direction, 2009; Strategic Direction, 2012). The use of heat and the resources necessary to generate heat can be too expensive, increase the amount of pollution or be unattainable in the local markets (Bell, 2013a). The carbon footprint generated in the act of washing clothes can be reduced greatly through the elimination of heating the water that activates most detergents. The use of ordinary, readily available cold water has allowed communities to improve hygiene, reduce environmental waste by utilisation of products such as these to even the poorest of communities (Bell, 2013b).

The original motivation for Unilever to seek outside partnerships was to outsource certain research and development (R&D) innovation to UIP relationships. When an organisation is lacking knowledge internally, that organisational can seek knowledge outside of other organisations. The process of innovative pursuits outside an organisation is called Open Innovation (Chesbrough, 2003). This gap in internal organisational knowledge and the process to seek outside knowledge is referred to as absorptive capacity**.** Absorptive capacity can augment greatly the efforts in innovation by a firm. Absorptive capacity, sometimes called the *'second face of R&D'*, is a firm's ability to identify, assimilate, transform, and apply valuable external knowledge back into the internal R&D processes of the organisation. This strategy of seeking outside knowledge does have its limits and is meant to provide whole new areas of knowledge (Beise and Stahl, 1999; Griffith, Redding and Reenen, 2000; Balconi and Laboranti, 2006; Bekkers and Bodas-Freitas, 2008; Bishop, D'Este and Neeley, 2011; Bell, 2013a; Bell, 2013b; Birx, Ford and Payne, 2013).

Unilever's strategy was to use the CMD UIP as a vital component of the Unilever R&D efforts for NCE discovery as internal programmes yielded very little NCEs historically (Unilever Strategic R&D Report, 2005). In the knowledge economies of the 21st century, the industry has shifted towards a blend of R&D efforts that comprise in-house R&D and the out-sourcing of R&D to strategic partnerships (i.e. Absorptive Capacity). An organisation's ability to stay current with rapid and technical knowledge advances can be limited. Innovation models utilising absorptive capacity concepts have become important in staying competitive in global markets (Lane and Lubatkin, 1998; Lane, Salk and Lyles, 2001; Reitsma, 2001; Jones, 2005; HRMD, 2009; Strategic Direction, 2009; Strategic Direction, 2012; Jopson, 2013).

The CMD also served as a centre of excellence (COE) in the computational chemical sciences for the Northwest of England. The Northwest of England has historically been a strong academic source in physics, chemistry and computer sciences outside of London city region (Meadway and Mateos-Garcia, 2009; von Tunzelmann, 2010; Adams, 2011; Wilson, 2012; Owen and Hopkins, 2016). Economic development entails job creation, raising the quality of life, expansion of existing and new sectors of business and the promotion of larger efforts of innovation schemes (Shane, 2005; Todaro and Smith, 2009). The U.K. government's strategic economic development planning used COEs as an instrument to develop new technology capability. The development of new technology sectors had been part of economic development in the regions (Lambert, 2003; Adams, 2011; BIS, 2011; HM Treasury, 2011; Wilson, 2012). The policy focus of the COE strategy was to upgrade and expands the UK region's assets. In the UK, COEs were focusing on knowledge sectors supporting 21st-century industries such as computer sciences, biotechnology and medicine (BIS, 2011; Wilson, 2012; Owen and Hopkins, 2016). The guiding principle for the potential COE selection of the targeted region was the motivation, and foundational assets present within the community to build upon. The university and its ability to generate knowledge was a critical key component of the COE models (BIS, 2011; Wilson, 2012; Owen and Hopkins, 2016).

Universities play a major role in providing the underlying foundation of intellectual know-how generation in the COE model (Owen and Hopkins, 2016; Wilson, 2012). Universities are more expansive in their capabilities and can span multiple areas of interest that a company may not be able to do. The broader element of knowledge diffusion was what made universities so valuable in their communities (Etzkowitz, 2000; Lambert, 2003; McClellan and Dorn, 2006). The COE model was designed to leverage existing assets that have potential to grow. This growth of capability through a COE approach has been shown to materially improve the economic status of society in the region (Lambert, 2003; Link and Scott, 2003; Wilson, 2012). There can be knowledge knock-on effects of the COE as the activities and outputs can transfect other regions of the UK. The COE model is also used to ensure that public money is shared equitably for future economic growth investment in the sectors that make up the COE (Wilson, 2012). Different COEs are scattered around the U.K. to evenly distribute the dissemination of knowledge, wealth and job creation through different industrial sectors and university schools of research (Harris and Albury, 2009; Adams, 2011; HM Treasure, 2011; Owen and Hopkins, 2016).

Despite UIPs having had a history of successful contributions, the factors that contribute to the sustained longer-term success of any individual UIP remains unclear (Steger, *et al.*, 2008; Andersén and Kask, 2012; Aslan, Şendoğdu and Diken, 2013; Vonortas, Rouge and Aridi, 2014). The partnership between the UoL and Unilever utilising the CMD is notable for its sustained success. The aim is to explore the factors that have contributed to the operating success of the CMD UIP and the extraordinary sustained success of the CMD UIP. From the empirical research, I will construct an actionable framework for innovation professionals in technology transfer and partnerships. The framework will allow innovation professionals to develop strategies for the sustained success of their UIP from design and formation to operational and structural success.

1.1.2 Importance

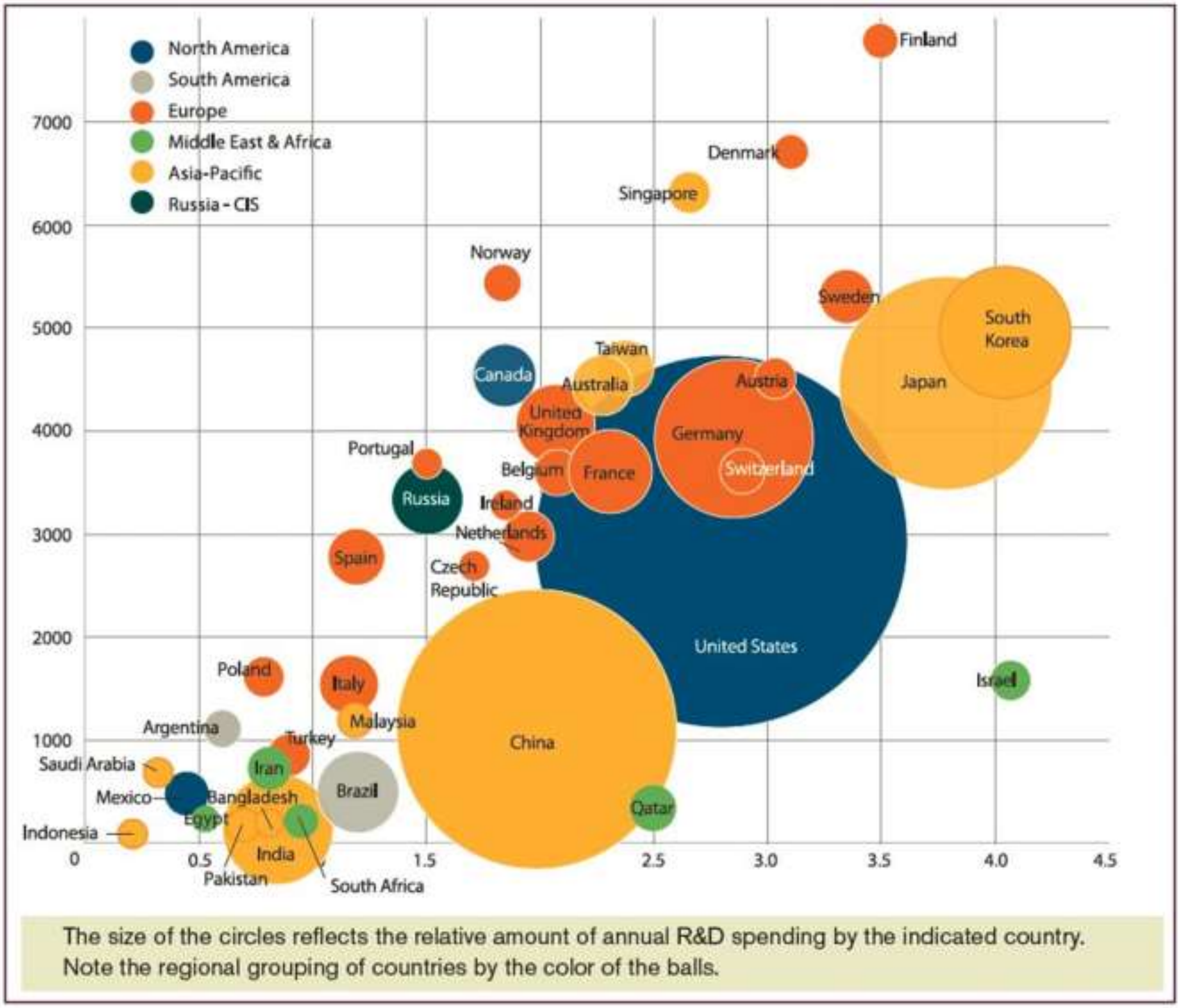
The strength of a nation's wellbeing is centred on several sovereign core assets such as literacy, health, wealth and economic stability (White, 1964; Pacey, 1992; McClellan and Dorn, 2006; Wilson, 2012). One benefit is raising the quality of life through economic development (Etzkowitz and Leydesdorff, 1995; Shane, 2005; Todaro and Smith, 2009; Engel, Fischer and Galetovic, 2014). In developed countries, economic development through innovation schemes comes largely from three players: universities, industry and non-profit organisations (Etzkowitz and Leydesdorff, 1995; Vaivode, 2015). The role that government plays in the national and local scenes is to add additional varieties of support programmes that are regionally focused. Partnerships amongst these three, if successful, contribute greatly to economic development (Etzkowitz and Leydesdorff, 1995; Wesser, 1999; Etzkowitz, 2000; Etzkowitz, 2002; Link and Scott, 2003; Wesser, 2003a; Perkmann and Walsh, 2007). The lack of investment in innovation and knowledge systems can stifle a nation's ability to advance itself (White, 1964; Boccanfuso, 2010; Wilson, 2012; Owen and Hopkins, 2016). Universities have played an important role in efforts to increase the level of competitive knowledge in a country's economy (Furman, 1990; Balconi and Laboranti, 2006; Global R&D Funding Report, 2017).

A metric of a nation's industrial ability to innovate is the amount of money spent on R&D within a nation's economy. The economic foundation of innovation relies upon consistent investment into institutions that create knowledge, research, development and commercialisation of innovative outputs (Link and Scott, 2003; Adams, 2011; Link, Siegel and Van Fleet, 2011; Dudin, *et al.*, 2014). Each year, the Institute of International Research in conjunction with R&D Magazine publishes a report on the global economic investment ranking in the innovation of science and technology. In Figure 1, a nation's relative amount of annual R&D spending is shown with the regional grouping of countries highlighted by the same colour spheres. The investments in R&D programmes are highest in countries where there are economic stability, strong academic systems and commercial markets for industry (Global R&D Report, 2017).

This economic stability is measured through the gross domestic product (GDP). The percentage share of R&D expenditures out of the GDP is the relative measurement across countries for innovation outputs. Those countries with greater stability have larger and growing GDP with either consistent or increasing percentages of innovation investment (Global R&D Report, 2017). The UK economy continues to outpace many other Western economies with strong programmes for innovation. Supporting this UK. Innovation ecosystems are a strong cadre of academic institutions, a solid organisation of UK. National and local programmes for funding and strong multi-national industrial organisations (OECD Report, 2016; Owen and Hopkins, 2016; Global R&D Report, 2017). Innovative partnerships amongst universities and industry are a key part of the growth of science and technology assets and their corresponding value in the UK (OECD Report, 2010; Wilson, 2012; Owen and Hopkins, 2016). The UK was expected to invest £37.4 billion[†] (USD 48.2 billion) on R&D in 2017 or a 2.3% share of the global total R&D investments and an 11.2% share of the expected 2017 European total. The UK globally was the ninth largest creator of intellectual property in the world. Much of this intellectual output was created in academia (Global R&D Report, 2017). The UK has some of the world's oldest and most productive research universities with four in the top twenty globally (THE, 2016-2017; Global R&D Report, 2017). The UK's R&D investment scheme for innovation was organised around innovation frameworks that involve partnerships between universities, industry and government research laboratories. The UK innovation funding has been fairly stable with sources of capital coming from industry (48%), government (21%), offshore accounts/partnerships (18%), academia (9%), and non-profit/charitable organisation (4%) providing the remainder (Global R&D Report, 2017).

Building a nation's strategy around innovation involves various forms of collaboration. UIPs form a component of the backbone of a national innovation and knowledge strategy (Furman, 1990; Wesser, 1999; Wesser, 2003b; Boardman, 2009; Boccanfuso, 2010; BIS, 2011; Bishop, D'Este and Neely, 2011). The importance of innovation frameworks is the ability to link together successfully, universities, industry and where appropriate, governmental agencies and non-profit organisations (Leydesdorff and Etzkowitz, 1997; Fazackerley, Smith and Massey, 2009; Fagerberg and Mowery, 2015). Although each situation is unique regarding innovation and UIPs, there can be trends or patterns worth noting that may be transferable to other UIPs (Mays, 1999; Rampersad, Quester and Troshani, 2010). The Challenge for an industry is to have knowledge creation and diffusion rapid enough to meet the needs of commercialisation of key products that generate revenue (VanGundy, 2007; Vonortas, Rouge and Aridi, 2014).

Figure 1 . Global Annual Research & Development Spend by Country



Source: 2017 Global R&D Funding Forecast; Industrial Research Institute (IRI); EU-CORDIS; World Bank R&D, 2016.

1.1.3 Implications

The importance of structuring partnerships that can leverage national and local resources can stimulate economic development and growth. One reason governments intervene and stimulate innovation policies is to improve the leverage that can be created in the innovation process. Nations and their various agencies must work together in a public-private ecosystem that enables knowledge creation with universities, industry and government in processes that further the work of each stakeholder (Hiltzik, 2000; Mower and Sampat, 2004; Perkmann, 2007; Dudin, *et al.*, 2014). The rise of the entrepreneurial university has improved applied research approaches to knowledge creation and utilisation (Etzkowitz, *et al.*, 2000). Industrial organisations must invest in their knowledge systems and R&D efforts if they want to stay competitive (Smith, Collins and Clark, 2005; Acworth, 2008; Fabrizio, 2009). Industries understand that commercial success can be leveraged in the sharing of knowledge in more formal arrangements with support from government policies and initiatives (Bishop, D'Este and Neely, 2011; Ye and Kankanhalli, 2013). The commercial distinction between research and development has become blurred as partnership models continue to evolve. Applied research programmes can also have components of basic research. The complexity of R&D and the path towards commercialisation has stimulated a wider range of UIP structures to accommodate the emerging needs of the knowledge economy (Monjon and Waelbroeck, 2003; Fagerberg and Mowery, 2015). These formal arrangements between universities, industry and government have become essential innovation frameworks (Etzkowitz and Leydesdorff, 2000; Vaivode, 2015; Chai and Shih, 2016). The combined R&D efforts leverage more resources which increase chances for success, lower risk and provide the necessary content for further research (Fabrizio, 2009; Boccanfuso, 2010; Ye and Kankanhalli, 2013; Chai and Shih, 2016).

1.2 Research Questions

The knowledge economy of the 21st century will require approaches to address innovation and knowledge creation (Jaksić, Jovanović and Petković, 2015). In building innovation frameworks, professionals in UIPs will look to the past and present for insights from research conducted.

Understanding these key factors of success and their evolutionary changes should help design, organise and operate increasingly complex partnerships (Alder, Shani and Styhre, 2003; Heidrick, Kramers and Godin, 2005; Jain, George and Maltarich, 2009). We now operate in a globally competitive environment that requires new thinking around innovation and the structure of UIPs, especially geographically dispersed ones (Perkmann and Walsh, 2007; Evaristo and Ouderkirk, 2014). The CMD is notable for its high-performance output of NCEs and the sustained success over ten years as a UIP. The actionable framework resulting from this research should help innovation professionals to develop strategies for the achieving sustained high-performance of their UIP.

1.2.1 Research Question #1: What Factors Contributed to the Success of the CMD UIP?

Understanding the contributing factors that provided successful outcomes in the CMD UIP would add to current literature and provide insights for generating an innovation framework regarding UIPs. Innovation professionals who work with UIPs are interested in learning about new design criteria or operational structures that may lead to more efficient processes and successful outcomes (Anderson, Daim and Lavoie, 2007; D'Este and Patel, 2007). Success, in this context, is the ability for a UIP to meet its targeted objectives and goals (Etzkowitz, *et al.*, 2000; Fagerberg and Mowery, 2015). The CMD UIP, between UoL and Unilever did experience successful outputs in NCE discovery and commercial viability (Barr, *et al.*, 2013; Business Department, 2013). The CMD UIP was notable for exceeding the normal levels of NCE discovery outputs (Barr, *et al.*, 2013; Business Department, 2013). Most organisations in NCE discovery would expect outputs of new compounds to normally be in the less than 1% to 3% range (DiMasi, Bryant and Lasagna, 1991; Walters and Namchuk, 2003; Borchardt, *et al.*, 2004).

This research question explores the CMD UIP and the factors relating to design, formation, operating and supporting resources for creating successful UIPs by innovation professionals. The next research question seeks to elucidate the factors that have led to the extraordinary outputs of NCE discovery by the CMD UIP.

1.2.2 Research Question #2: What Factors Allowed the CMD UIP to Achieve High-Performance in NCE Discovery?

The CMD UIP centres on NCE discovery and commercialisation of new products. As the CMD success is highly unusual as it pertains to the percentage of successful NCEs, the elucidation of the factors would contribute greatly to innovation in UIPs focused on computational chemistry partnerships. According to industry sources, NCE discovery across multiple industry sectors can be as low as less than 1% to an average high of 3% (DiMasi, *et al.,* 1991; Devlin, 1997; Borchardt, *et al.,* 2004; Fox, *et al.,* 2004; Keserü and Makara, 2006; Macarron, 2006; Posner, Xi, and Mills, 2009; Farrant, 2012; Hansson, *et al.,* 2013). The actual performance by the CMD UIP in the first ten years of operations yielded over 10% NCE discovery success (actual compounds and yield rates are confidential) and have led to several products for Unilever that could generate billions of pounds in growth revenue (Business Department, 2013). The new products being developed from the CMD UIP are central to Unilever's sustainability corporate strategy for environmentally and economically made products for developing country markets (Bell, 2013a; Bell, 2013b). The extraordinary high-performance of the CMD UIP has led the UoL and Unilever to renew the CMD UIP for an additional five to ten years based upon the NCE discovery performance to date (Business Department, 2013). The factors that have led to extraordinary high-performance in NCE discovery in the CMD UIP will contribute to innovation frameworks for professional practice in drug discovery and chemicals. Research question #2 leads us to ask further the third research question on how the CMD UIP has been able to achieve this sustained extraordinary success in the CMD UIP. What factors are driving this sustainable high-performance?

1.2.3 Research Question #3: What Factors Contributed to the Sustained High-Performance Success of the CMD UIP?

Sustainability in the context of this thesis research is the long-term duration of the extraordinary output of NCE discovery and characterisation from the CMD UIP. Long duration UIPs are rarer, and the literature is smaller regarding them. Some UIPs are designed for short-term process and outcomes. In particular, when UIPs are formed, and the partners wish long-term success, this is where the literature is sparse on key factors driving sustainability (Foster, 1986; Adler, Shani and Styhre, 2003; Fong-Boh, Evaristo and Ouderkirk, 2014; Matulevieiene and Stravinskiene, 2015).The two most common models used for structuring UIPs are contract research/consulting and co-development-related projects that have a defined endpoint and a relatively short duration measured in 1 to 3 years (Reams, 1986; Chesbrough, 2003; Chesbrough, 2003a; Bekkers and Bodas-Freitas, 2008; Chang, Yang and Chen, 2009; Thursby and Thursby, 2011c). Contracting/consulting and co-development were the first two types of UIP frameworks that emanated out of a UIP model from the Massachusetts Institute of Technology* (MIT) (Etzkowitz, 2002). The MIT model was a work for hire concept that teamed up university researchers (many with industry backgrounds) with industry to specifically solve an industry problem. From the empirical research, I will discuss the key factors that led to the sustained extraordinary success of the CMD UIP.

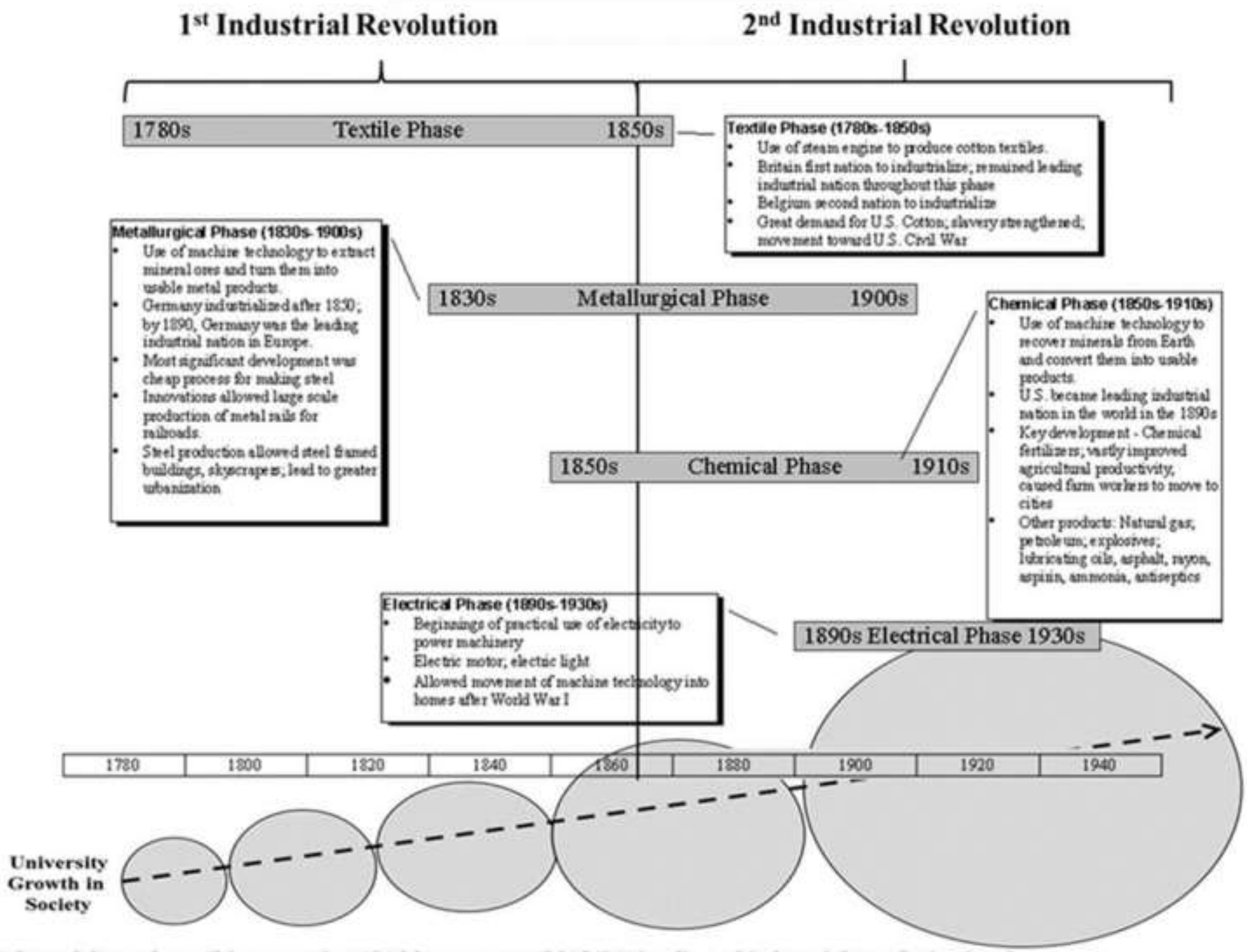
1.3 Historical Overview of University-Industry Partnerships

Universities have played a role in innovation and knowledge creation for hundreds' of years (Etzkowitz, 2002; McClellan and Dorn, 2006). These original insights from academic research formed the basis for invention and discovery in society. The invention and discovery were enriched by people with university training (White, 1964; Pacey 1991; McClellan and Dorn, 2006). Universities provided knowledge creation and diffusion towards a problem. Industry translated and developed that initial understanding of applied learning and uses. The applied learning and use would be utilised into new products and services for society (White, 1964). Understanding the historical perspective of UIPs would help understand and appreciate what has occurred. The past and present knowledge for UIPs is necessary for researching new forms of UIPs that will be needed in the 21st century (Gray, 1989; Audretsch, Link and Scott, 2002; Barnes, Pashby and Gibbons, 2002; Boardman, 2009; Boardman and Ponomariov, 2009; Bellgardt, *et al.*, 2014).

The first industrial revolution, from the late 18th century to the early 19th century, began in Great Britain and quickly spread to the newly formed colonies in America. It brought many advances to society, including inventions such as the cotton gin, steam engine and textile mills that significantly changed the routine of daily life for farming communities and greatly improved the standard of living in many rural villages and cities, impacting the way people lived, travelled and communicated (Pacey, 1992; Millard, 1993; McClellan and Dorn, 2006). This first industrial revolution had inventors that came from society who tinkered to solve problems in society (Millard, 1993; McClellan and Dorn, 2006). Universities were not as collaborative in the early years of the first industrial revolution. During the latter part of the 19th century, inventors began to collaborate more with universities. Inventors like Thomas Edison hired university-trained people to address shortfalls in knowledge (Millard, 1993; Okasaki, 2001).

As industrialisation of society took shape in Britain and eventually America, there was a second wave of innovation in the latter half of the 19th century. The role of science and technology influenced from the first revolution birthed a more serious interest in invention and innovation methods (Pacey, 1992; Evans, 2004; McClellan and Dorn, 2006; Delanghe, Muldur and Soete, 2010). The wave of new Inventions contributed to making cities more livable. The inventions also changed society and allowed for a dual-economy between the more rural agrarian way of life and the life in the working towns (Dickson and Dickson, 1894; Henry and Walker, 1992; Dasgupta and David, 1994; Johnson, 2010). In Figure 2, I illustrate the parallel growth of the university with the first and second industrial revolutions expansion of industrial growth.

Figure 2. The Parallel Growth of Universities and Industry Expansion



Adapted from: http://historyproject401.blogspot.com/2013/04/timeline-of-industrial-revolution.html

The second industrial revolution began in the United States in the 1870s and lasted until the Great War of 1914-18. This period of rapid economic growth formed an advancement of knowledge in what became known as 'scientific industries' in electricity, steel, chemicals, and communications (Pacey, 1991; Munson, 2005; McClellan and Dorn, 2006). During the second industrial revolution, informal interactions with universities became more formal. Inventors sought out people and organisations that had experience and knowledge in various disciplines that usually had some connections with universities (Millard, 1993; Mays, 1999; Etzkowitz, 2000, Etzkowitz, 2002; Gould, 2012). Thomas Edison, an American inventor, came to the forefront of this rapid economic rise in the United States during the late 19th and early 20th centuries. Edison developed the first industrial research laboratory complex dubbed 'the invention factory'. The Edison invention factory was made up of many men who were university-trained and in some cases full professors of their fields. The importance of the university-trained inventor and invention process became a turning point in the industrialisation of knowledge management and industrial application (McClure, 1879; Millard, 1993; Israel, 2002; Jonnes, 2003; Evans, 2004). Edison built his first industrial laboratory at Menlo Park, New Jersey in the US in the late 19th century. At the time, Menlo Park was the largest private laboratory in the world and the largest devoted to creating industrial inventions such as the phonograph, lightbulbs and communications (McClure, 1879; Millard, 1993; Okasaki, 2001; Jonnes, 2003; Salkind and Israel, 2004). This invention factory illustrated in Figure 3, served as a model for industrial organisations to establish their own internal 'knowledge universities' to address internal problems relating to their R&D efforts. Edison's invention factory eventually became the General Electric Company and the first fully functional industrial research organisation (Millard, 1993; Salkind and Israel, 2004).

Figure 3. Thomas Edison's Menlo Park, New Jersey "The Original Invention Factory"

The first industrial Research Organisation. Eventually Became General Electric (GE)

Edison's extraordinary invention performance being stimulated by outside collaborations eventually became the predicate model for industrial research and collaboration approaches in the U.S. The work Edison accomplished helped to speed up the importance of partnerships between universities and industry (Millard, 1993; Israel, 2002; Gelb and Cadicott, 2007). As the 20th century evolved, society's fascination with applied sciences became more prevalent (Israel, 2002). The emerging needs of society provided new impetus for continued tinkering and invention (Millard, 1993). The challenges in meeting these evolving societal needs became more, urgent and complex. The societal expectations also grew and required more diverse knowledge sources and applications from several disciplines (Israel, 2002).

The days of individual inventors were declining as the need to address the complexity required a greater understanding of the various fields of science and technology. Innovation success could result from interactions with university-trained inventors and innovators (Jonnes, 2003; Salkind and Israel, 2004). University-trained inventors were still a small percentage of the innovation landscape in the late 19th century (Munson, 2005). As the world entered the 20th century, the role of universities and knowledge generation became more commonplace in innovation models (Evans, 2004). Innovation became both an inventive as well as a discovery-driven set of approaches to addressing societal needs. Inventive partnerships between universities and individual inventors like Thomas Edison, Vanderbilt, J.P. Morgan, and Westinghouse, became industrial partnership models for new collaborative approaches to innovation (Dasgupta and David, 1994; Jonnes, 2003; Munson, 2005). The 20th century brought greater challenges that required a wider range of resources to engage in solving problems (Israel, 2002; Munson, 2005; Todaro and Smith, 2009).

The early 20th century saw a combining of science and technology fields that eventually formed new integrated and interdisciplinary fields. The new fields of science and technology had a theoretical underpinning from academic research and a more practical applied form of research that came from industry. These new integrative areas such as materials sciences, advanced chemicals, electrical circuits led to more advancement in science and technology and the breadth of expertise within universities in the early 20th century (Israel, 2002; Gelb and Cadicott, 2007). During the middle of the 20th century, industry and government sought out greater sources of knowledge and enabling resources to solve more complex problems. During WWII, a shifting focus was created on larger, more complex projects that required more knowledge and innovative approaches. The solution to address this need was to bring together teams of academic researchers into a more unified system of industrial innovation (Evans, 2004; McClellan and Dorn, 2006; Millard, 1993; Pacey, 1992). In the US and UK, the need grew for a more focused effort on innovative national partnerships centred on national security and industry needs. The'nationalisation of innovation' forged new thinking about forming national research centres of excellence or national research universities (Furman, 1990; Mays, 1999; Wesser, 1999; Wesser, 2003a; Wesser, 2003b; Gelb and Caldicott, 2007).

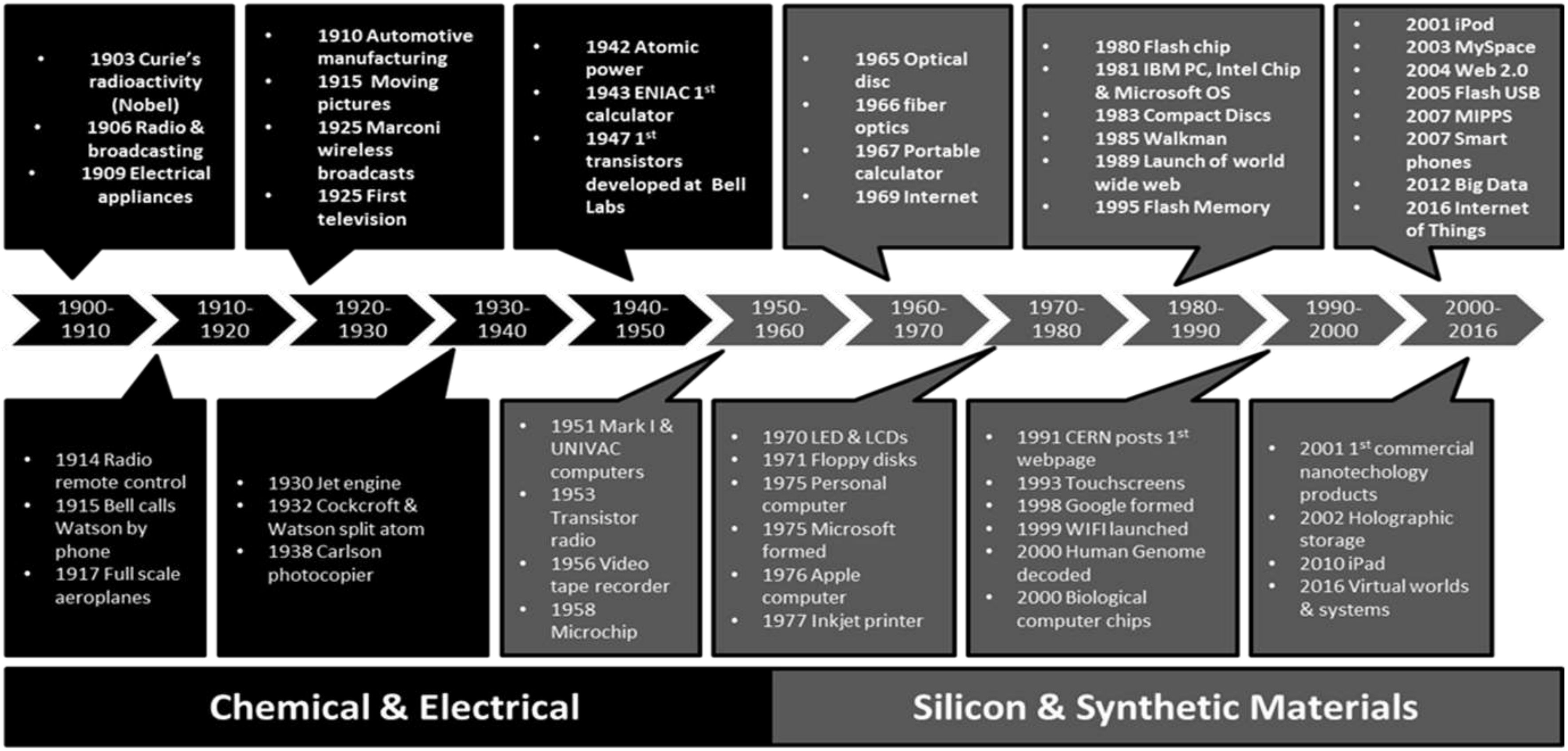
The influences of the 20th century forced universities, industry and governments to create new ways of innovative R&D (Furman, 1990). The result was the applied research university (Hiltzik, 2000; Etzkowitz, 2002; Perkmann, King and Pavelin, 2011; Perkmann, *et al.,* 2013). In the book, *MIT and the Rise of Entrepreneurial Science,* the transformation of the role of universities in the United States as one of applied research or 'quasi-research' centres for industrial applications. This MIT model for university development of industrial needs led to the first formalised and structured collaborative model of UIPs (Etzkowitz, 2002). MIT was formed to take a more commercial approach to research through applied mechanisms that made interactions with industry the core premise of its existence (Etzkowitz, 2002).

The genesis of the driving blueprint for this MIT model started to develop in the 1930's in Boston, Massachusetts in the U.S. That first section of real estate around MIT grew into what became known as 'research row'. Research row was a stretch of land between MIT and Harvard University in Cambridge, Massachusetts's Memorial Drive. MIT became the first commercially oriented incubator campus in the world. With the start of this research row, the MIT model eventually led to what is known today as the modern UIP focused on commercially-viable research and development (Etzkowitz, 2002).

The role of government has also played an important part in UIPs since the early 20th century. Governments increased funding to support areas of research and provided policy formation to ensure that proper support was provided to UIPs that were part of the national agenda (Mansfield, 1998; Phan and Siegel, 2006). In these UIPs, the government's goals were to stimulate positive economic development impact (Henry and Walker, 1992; Mays, 1999; Delanghe, Muldur and Soete, 2010). We are now firmly in the midst of a Third Industrial Revolution that started after WWII and is moving us towards a Fourth Industrial Revolution in the early 21st Century. The 3rd industrial revolution could be highlighted with selected major advancements for each decade during the 20th century and into the first decade of the 21st century as presented in Figure 3. The global nature of collaboration involved more stakeholders. Technology and communications are now real-time and create more interactive challenges. The contributions of UIPs historically have been great. The expectation that UIPs will contribute to the future is given. The future is complex in knowledge economies, and future UIP frameworks must be adaptable, modular, efficient and dynamic enough to address the changing needs of future innovation.

Figure 4. The 3rd Industrial Revolution

- *Science & Technology Evolve Towards More Applied and Integrated Uses*
- *Universities Collaborate More with Industry and Government*



Adapted from: http://www.slideshare.net/lynettegoodnight/md4assgngoodnight1-1

1.4 The Motivation for the Research Topic

I've worked for over 30 years in the research, development and commercialisation of science, technology and medicine. The areas of my professional experiences are life sciences, biotechnology, pharmaceuticals, diagnostics, medical devices, nanotechnologies, high-performance computing, material sciences and machine learning/artificial intelligence. My motivation has been greater improvements in the creation, formation and execution of UIPs in science and technology. If these greater improvements are achieved, then success in UIP design and operations will help to stimulate more accretive outputs that impact our innovation objectives. I have a large role in designing, forming and overseeing UIPs as part of my professional career. If a UIP can perform extraordinarily and consistently over a longer period, the impact on my professional career would be significant.

I have also contributed as an adjunct faculty member and research fellow in universities for over 20 years. My experiences in the academic world have been a part-time lecturer, research fellow and advisory board member for graduate school programmes. The experience of teaching, writing for internal academic communications and trade press journals convinced me that a larger world existed outside of the academe that I was experiencing before the start of my D.B.A. The professional doctorate blends real-world professional practice with a more scholarly approach from academia.

1.5 Introduction to Centre for Materials Discovery (CMD)

The Centre for Materials Discovery or CMD is a university-based advanced research and development centre for materials science, nanotechnology, combinatorial and computational chemistry. You may find more up to date information by going to the reference section under (Centre for Materials Discovery, 2017). The CMD is located in the College of Science and Engineering as part of the Chemistry school on the campus of the University of Liverpool. The University of Liverpool and the CMD are in the Northwest of England and comprise a large industrial and academic region with other city clusters. The CMD was set up as a centre of excellence (COE) providing multi-disciplinary integrated research, applied research and commercial development for advanced chemicals. The CMD utilises computer science, mathematics and a wide range of physical sciences to create a mix of NCEs.

The CMD can discover, characterise, and formulate a wide variety of chemical compounds for a large number of industrial applications. The NCE outputs are catalysts, consumer products, beverages, personal care, industrial lubricants and adhesives, pharmaceuticals, biomedical devices and chemical coatings are some of the commercial products derived from the work at the CMD. These new chemical compounds are new to science, have never been published or described and constitute new intellectual property for commercial exploitation and academic publishing. The objective in the CMD UIP is to develop a portfolio of NCEs that are original and allow the UoL and Unilever to develop a programme of intellectual property rights of chemical compounds that can be monetised through commercialisation.

1.6 Chapter Synthesis

1.6.1 University-Industry Partnerships

In the 21st-century knowledge economies, collaborative partnerships have become an important vehicle for innovation. The partnership with the University of Liverpool and Unilever through the venue of the CMD has created an extraordinarily successful and sustainable partnership. This success, at the time of this thesis writing, has produced several consumer good products for over ten years with billions of pounds of revenue potential in new products for Unilever. This new growth revenue will happen in their personal care, cleaning and consumer packaged goods businesses and is part of the Unilever sustainability corporate strategy. The success has provided for expansion of Liverpool faculty, funding, publishing, patenting and influenced a rising of prominence in university research table rankings. My thesis will discover what key factors have led to the sustained high-performance success of the CMD UIP for NCE discovery. When the empirical research findings are presented and discussed, I will construct an actionable framework for innovation professionals to design and operate a sustainable UIP. The goal of this actionable framework is to make the CMD UIP model portable, ubiquitous and usable by any innovation professional regardless of the industrial sector or field of academic interest.

1.6.2 Thesis Contents

Chapter 1, ‘Introduction’ highlights the research thesis. UIPs have a long history of contribution to the knowledge economy and society. In my professional experience, it is rare to encounter a UIP that demonstrates sustained high-performance. The CMD UIP is notable for its long sustained success in NCE discovery. Chapter 1 introduces the thesis by discussing the purpose, importance and implications of the thesis research. The forming and framing of the research questions are developed and presented. A selected historical overview of the last two hundred years of UIPs provides some context for the rise of the entrepreneurial university and the birth of industrial research and development model. I also highlight the historical aspects of the evolving roles that government has played. I discuss my motivations for this thesis research and potential applications for my professional practice. A first descriptive introduction to The Centre for Materials Discovery (CMD) is presented. The Chapter closes with a synthesis of UIPs, the research questions posed and the structure of the thesis itself.

Chapter 2, ‘Literature Review’ is a detailed selected review of the literature surrounding UIPs, high-performance and sustainability (long duration) of performance in UIPs. Chapter 2 discusses the literature review approach. The chapter outlines a conceptual literature mapping strategy, search topics and keywords. Historically, individual UIPs were created to address known (specific) needs of industry. Over time some standard models emerged for UIPs that was transactional. The key performance parameters for such models are known (people, technical capabilities, technical interest match, contract requirements, etc.).

The dynamism and complexity of the contemporary economic landscape (globalisation) suggest that traditional models are not sufficient to meet the more fluid and complex knowledge-based industries and economies. To meet this emerging set of challenges, new UIPs must be more fluid and dynamic. The partnership models that have evolved (i.e. the Triple Helix literature) are trying to address these problems. The refinement of issues regarding UIPs is researched in the literature review. This refinement relates to designing partnerships that can adapt to shifting economic imperatives. This evolving understanding of UIPs suggests that the empirical work needs to explore partnership practices related to the structure of UIPs, high-performance and sustainability. In Chapter 2, the literature helps to inform about these concepts and provides teaching into the design of the thesis research and future discussions of findings.

Chapter 3, ‘Research Methodology’ discusses the approach, design, and activities of the thesis research. A qualitative methodology will be used to build a rich understanding of the practices of the CMD UIP, the needs of the actors and how a government may play a role in UIPs. The use of ethnographic study approach achieved through a single case study of the UoL and Unilever partnership will provide empirical data to help understand the CMD UIP as a partnership, high-performance and sustainability factors. An overview of the data collection, analysis and presentation will be presented.

Chapter 4, ‘Case Study of CMD UIP’ provides an introduction, historical background, present context and range of stakeholders involved in the CMD UIP. An economic-historical context of the University of Liverpool and its present-day contributions. Unilever, the industry actor with its historical association with Liverpool and partnership with the university. The role of government in the city region and this university will be highlighted. A more thorough description and understanding of the CMD itself, its scientific strengths, key actors and history will be presented. Finally, a brief discussion regarding the CMD and the CMD UIP’s implications for my research and applications for my professional practice.

Chapter 5, 'Research Findings' presents the findings from the empirical research. Also presented will be general themes that emanated from the findings regarding the CMD and CMD UIP. The findings will be sorted into emerging themes. The emerging themes and highlighted factors will be coded and categorised into thematic groups that emerge. The empirical findings will provide a structure for implications and discussion in Chapter 6.

Chapter 6, 'Research Discussion' presents the findings from Chapter 5 and develops the main themes and underlying sub-themes into areas for discussion. The discussion of findings will be informed by the literature review insights, my professional experience, the experiences of being embedded into the CMD and the CMD UIP. Chapter 6 will explore and elucidate key factors from the findings surrounding success in individual UIPs, high-performance and sustainability.

Chapter 7, 'Conclusions and Implications for Professional Practice' explores a synthesis of actionable options created from the themes that emerged from the empirical research. These options will come from key factors that were output from the study. I will develop an actionable framework for innovation professionals in UIPs, which allows them to develop strategies for the sustained successful design, formation and operation of UIPs in their professional practice.

Chapter 8, 'Reflections of a Scholar-Practitioner' provides an aggregate discussion of the candidate's doctoral journey. A synthesis and critical discussion regarding the professional doctorate and the impact that is has and will have on my professional practice.

Chapter 2: Literature Review

2.1 Introduction to Literature Review

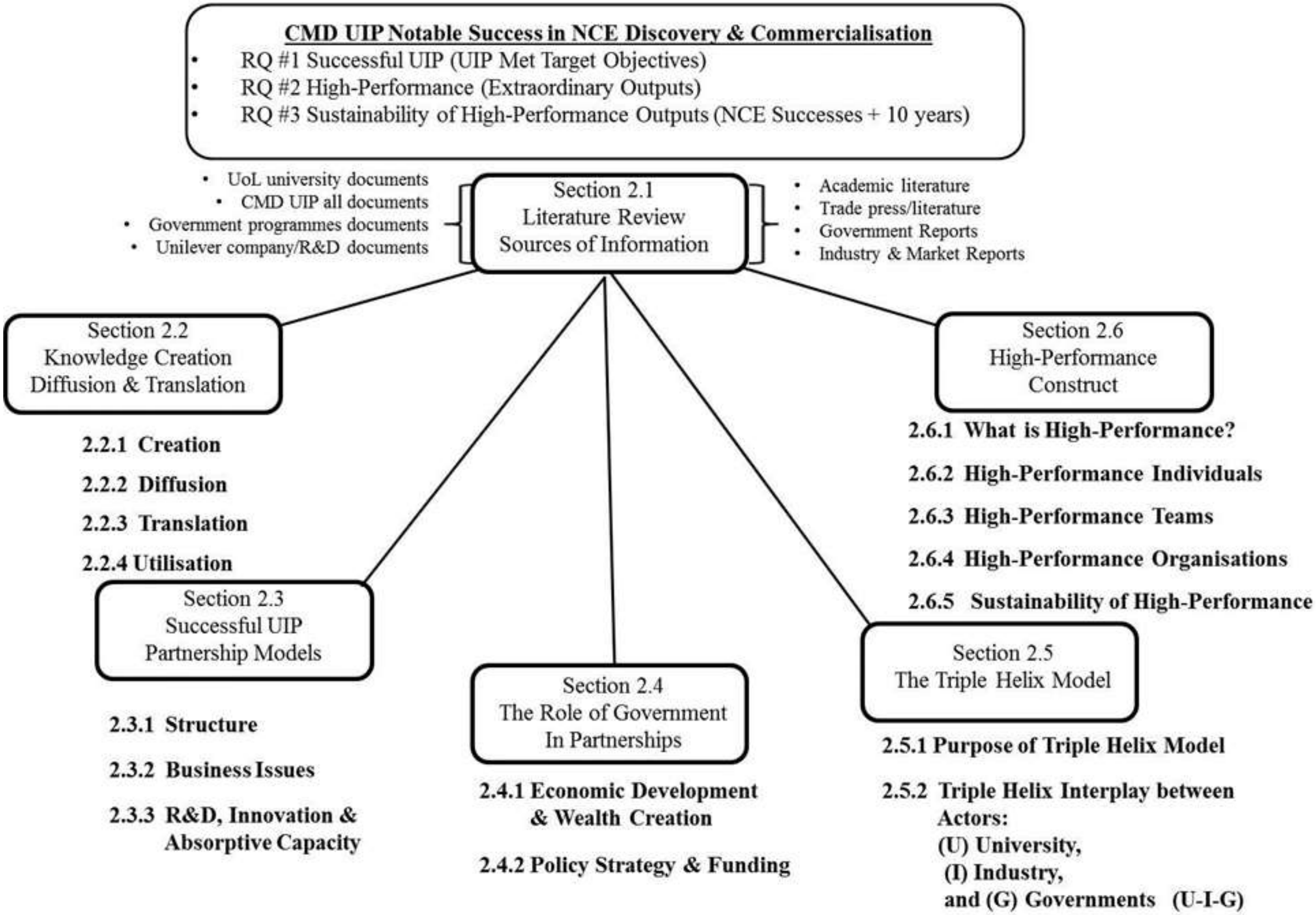
This chapter focuses on a review of the existing literature both academic and trade, regarding relevant factors associated with partnerships, specifically UIPs. In approaching this review, I have focused on the process of knowledge as it pertains to UIPs. Knowledge creation and the application to society are the vast majority of motivations for forming UIPs today (Etzkowitz and Leydesdorff, 1995; Etzkowitz *et al.*, 2000; Poyago-Theotoky, Beath and Siegel, 2002; Perkmann *et al.*, 2013). As part of the literature strategy, I wanted to understand what sources existed along with the breadth and depth of literature surrounding UIPs first. Initially, I used a keyword search strategy involving more common terms such as 'open innovation', 'university-industry partnerships', 'contract research' for example. From the initial readings of the literature on UIPs, it started to emerge that governmental interactions had influence and material bearing on UIPs. It appeared that governmental involvement was for the economic development of society and wealth creation for the nation.

As part of a national or regional agenda, governments would promote policies and funding schemes to enable or expand innovation through UIPs (Audretsch, Link and Scott, 2002; Cohen, Nelson and Walsh, 2002; Cooke, 2007; D'Este and Patel, 2007; Boardman, 2009; Delanghe, Muldur and Soete, 2010; Wilson, 2012; Leydesdorff, 2013; Bellgardt, *et al.*, 2014; Dudin, *et al.*, 2014; Arocena, Göransson and Sutz, 2015; BIGT, 2015). In this first general survey of the literature, the UIP as a construct emerged into what appeared to be three main areas: 1) structures/organisational parameters of UIP models, 2) business and legal issues that surround the formation, operation and outputs of UIPs and lastly, 3) the underlying motivations for various parties to consider and engage when forming and operating a UIP. As I gained more experience with the UIP literature, I discovered a well-accepted global framework called the Triple Helix Model (THM). The THM serves as a framework for contextualising UIPs, the motivations and the actors involved in UIPs.

As mentioned previously, I had three research questions of interest in studying this particular UIP. The three research questions were: 1) what factors lead to successful UIPs? 2) How is extraordinary UIP output (high-performance) achieved? And 3) how is the high-performance of UIP output made sustainable? The first research question focused on the elements that make successful university-industry partnerships. The second research question asks what key elements are present in high-performance environments, in general, and specifically, those doing HTS chemical screening for NCEs. The last research question was focused on understanding key elements that allow for sustainable high-performance in UIPs. What follows in this chapter is a selected synthesis of the literature on Knowledge processes (section 2.2), UIP partnership success factors (section 2.3), the role of government in UIPs (section 2.4), a model of stakeholder interactions entitled ‘The Triple Helix’ (section 2.5) and the components of the high-performance construct (section 2.6). My professional practice experience of over 30 years was helpful in exploring deeper potential factors in UIPs. In the follow-on rounds of the literature search, the previous literature helped to inform new keywords and concepts for searching. Advanced keywords such as ‘common ground in partnerships', ‘knowledge transfer initiatives (KTIs), ‘knowledge communities', ‘knowledge policies', ‘innovation sectorial channels' were some of the keywords used. After review of literature about the Triple Helix, I decided a separate section (2.5) was warranted in the literature review. The repeated rounds of literature reviewing led me to conceptualise and framing a key literature mapping approach used in this thesis. The key literature map I developed for the literature review strategy and mapping of the main areas of focus in the literature are illustrated in Figure 5. I used several strategies for increasing the sources of potential literature to review. I scanned the reference tables of document sources for additional sources. If possible references provided for further information and possible direction, the citations were searched via an electronic library. I also kept an electronic log in EndNote, an advanced research software organiser EndNote allowed me to analyse the higher cited papers and impact scores in the outstanding literature. Lead author frequency and authors as groups publishing were also analysed to capture literature that might be referenced more often or used to validate points of argument.

In conducting the literature review, materials were accessed via electronic library (Liverpool Online Library, Google search and Google Scholar) for papers and ebooks whenever possible. Books, trade reports and other printed source materials were accessed through university, public libraries or purchased through retail online or bricks and mortar bookstores. To understand the perspective of governments, I surveyed sources of government reports, working papers, policy discussion reports, and published sources of government activities, quasi-governmental economic agencies in the U.K. and agency websites. I also accessed an extensive collection of documents as part of my professional library. My professional library consisted of trade journals, trade/industry books, business/textbooks, investment banking, analyst/market reports and documents relating to former UIPs and innovation programmes.

Figure 5. Literature Review Key Concepts Map



2.2 Knowledge Processes

Epistemology or theory of knowledge is the branch of Western philosophy that studies the nature and scope of knowledge. Knowledge is a familiarity, awareness, experience or understanding of someone or something, such as facts, information, descriptions, and ways of doing something, events, ideas, objects or skills, which is acquired through experience or education by perceiving, discovering, or learning. Knowledge can refer to a theoretical or practical understanding of a subject (Dretske, 1969; Science Daily, 2016). Practically speaking, knowledge is a system of beliefs, observations, experiences and interpretations that we go through to try and make sense of the overall essence of the world around us (Audi, 2011). In UIPs, the main objective was to create or use knowledge and its derivatives for either intellectual or commercial gain. In UIPs, the motivations from stakeholders are to augment, increase or acquire knowledge so that the results are better than if left to their organisation (Beise and Stahl, 1999; Goldman, 1999; Arvanitis, Kubli and Woerter, 2008; Cooke, 2007; Jong, 2008). If knowledge processes and commercialisation are important to UIPs, what factors in the process of knowledge development are key to sustainable, high-performance UIPs?

2.2.1 Creation.

The creation of knowledge is either through planned or unplanned activities by one or more actors interested in some phenomenon, observation or event that has occurred around or to them (Landes, 1970; Audi, 2003; Munson, 2005; Feldman, 2003; Kingdon, 2012). If society experiences an action, it may want to explore it further to understand. If that action affects the society in some way, the motivation to study, explore and understand increases (Landes, 1970; Audi, 2003). The need to understand and control (harness) an event or observation is what leads many inventors, scientists and researchers to seek a common explanation for society and make it useful, if possible (NESTA, 2008). Universities seek to understand what is around them through basic or original research approaches (Etzkowitz, 2000; Van Gundy, 2007). The exploration through various research methods provides information on which to test hypothesises. These hypothesise usually directed towards problems to solve or issues to understand clearer (Audi, 2003).

The university or university-trained men have been the main drivers, historically, for original research in society (Landes, 1970; Pacey, 1991; McClellan and Dorn, 2006). Whether invention (research towards a planned outcome) to solve a particular problem or discovery (research towards the generation of data, observations, etc.) to explore further and expand understanding, knowledge creation has usually emanated from university or university-influence organisations (Etzkowitz, 2002; Wesser, 2003b). The influence of university research activities can accentuate the societal interest in addressing problems in society and stimulate involvement from various sources. Engagement of academic scientists and researchers with societal or industrial issues can be influenced by both intellectual curiosity and real applications of their research (U.K.C.R.C., 2005; Thursby and Thursby, 2011c; Tartari, Perkmann and Salter, 2014; Thune and Gulbrandsen, 2014; Vonortas, Rouge and Aridi, 2014).

In today's knowledge economies, society seeks understanding and application of knowledge faster, more efficient and applicable to the problems or issues Gray, 1991; Wesser, 1999; Wesser, 2003a; Wilson, 2012). Creation of knowledge in today's knowledge-based economies is challenging. The knowledge creation focus has a greater emphasis on the applications and technologies are more interdisciplinary and multimodal (Wratschko, 2009; Ye, Yu and Leydesdorff, 2013; Zouain and Plonski, 2015; Owen and Hopkins, 2016). Where possible, academia will research topics that are of great interest to industry or government to gain greater support for research resources (Clark, 2004; Christensen, Olesen and Kjær, 2005; Arocena, Göransson and Sutz, 2015).

Industry in the knowledge economy seeks to have both proprietary and leading-edge science and technologies in which to exploit commercially (Chesbrough, 2003; Balconi and Laboranti, 2006; Chandy *et al.*, 2006). In the 21st century, industry is increasingly seeking open innovation from outside resources such as universities, government labs, non-profit research centers and crowdsourcing the internet for solutions to commercial problems (Schartinger, *et al.*, 2002; Link and Scott, 2003; Chang, Yang and Chen, 2009; Bishop, D'Este and Neely, 2011; Changsu, 2011; Haeussler, 2011; Link, Siegel and Van Fleet, 2011; Haeussler and Higgins, 2014). The greatest support financially comes from commercial applications for the actors, including society, involved in the knowledge creation (NAO, 2013; Ye and Kankanhalli, 2013; Owen and Hopkins, 2016).

2.2.2 Diffusion

Diffusion is the sharing of knowledge created by one party to another party who is interested in that knowledge. The parties can be within the same organisation, outside the organisation or organisations that are in some form of relationship with each other (Isaacs, 1993; Etzkowitz, 2002; Schofield, 2013). Diffusion can occur quickly after creation or evolve when the knowledge is ready for others to interpret or translate (Powell, Koput and Smith-Doerr, 1996; Martinelli, Meyer and Von Tunzelmann, 2008). The creation of knowledge by an organisation will reside within that organisation unless it has channels in which to disseminate the knowledge to interested parties. Sometimes withholding of knowledge is part of the process of knowledge creation (Alder, Shani and Styhre, 2003; Audi, 2003; Colyvas, 2007). The withholding, many times, is part of the internal process to general a flow of data that will lead to an eventual seminal discovery of the research topic.

The release of knowledge won't occur until the parties believe it has merit and will meet existing standards or establish new gold standards (; Link and Tassey, 1989; Hatakenaka, 2004; Clarysse, Tartari and Salter, 2011). Universities typically do this for publishing a series of discoveries or processes that build in technical scope and in reporting for the peer-reviewed literature (Reams, 1986; Mays, 1999; Perkmann and Walsh, 2008). The industry will follow this approach when it wishes to protect its knowledge through intellectual property mechanisms (Heidrick, Kramers and Godin, 2005; Anderson, Daim and Lavoie, 2007; Andersén and Kask, 2012).

Knowledge diffusion is important in the process of validating the work of others. Diffusion also allows other to conduct research and add to this knowledge pool of data (Link and Scott, 2003). Diffusion is an important first step after creation in that it provides a first look and interpretation of the knowledge constructs, rationale, data and potential usefulness to society (Jo and Joo, 2011; Ankrah *et al.*, 2013). In the 21st century, diffusion can have different meanings and travel different paths in various fields of science and technology or industry sectors. This incorporation of interpretation is the basis of translating the knowledge created into workable parts that can be further analysed for applications in various sectors (Bekkers and Bodas-Freitas, 2008; DeFuentes and Dutrénit, 2012). Diffusion occurs by various routes. Diffusion is both direct and indirect transfer of knowledge (Murphy, 2013). The route that diffusion takes is not always obvious or can be charted out. The non-linear paths that knowledge can take are why diffusion can be hard to study as there are more ways of transferring knowledge than many can observe (Johnson, 2010; Kingdon, 2012). Diffusion can be spill-overs or knock-ons (Nelson, 2009) where initial work leads to new understandings parallel to the main knowledge. This knowledge spill-over can be repurposed to be used in other parallel applications (Barnes, Pashby and Gibbons, 2002; Balconi and Laboranti, 2006).

Repurposing is taking one set of known data used for a vertical application, say biology, and using it for a different parallel use, say chemistry, that is non-competitive to the original use. An example would be a chemical compound that can strip rust from metal without damaging the metal surface. A new group in biochemistry learns about the basic properties of the compound. The repurposing research group then uses it to remove impurities from iron smelting processes that create a nanotechnology-based new steel alloy for construction purposes. A form of knowledge reused or repurposed. When more than one organisation shares some knowledge with another organisation, there is a hybridisation of the original knowledge transfer. Combining knowledge elements can lead to new levels of knowledge created and reused in a cycling pattern between the original as well as new organisations (Bekkers and Bodas-Freitas, 2008; Fabrizio, 2009; Bishop, D'Este and Neely, 2011).

The routes of dissemination for universities are usually peer-reviewed journals, books, seminars, conferences on the academic side. On the academic side for industry dissemination, the best channels are through interactions between parties at conventions, congresses, publications and face-to-face meetings (Morone and Taylor, 2004; Jong, 2008; Jo and Joo, 2011; DeFuentes and Dutrénit, 2012). Industry dissemination of knowledge usually occurs through intellectual property processes of patent, trademarks and know-how. Industry, outside of collaborations, will protect the knowledge generated by the company and only share when necessary (Reams, 1986; Powell, Koput and Smith-Doerr, 1996; Prigge and Torraco, 2006; Nelson, 2009; Von Tunzelmann, 2010). Industry's diffusion is not as effective (usually due to intellectual property concerns) in knowledge transfer unless there are a partnership or contractual protections. The knowledge transfer to industry is seen in final outputs of goods and services (Haeussler, 2011; Aslan Şendoğdu and Diken, 2013).

2.2.3 Translation

Translations of knowledge are the steps taken by receiving parties of knowledge towards an intended goal or objective for the use of that knowledge. Knowledge can also be translated before diffusion if the nature of the research is conducted by exclusive or limited groups (Blaug, Chien and Shuster, 2004; Chandy *et al.,* 2006; Barbolla and Corredera, 2009). Translation in a UIP can be difficult when either side doesn't have a clear understanding of two elements. The first element is the intended knowledge output being transferred and translated properly. This first element needs clarity and completeness in definition and acceptance of what is useful. The structuring of the UIPs and working guidelines help to manage this problem (Davis *et al.,* 2003; Chang, Yang and Chen, 2009). The second element is how the information is interpreted by the receiving party about the original objectives of the knowledge transfer and partnership tenets. Having clear research objectives, processes and defined intended outputs can address this element if it becomes an issue (Heidrick, Kramers and Godin, 2005; Singh, 2005; Nelson, 2009; Changsu, 2011).

Translation of knowledge is an important step towards that intellectual property being properly and fully utilised by the receiving parties. If knowledge creation and diffusion occur, but the translation doesn't happen or is inefficient, the chances of extracting value from that diffusion will be limited at that time. A large amount of knowledge can be generated and diffused, but if there are no guidelines or mutual understanding on how to interpret the new knowledge, then translation doesn't occur efficiently or not at all. In partnerships, the rules, laws, guidelines or other classifications are set out before the partnership formed. If there is no way of forming some common understanding, interpretation or agreement upon common grounds, then translation has failed to transfer the knowledge. The improper use or lack of understanding is a common issue (lack of proper translation) in UIPs as all parties to the UIP don't spend enough time defining the objectives, deliverables and what constitutes success. (Barnes, Pashby and Gibbons, 2002; Davis, *et al.*, 2003; Blaug, Chien and Shuster, 2004; Anderson, Daim and Lavoie, 2007; Cabrera, Collins and Salgado, 2007; Graham and Tetroe, 2007; Lang, Wyer and Haynes, 2007; Baumbusch, *et al.*, 2008).

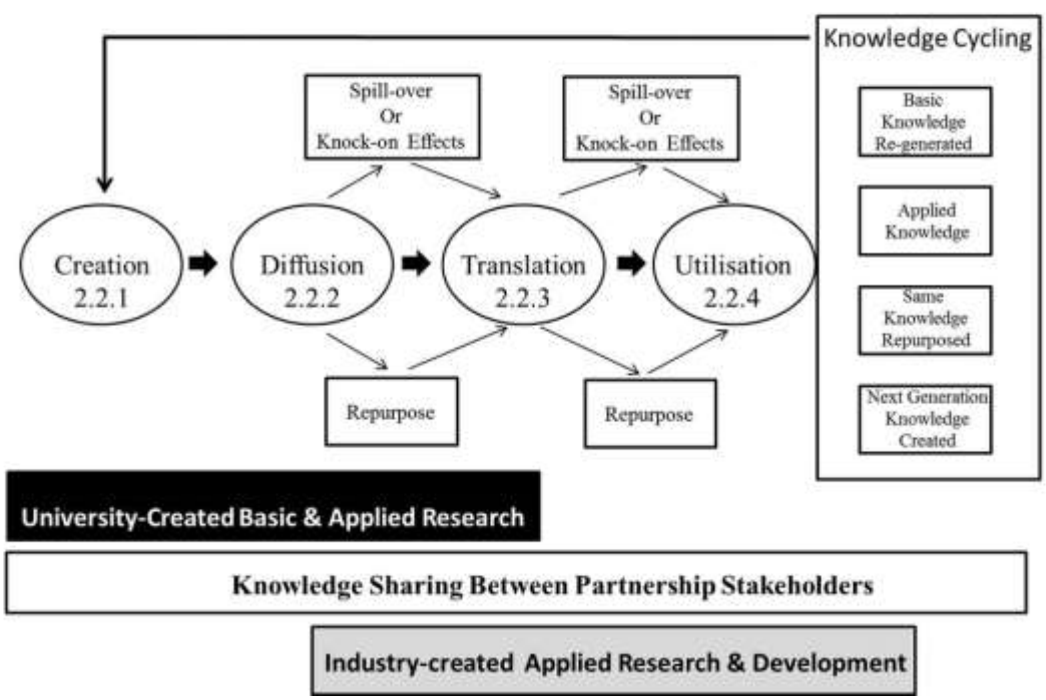
For knowledge translation to work properly, all parties must be clear from the outset of the intended information that will be created, diffused and delivered to the parties of the collaborative partnership (Chandy *et al.*, 2006). The next step in successful translation is mutually agreed upon variables, definitions, formulas and current understanding of state of the art surrounding the knowledge constructs being shared and evaluated (Balconi and Laboranti, 2006; Chandy *et al.*, 2006). The last step and one of the hardest is the composition of the individuals and teams of each organisation involved in the knowledge translation.
There must be flexibility, openness, willingness for an intellectual and positive challenge discussing the knowledge materials being shared and interpreted amongst the parties (Bessant and Tidd, 2007; Bercovitz and Feldman, 2011). As knowledge is shared and interpreted, there may be more knowledge created, diffused and shared in repeating cycles. This cycling leads to validation and acceptance by others outside of the core partnership through publication or patenting (Nelson, 2009). The cycling can also occur inside the partnership and only shared with members of the collaborative organisations. Regardless of the information being shared is publically available or not, translation is a crucial step towards using the knowledge for public good, wealth creation and general economic development (Lang, Wyer and Haynes, 2007; Harris and Albury, 2009; Schofield, 2013).

2.2.4 Utilisation

Utilisation of knowledge constructs can be made by some parties such as universities, industry, government agencies and non-profit organisations. Utilisation is the last step in the knowledge process from my selected review of the literature. Utilisation is an important step in the knowledge process as it usually means commercialisation and creation of value (Salter and Martin, 2001; Weisberg, 2003; NESTA, 2008; Boccanfuso, 2010). Utilisation is what brings the fundamental knowledge to life and delivers impact for economic development and advancement of knowledge (Etzkowitz *et al.,* 2000; Etzkowitz, 2002; Shane, 2005). Utilisation can be in many forms such as continued research from the original information, new product or service development or modifications to existing knowledge, products and services (Siegel *et al.,* 2003; Siegel *et al.,* 2004; Boardman and Corley; 2008; Borzillo and Kaminska-Labbe, 2011). Utilisation is the step in the knowledge process that provides lasting value to society through knowledge enhancement and use.

It is the step of utilisation that UIPs strive for in their partnerships as it means commercial execution (Etzkowitz, 2000; Boccanfuso, 2010). Utilisation provides monetary and intellectual benefits for universities and industry (Chesbrough, 2003; Chesbrough, 2003a; Cummings and Teng, 2003; Chandy *et al.,* 2006). Governments strive in their innovation policies and funding schemes to promote effective utilisation of knowledge (Delanghe, Muldur and Soete, 2010; Engel, Fischer and Galetovic, 2014). The sharing of resources to promote knowledge advancement is critical to a nation’s innovation strategy (Hargroves and Smith, 2005; Etzkowitz and Leydesdorff, 1995; Boardman, 2009; Dudin *et al.,* 2014). A synthesis of the selected knowledge literature surveyed regarding knowledge processes in partnerships is illustrated in Figure 6 on the next page. There are four distinct stages of knowledge processing. The first is the creation of knowledge. The second stage is sharing or diffusion of that knowledge to others who are interested. The third stage is the translation of the new knowledge by those who value the knowledge and wish to apply the knowledge to their needs. Once the knowledge is understood and integrated into the thinking of an organisation, the last stage occurs. This final stage is utilisation of knowledge by incorporation into new products, services or as a component of further experiments that will build on this new knowledge. During this knowledge process, there can be spill-overs that feed into other areas that help to develop new knowledge applications. This is sometimes known as 'repurposing'. The knowledge process continues this knowledge cycling with four main paths as presented in Figure 6. The industry is more engaged in the later stages and universities in the earlier stages of the knowledge process.

Figure 6. The Process of Knowledge Systems in a Knowledge Economy



2.3 University-Industry Partnerships

2.3.1 Structure

Today, we are experiencing rapid technological change and global complexity in our personal and professional lives. UIPs, historically, were created to address apparent needs within society (Etzkowitz, 2002). Over a period, UIPs became a new form of a ‘quasi-firm’ to bridge the research knowledge gaps between universities and industry (Etzkowitz, 2003). The models employed in UIPs became a standard group of structures such as ‘sponsored research’, ‘scientific consulting’, ‘co-development’ as examples of the way in which industry approached and collaborated with universities (Etzkowitz, 1998; Etzkowitz, 2003; Balconi and Laboranti, 2006; Bekkers and Bodas-Freitas, 2008; D’Este and Perkmann, 2011). The dynamism and complexity of the contemporary economic landscape mean that traditional models are not sufficient.

The knowledge-based economies require more refinement to partnership models so UIPs can adapt to shifting economic imperatives and globalisation. The importance of structuring partnerships that can leverage national and local resources along with collaborative approaches have been historically critical. In the future, UIPs will need to access more global and disparate resources that will be part of the fabric of future success in innovation (Henry and Walker, 1992; Mansfield, 1998; Perkmann and Walsh, 2007; Gould, 2012). Nations and their various agencies must work together in a public-private and public - public ecosystems that enables knowledge creation with universities, industry and government in processes that further the work of each stakeholder (Hiltzik, 2000; Mower and Sampat, 2004; Perkmann, 2007; Dudin *et al.*, 2014). These UIP models had to move away from being merely transactional, shorter-term and focused on one deliverable to a structure that has an evolutionary path as science and economics change (Etzkowitz, 2002; Etzkowitz, 2003). The UIP model has become a proposed and used framework towards diffusion, translation and utilisation of knowledge from universities to industry. Industry has now begun to transfer knowledge back to universities through UIPs to further provide knowledge for additional advancement by universities under contracts though UIPs (Henry and Walker, 1992; Isaacs, 1999; Israel, 2002; Etzkowitz, 2003; Heidrick, Kramers and Godin, 2005; Jain, George and Maltarich, 2009).

The efficiency of the knowledge process through the stages of transfer is critical to creating successful collaborations in UIPs (Anderson, Daim and Lavoie, 2007; Arvanitis, Kubli and Woerter, 2008; Wright *et al.*, 2008). The mechanism of knowledge transfer best suited to fill the gap between university and industry knowledge needs has mostly become the entrepreneurial UIP model initially proposed by MIT (Etzkowitz, 2002). As these more traditional models of UIPs adapt to growing pressures from globalisation and increased competition, stakeholders are defining more adaptive and fluid models that can shift towards more shared dynamic knowledge processes (Powell, Koput and Smith-Doerr, 1996; Vonortas, Rouge and Aridi, 2014; Owen and Hopkins, 2016). This commercialisation of university research can take many shapes and sizes. The intellectual property can pass through these various channels of knowledge transfer and collaboration through UIPs. Schools can achieve successful outcomes that are shared by both sides in a UIP (Perkmann and Walsh, 2007; Perkmann *et al.*, 2011; Perkmann *et al.*, 2013).

According to Perkmann *et al*., (2013), academic engagement is partly influenced by the type of research and sectoral fields where alignment with research interests of universities and industry drive the potential for initial interest and preliminary commitment. Faculty in schools may also follow sectorial patterns that may influence their willingness to collaborate with industry (Perkmann, King and Pavelin, 2011). Sectoral patterns are crucial in which universities and industrial companies may seek each other (Pavitt, 1984). The dynamism and complexity of the contemporary economic landscape (e.g. globalisation) mean that the more traditional models of UIPs are not sufficient to meet this demands of the knowledge-based economies (Chandy *et al,* 2006; Baumbusch *et al.,* 2008; Chang, 2011).

The method and organisational framework of the university engagement with industry can follow many structures from more straightforward contract research to more complicated co-development UIPs (Barnes, Pashby and Gibbons, 2002; Bekkers and Bodas-Freitas, 2008; Fabrizio, 2009; Fong-Boh, Evaristo and Ouderkirk, 2014). According to D'Este and Patel (2007), more university faculties are seeking to align their departmental needs with those of industry. Each structure of a UIP is defined by the objectives and outcomes. What makes UIPs hard to compare on a longitudinal basis is the varying degree of each element, milestone and deliverable within a UIP. Take the UIP channel, consultancy, as an example of a partnership. The adviser can be very short-lived, have one deliverable and provide small benefits to the university. Consultancy took in the same definition, but expand the scope of work into something more significant and you have potentially significant benefits for the academic researchers themselves. In one instance, small contract research UIP working on a series of experiments to augment the other partner's lack of time or resources versus a large contract research UIP that replaces or supports an overall R&D function for a company in the industry. The literature surveys UIPs in general terms, but the main focus of materials is specific to the situation of the UIP being studied. (Rogers, 1995; Powell, Koput and Smith-Doerr, 1996; Etzkowitz, 2003; Fontana, Geuna and Matt, 2006; D'Estes and Patel, 2007; Bekkers and Bodas-Freitas, 2008; Fazackerley, Smith and Massey, 2009; Ankrah, *et al.,* 2013; Plewa, *et al.,* 2013a; Plewa, *et al.,* 2013b)

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Sponsored research and contractual research is akin to the fee-for-service approaches that industry would adopt in outsourcing smaller pieces of work. Sponsored research is usually one-sided for the industrial organisation and doesn't convey many benefits to the university (Bekkers and Bodas-Freitas, 2008). The benefits can be large if the research is successful in the form of royalties on future commercial sales of the research (Blaug, Chien and Shuster, 2004; Boccanfuso, 2010; Engel, Fischer and Galetovic, 2014). The importance of the channel (UIP format or structure) selected can improve the success of the UIP through a greater shared view and mutually beneficial outcomes (Blaug, Chien and Shuster, 2004). According to Bekkers and Bodas-Freitas (2008), the most important variables that increase the chance of success in mutually-engaging UIPs are structures that are mutually collaborative, championed and supported by both sides at all levels and operate on an articulated plan. Establishing a baseline relationship is important and comes from an informed understanding of what each party brings to the UIP and what each party's responsibilities are as they relate to the UIP (Aslan Şendoğdu and Diken, 2013). It is in the pre-formative stages of a UIP that all parties to the UIP may not fully understand what it is they want out of the UIP itself. This is a common problem when establishing UIPs and effects the rates of success (Barnes, Pashby and Gibbons, 2002; Barbolla and Corredera, 2009; Barr *et al.,* 2013; Matuleviciene and Stravinskiene, 2015).

There are anywhere between a dozen and two dozen models (some are hybrids) of UIPs in the literature I could find. In a paper by Bekkers and Bodas-Freitas (2008), the authors' layout 22 channels or partnership structures that deal with various organisational or operational limitations between parties. They state that the most familiar two forms are sponsored research and contracts research/consulting. Sponsored research is usually more open to experimenting with the study groups, and contract research tends to have a more definitive set of outcomes that should as part of the UIP (Bekkers and Bodas-Freitas, 2008; Boardman and Ponomariov, 2009). When you have multiple stakeholders in a partnership, the degree of complexity can increase quite rapidly. The way these frameworks are set up and the linkages (key guiding principles and guidelines) that exist amongst stakeholders are key to either success or failure in their ability to work together in the UIP and deliver acceptable outcomes (Plewa *et al.*, 2013b).

2.3.2 Business and Legal

The importance of clear and workable guidelines that outline the purpose and operations of a UIP are key to establishing successful UIPs. The desired outputs and daily operational processes that involve all parties to the UIP are critical to lie out in written form. Critical issues from all sides of a UIP must be articulated, and a common ground reached to establish a workable framework (Wood and Gray, 1991; Christensen, Olesen and Kjær, 2005; Singh, 2005; Prigge and Torraco, 2006; Schalteffer and Wagner, 2011). According to Reams, (1986), one of the most common problems in establishing UIPs are the parties' willingness to fully engage and discuss the issues and outcomes sought by each side to the UIP. The common mistake in early discussions relating to the formation of a possible UIP is lack of full disclosure by one or more parties in the UIP. The reasoning behind this lack of full expression of interest and intention is fear of not consummating an agreement when the parties need to work together.

UIPs do get formed and operate without a common ground agreement to the terms of the relationship. These UIPs usually struggle to achieve results, and many fail outright (Reams, 1986; Prigge and Torraco, 2006; Schofield, 2013; Owen and Hopkins, 2016). The importance of a well thought out plan of action from all sides of a potential partner has been shown to be key in pre-discussion readiness (Thune and Gulbrandson, 2014). The clearer the objectives of the UIP and the role and responsibilities of each party, the higher the likelihood that a UIP will be formed (Beise and Stahl, 1999; Boccanfuso, 2010; Sharifi and Liu, 2010; Thursby and Thursby, 2011c; Schofield, 2013). There are many reasons known in the literature for the failure of partnerships. One common thread to these failures is a lack of mutual understanding and agreement between the key stakeholders. This failure is important as it is one of the dominating themes that define a partnership (Deakin, 1996; D'Este and Patel, 2007; Perkmann and Walsh, 2007; DeFluentes and Dutrénit, 2012; Perkmann and Salter, 2012; Perkmann *et al.*, 2013).

Common ground is critical in successful relationships as it provides the bonds of trust, engagement and agreement in desired outcomes (Isaacs, 1999; Matuleviciene and Stravinskiene, 2015; Owen and Hopkins, 2016). Common ground is what allows the mutually acceptable benefits to inure to the stakeholders and provides the stimulus, incentive and perseverance during the negations and formation of a UIP (Bruneel, D'Este and Iammarino, 2010; Perkmann *et al.*, 2013). In Isaacs book (1999) *Dialogue and The Art of Thinking Together*, having shared frames of reference and a willingness to understand all perspectives of others first before socialising your own, helps to build a common understanding, trust and willingness to engage with others.

2.3.3 R&D, Innovation and Absorptive Capacity

Historically, individual UIPs were created to address specific needs of society White, 1964; Landes, 1970; Pacey 1991; McClellan and Dorn, 2006). As time evolved and the rise of the entrepreneurial university took shape, various models became standard for UIPs (Etzkowitz and Leydesdorff, 2000; Poyago-Theotoky, Beath and Siegel, 2002; Perkmann and Walsh, 2007). The rise of the entrepreneurial university has improved applied research approaches to knowledge creation and utilisation (Etzkowitz *et al.*, 2000). Industrial organisations must invest in their knowledge systems and R&D efforts if they want to stay competitive Smith, Collins and Clark, 2005; Acworth, 2008; Fabrizio, 2009; Bishop, D'Este and Neely, 2011; Ye and Kankanhalli, 2013). Industries also now understand that commercial success can be leveraged in the sharing of knowledge in more formal arraignments. The commercial distinction between research and development has become more blurred as partnership models continue to evolve (Monjon and Waelbroeck, 2003; Fagerberg and Mowery, 2015).

These formal arraignments (i.e. partnerships) between universities, industry and government have become essential innovation frameworks as complexities increase in design and execution (Etzkowitz and Leydesdorff, 2000; Vaivode, 2015; Chai and Shih, 2016). What the innovation process requires is a strong entrepreneurial focus on R&D, both inside and outside of an organisation (Van Gundy, 2007; Vonortas, Rouge and Aridi, 3014). The combined R&D efforts leverage more resources which in turn increase changes for success, lower risks and provide the necessary content for further research (Fabrizio, 2009; Ye and Kankanhalli, 2013; Thune and Gulbrandsen, 2014; Chai and Shih, 2016). Research that was applied for very specific reasons would not become mainstream until the middle of the 20th century.

The practice of researching for strictly commercial benefit would evolve and become one of the more common reasons for UIPs to be formed (Etzkowitz, 2002). The first university devoted to academic economic research or what later become known as ‘applied research' was the Massachusetts Institute of Technology (MIT). The engagement thesis of MIT was commercially oriented research that could be transferred to industry and deployed into the marketplace (Etzkowitz, 2002). In the MIT model, the goal was mutually supported outcomes. MIT and the partnerships it formed in the early years had a strong emphasis on the notion of shared responsibilities, accountabilities and clear deliverables that met both the academic needs and commercial needs. This ‘mutuality of interests' made the MIT model unique, successful and blueprinted for future models of UIPs (Etzkowitz, 2002).

When the government or industry tried to expand this applied commercial research model with universities, many in the academic communities around the world had a visceral disdain for the ‘industrialization of academic research' (Etzkowitz and Leydesdorff, 1995; Etzkowitz *et al.*, 2000; Fagerberg and Mowery, 2015). The pristine ivory tower mentality of more pure research universities still creates a dynamic tension that still exists in the 21st century (Etzkowitz, *et al.*, 2000). One important contribution of the MIT model to UIPs was the articulated benefit of having each party in a partnership, alliance or collaboration provides distinct benefits to the other members that only that particular party could do. A demarcation of knowledge that didn’t overlap, but augmented and enabled each party's research capabilities (Etzkowitz, 2002). Universities were encouraged by industry and government to be more expansionary in thinking. This shift towards industrialised research practices is where the term, 'applied research' originated from (Furman, 1990; Wesser, 1999).

The immediacy of needs by government and industry provided commercial gain through revenues and sponsored research with universities. The entrepreneurial university model would become more common as the university could conduct basic research in keeping with its historical charter, but also use that knowledge for commercial good (Etzkowitz, 2002; Weisberg, 2003; Hatakenaka, 2004). In a paper by Fabrizio (2009), the author refers to the balancing act that industry struggles with when they must decide between in-house (internal knowledge) and out-of-house (external knowledge). Absorptive capacity of firms is a critical issue that affects commercial competitiveness and substantial success. The theory and application related to a *"firm's ability to exploit internal and external knowledge to generate commercial-viable innovations"* (Fabrizio, 2009, p. 255).

Larger companies engage with outside sources of knowledge usually to augment their internal capabilities. In the 21st century, large companies are using this outside engagement (i.e. open innovation) as a way to grow and keep current the company's R&D capabilities (Boardman and Corley, 2008; Etzkowitz and Dzisah, 2008; Bishop, D'Este and Neely, 2011; Andersen and Kask, 2012; Birx, Ford and Payne, 2013). Smaller companies can seek greater leverage from outside so their approach regarding absorptive capacity can be to replace or augment a key part of their R&D (Griffith, Redding and Van Reenen, 2000; Wesser, 2003a; Wesser, 2003b). During the middle of the 20^{th} century as the government became more active in academia and industry, absorptive capacity became a critical issue. Government decided to greatly increase the academic and industry interactions and use absorptive capacity as the reasoning for national and local strategies focused on growing the industrial complex through new science parks, cities and national laboratories (Wesser, 1999; Link and Scott, 2003; Wesser, 2003a; Wesser, 2003b) Highlighting the key issues surrounding UIPs from the literature review is outlined in Table 1 on the next page.

Table 1. Selected Key Issues in UIPs Highlighted from Literature Review

Key Issues	CMD UIP	University	Industry	Governments
Structure	?	Yes	Yes	Maybe
Scope	?	Yes	Yes	No
People	?	No	Yes	No
Funding	?	Yes	No	Yes
Endpoints	?	Yes	Yes	Yes
Intellectual Property	?	Maybe	Yes	Maybe
Economics	?	Maybe	Yes	Yes

2.4 The Role of Governments in Partnerships

2.4.1 Economic Development and Wealth Creation

The period from the 1890s to the middle twentieth century was the gradual turning point in the shift from invention to industrial innovation (Henry and Walker, 1992; Evans, 2004; Gelb and Cadicott, 2007; Johnson, 2010). This movement from the invention as a single effort to innovation as a systems effort changed the university as an essential research and teaching institution to one that became an entrepreneurial and applied one (Etzkowitz, 1998; Hiltzik, 2000; Etzkowitz, 2002; Evans, 2004). Prolific inventors and discoverers such as Thomas Edison, (McClure, 1879; Dickson and Dickson, 1894; Jones, 1907; Evans, 2004), Benjamin Franklin (Woodworth-Pine, 1916), Henry Ford (Evans, 2004; Wills, 2009), and Eli Whitney (Evans, 2004; McClellan and Dorn, 2006) were able to take advantage of societal shortcomings and translate these deficiencies into products and systems that provided solutions to the needs of individuals.

The industry also evolved and grew in the ability to bring knowledge to market for commercial gain. The early industrial companies, General Electric, Ford Motor Company and Franklin Institute also were the first to establish corresponding industrial research methods (Furman, 1990; Millard, 1993; Evans, 2004; Zouain and Plonski, 2015). Universities have played a central and critical role in economic development of a region. The school can act as a stimulus of redevelopment in an area and stimulate the economy by providing jobs, education and graduates (Boardman, 2009). Academic engagement can be quite impactful. The Bank of Boston (U.S.) in a 1989 report estimated that MIT spin-offs alone (spin-offs via formal and informal channels) contributed $10 billion annually and 300,000 jobs in the State of Massachusetts economy (Roberts and Malone, 1996, p. 17).

Governments in the latter half of the 20th century realised the importance of the economic development of society (Shane, 2005) and the creation of wealth that corresponds to economic prosperity (Van Looy, Debackere and Andries, 2003; Shane, 2005; Todaro and Smith, 2009; Sharifi and Liu, 2010). Government intervention in the innovation process became mainstream during WWII when the governments sought knowledge and expertise from both university and industry to solve national wartime problems (Furman, 1990; Wesser, 1999; Wesser, 2003a; Wilson, 2012). Governments opened national laboratories, office science parks, incubator systems to test new ideas and eventually developed schemes to entice academics and executives into new science and technology areas that the government wanted advanced such as communications, advanced travel modes, space, computers, robotics and the internet as some examples (Furman, 1990; Wesser, 2003a).

The UK has had an interesting history of government influence in societal innovation. Government interest in economic growth through global expansion came during the time of the British Empire. The establishment of the empire and the reach that Britain had during the reign of the empire provided many open laboratories in countries under British rule. Advances in many fields of science and technology were driven by entrepreneurs in various far-flung regions of the empire (Ashkanasy, Trevor-Robert and Earnshaw, 2002). In more modern times, the UK government has been very central and active in stimulus programmes to further interest in both universities and industrial research (NESTA, 2008; Von Tunzelmann, 2010; Wilson, 2012; NAO, 2013). Like the UK, governments in the Organisation of Economic Co-operation and Development (OECD) began to realise that funding and promoting public research schemes influenced industry and university (Furman, 1990; Salter and Martin, 2001; OECD, 2010).

An important consideration in governmental support of innovation has been the co-location of strong universities with knowledge creation capabilities, a capable labor market and an industrial base that can take knowledge diffusion and utilise it (Audretsch, Link and Scott, 2002; BIGT, 2003; Hargroves and Smith, 2005; BIS, 2006; BIS, 2011; Wilson, 2012; Dudin, *et al.*, 2014). There is a wide range of opinion in the UK currently on the ability of government to positively and materially impact innovation. A summation of this opinion is that government incentive programmes don't impact directly because other actors must be active at the same time for the government programmes to have an impact. The argument has been for more regional strategy than one-off organisational approaches (BIS, 2011). Areas such as integrating the national health services (NHS) and research (BIGT, 2003), building regional expertise through research councils (BIS, 2006) and tying together an ecosystem of investors, industry, universities in regional centres of excellence (Lambert, 2003; BIS, 2011; Wilson, 2012; Owen and Hopkins, 2016).

2.4.2 Policy, Strategy and Funding

Governments provide the broad framework of laws, regulations, guidelines, certifications and licensing in which society operates (Shane, 2005). The community and marketplaces that both universities and industrial companies work within are formally and informally influenced and

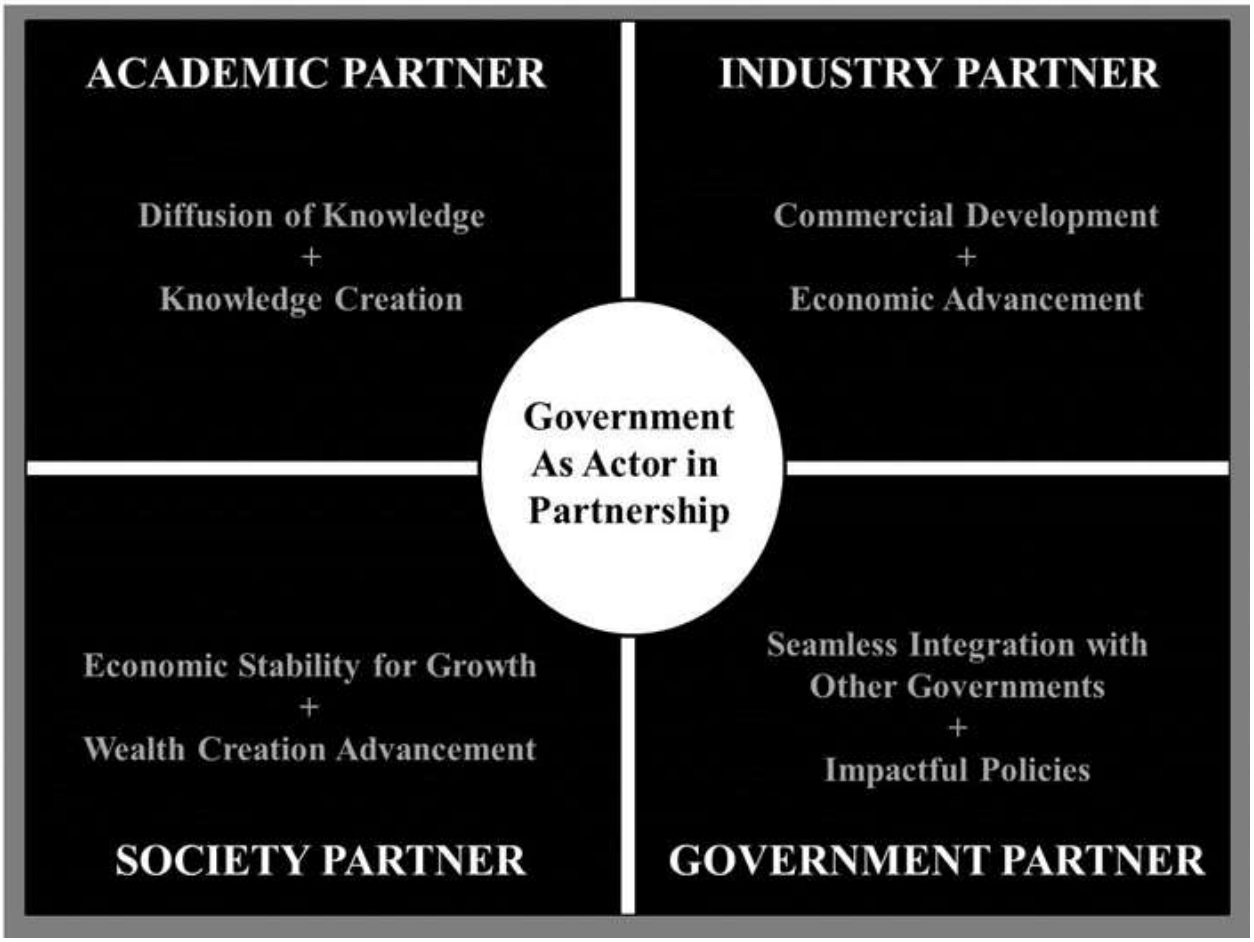
control through laws, regulations, policy and societal norms established by culture (Engel, Fischer and Galetovic, 2014). The impact of technological innovation varies by sector and industry (BIS, 2006; BIS, 2011; Owen and Hopkins, 2016). In Chang, Yang and Chen (2009), the authors discuss the value of social rates of return from academic research and through commercialisation by industry to derive a social gain for society and benchmark for measurement by governments on the effectiveness of policies, procedures and regulation.
The author Etzkowitz (2008) in his book, *The Triple Helix: University-Industry-Government Innovation in Action*, discusses the importance of the interplay between universities and industry by government. Etzkowitz (2008) stresses the importance for governments to ‘enable', but not intrude on the business of universities and industry. In their paper about Taiwan and the high technology sectors that have existed for years, the authors Chang, Yang and Chen (2009) introduce this notion of an intellectual ambidexterity that must live between universities and industry and how governments should support, enable and promote any engagement factors that make the two sides mutually advantageous. The ambidexterity is a grey line as research can be basic, clinical-in-nature and commercial at the same time.

According to the study conducted by Pavitt (1984), the author researched over 2,000 companies with significant innovations in Britain since 1945 (usually the line of demarcation for the post-war applied research growth). The study by Pavitt (1984) was heavily drawn from the UK Science and Technology Policy Research (SPRU) Data Bank on British Innovations and has been extensively studied by scholars both in and outside of Britain. Data from this study and data bank suggest that the degree of innovation is very dependent upon the sectors of interest from industry and the ability of a university to offer expertise and resources to that sectoral need.

The importance of matching the needs of industry with the research skills and capabilities of universities is one of the first elements that both sides must understand about each other. The more involved the sector, the more industry will seek out university involvement (Santoro and Chakrabarti, 2002; Schartinger *et al.*, 2002; Bekkers and Bodas-Freitas, 2008).

Industrial sectors like engineering, medicine, life sciences, biotechnology, material sciences, consumer products, and nanotechnology are some of the marketplace sectors that are very complex. In these highly complex sectors, the state of knowledge is always in flux, and the importance of current knowledge and expertise is paramount to stay competitively ahead of others. (Santoro and Chakrabarti, 2002; Schartinger *et al.*, 2002; Arvanitis, Kubli and Woerter, 2008; D'Este and Perkman, 2011; Ankrah *et al.*, 2013; Perkmann *et al.*, 2013). All authors in these papers stress the importance of the engagement alignment being similar to each other's need, in this case, that of the university and industrial organisation. A synthesis of the selected literature regarding government's role in UIPs and the main
motivators for each actor and government are illustrated in Figure 7.

Figure 7. The Role of Government in Partnerships Topline Objectives (Highlighted from Literature Review)



2.5 The Triple Helix Model

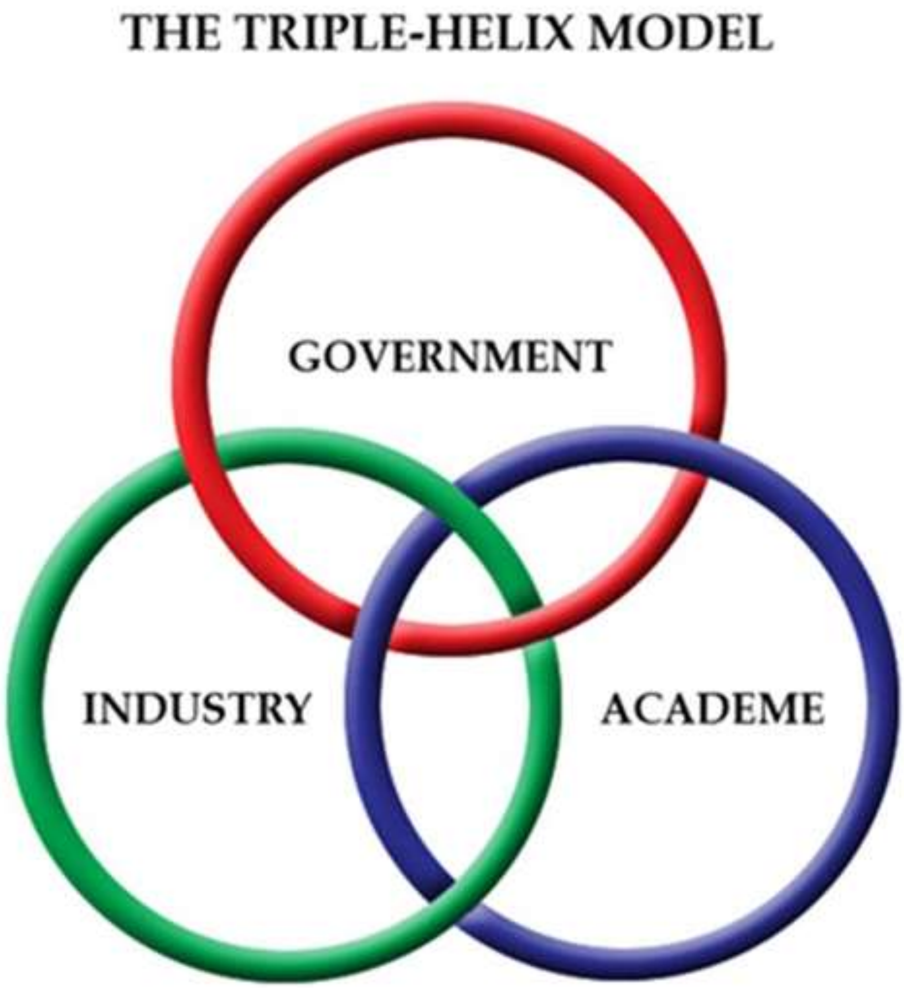
2.5.1 Introduction Triple Helix Model

In geometry, a triple helix (plural triple helices) is a set of three congruent geometrical helices with the same axis, differing by a translation along the axis. Each helix is both independent and dependent on each other for the structure to exist and function. Each helix provides and received inputs from the other helices. As one helix modifies, the other helices adapt and contribute to a system that is always dynamic and fluid (Bernués and Azorín, 1995). The triple helix is a metaphor for a system of innovation. The conceptualisation of THM came from Henry Etzkowitz' long-term interest in the study of university-industry relationships and Loet Leydesdorff's interest in regenerative overlay created amongst actors in processes of innovation. Together Etzkowitz and Leydesdorff would spawn an evolutionary model that would help to visually explain the interactions between the three major stakeholders of the THM: university, industry and government (Etzkowitz and Leydesdorff, 1995; Etzkowitz, 2008).

The THM began as a concept to address the increasing ways that universities were engaging with industry for innovation purposes (Etzkowitz, 2008). Universities were engaged in their original charter of creating knowledge, but also increasingly becoming more involved in industry influenced or sponsored research areas (Ernø-Kjølhed, 2001; Fabrizio, 2009). The industry was also adapting and shifting its resources and interests towards a blended model of R&D that comprised both in-house proprietary knowledge creation and augmentation with outside R&D knowledge pools from various organisations, chiefly universities (Poyago-Theotoky, Beath and Siegel, 2002; Colyvas, 2007; Fabrizio, 2009). By the late 1990s, THM started to shape itself as a more proactive model of how to formulate partnerships as well as help to visualise and define new types of partnerships between the three stakeholders. The defining moment was in 1998. The second conference on the Triple Helix brought over 160 delegates representing all types of stakeholders with the stated purpose of influencing all parties to thematically reorganise under the triple helix formally as an advanced interactive model for innovation. From the conference came a statement concerning this tripartite relationship: Industry exists to make a social return to its owners, be it for-profit or non-profit entities that offer its shareholders and stakeholders a return on efforts provided (Leydesdorff and Etzkowitz, 1998). Etzkowitz and Leydesdorff (2000) further elaborated the Triple Helix of university-industry-government relations into a model for studying more complex and dynamic knowledge-based economies.

It wasn’t until the early 2000s that the THM emerged as an important potential framework for explaining and constructing various ways that universities could interact with industry and where governments could play in those interactions in a more complex global environment (Ye, Yu and Leydesdorff, 2013).The triple helix framework that now exists is used widely to plan, explain and contextualise complex interactions between the three actors of the triple helix. The importance of the Triple Helix model is the dynamic relationship that exists amongst the three main actors. The flow of action is bi-directional, and activities can integrate as each actor influences the actions of the other actors. A simple diagram illustrates this congruent relationship in Figure 8.

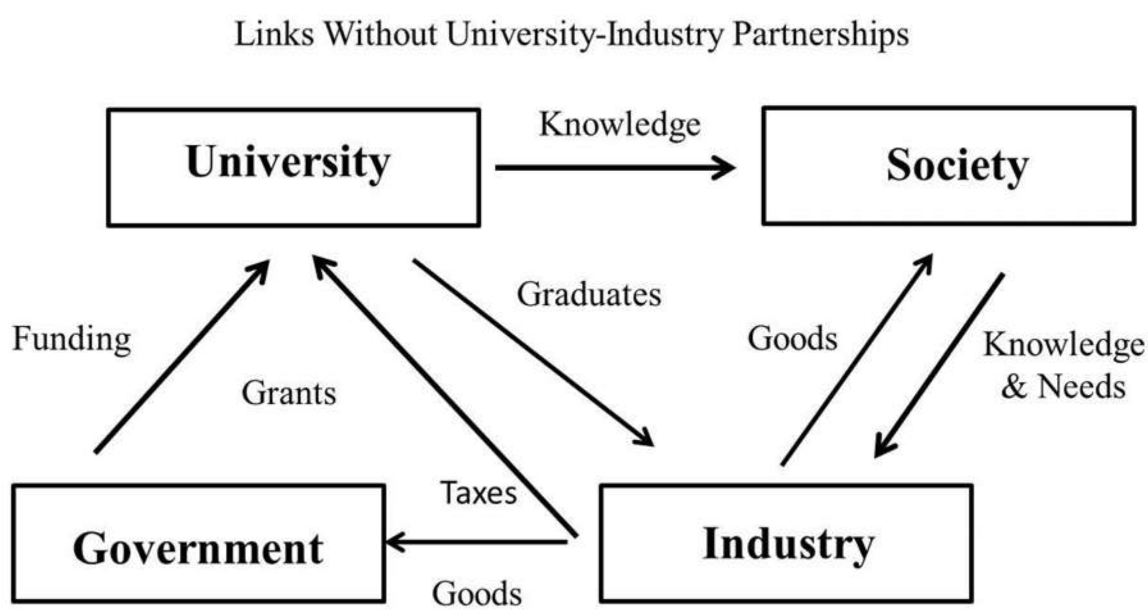
Figure 8.



Source: Etzkowitz, H. and Leydesdorff, L. (2000).
Diagram: www.techplnoytrend.blogspot.com (03 March 2011)

This model gained acceptance in the literature as it helped to explain the relationships and interplay between academia, industry and government in more dynamic terms (Etzkowitz *et al.*, 2000). The continuing influence of public research and funding on industrial R&D has added to the growing interest in modelling the interactions of the three partners as governments become more active (Cohen, Nelson and Walsh, 2002). Before the THM use, stakeholders would take a more traditional view of the interactions between universities-industry-governments. This interaction was uni-directional in most cases and was not aligned with policy or strategy. This created varied programmes with limited effects. The traditional uni-directional stakeholder model is presented in Figure 9a.

Figure 9a. Traditional Links Between University, Industry and Government



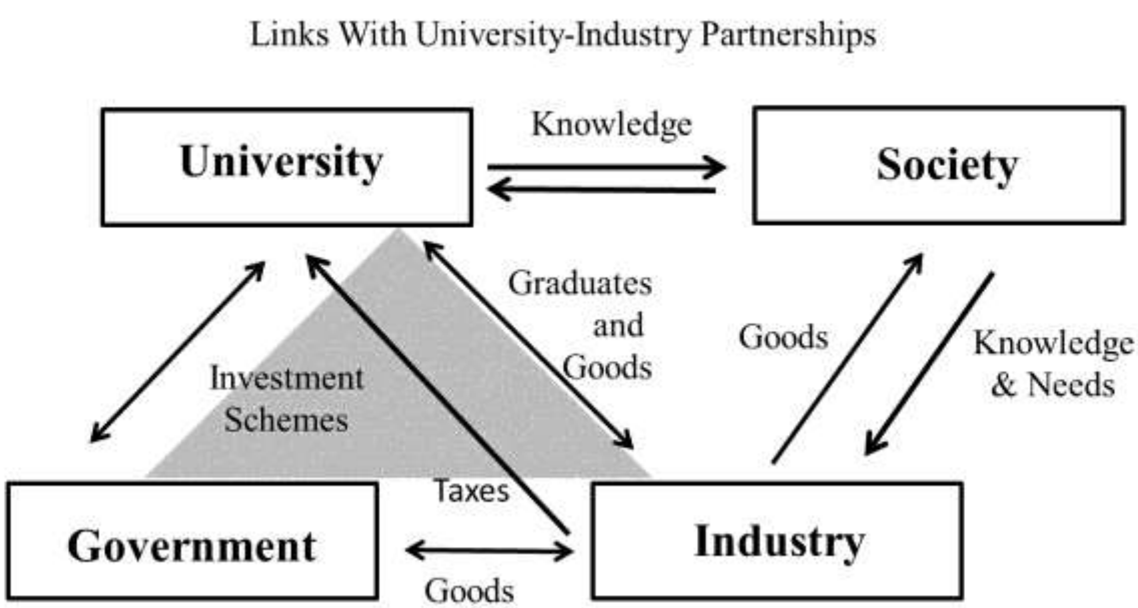
Source: Adapted from Etzkowitz and Leydesdorff, 1995; Etzkowitz, 2008.

In this traditional view, the flow is unilateral and don't leverage sources of knowledge from the other actors. Universities generate knowledge for society and provide graduates to industry for employment. The industry receives inputs from society on what it wants, and industry provides those goods and services. As industry provides these goods, they pay taxes to the government and provide secondary sources of funding to universities. The government collects taxes and provides funding and regulation to universities and society.

What makes the THM important is the constant interplay between the actors in the model. The transitions are caused by actions and reactions of one partner to another partner. When another partner acts out those actions then is received by the other two partners. An example of this would be when a university discovers a very important finding (creation) that is original research. The research is then published (diffusion) establishing a new knowledge belief. The discovery is patented to protect and ensure ownership of the intellectual property. This new intellectual property and research then are practised by others in universities and industry. This practising then creates value for the industry in revenue and possible funding for universities. After many months of new experimentation by parties other than the original inventors, new knowledge is created. This knowledge is then shared through public disclosures (diffusion) and is received and used by others a second time (translation and utilisation). This cycling continues to repeat itself and over time will further the knowledge level in the field of research.

In science and technology, this knowledge cycling occurs rapidly and can transform state of the art dramatically. Government notices the growth of publications, patenting and introductions of products and services to society from this interactive, collaborative effort amongst universities and industry. The government then decides to stimulate, enable and expand the cycling process and the benefits to each party. The government may decide to offer incentives that promote the interactions between parties and reward the parties when they do engage. The THM helps to explain these interactions. The THM also can be used as a planning framework for establishing new partnership schemes. In the case of planning, the THM can model out the cause and effect' actions as they migrate amongst the three parties in the THM. In Figure 9b, the more dynamic process of cycling is depicted by utilising proactively a THM approach than that of a stand-alone actor model of innovation previously represented in Figure 9a. The flow of collaborative efforts is bi-directional and works more in unison with each other. Policy and strategy considerations take into account the various needs of each partner in a greater relational perspective. This relational perspective is very important as the strategy and tactical plans from each partner leverages the aggregate of the efforts by the three parties. Figure 9b is simplistic in presentation, but the importance of a shared common vision, common objectives and common deliverables is what keep the harmony. This is not capable in the more traditional, uni-directional interactions as depicted in Figure 9a. Each partner in 9a works independently according to their needs, objectives and goals. Although each partner in Figure 9a does consider the others, it is from a distance and not shared understanding or commitment.

Figure 9b. Triple Helix Links Between University, Industry and Government



Source: Adapted from Etzkowitz and Leydesdorff, 1995; Etzkowitz, 2008.

In the THM, the basis for leveraging as many partner assets as possible provides a stronger chance of success in the desired outcomes. This also provides for creation of new sets of expertise that neither of the parties may have had previously, sometimes referred to as the knowledge ‘knock-on effect’ in knowledge spillovers (Erno- Leydesdorff and Etzkowitz, 1998; Mansfield, 1998; Kjolhede, *et al.*, 2001; Etzkowitz, 2002; Diamond, 2003).

2.5.2 Triple Helix and Partnerships

A model of UIP engagement that promotes innovation through shared needs and experiences is the Knowledge Integration Community Model (KIC) at the Cambridge (UK)-MIT Institute. The KIC comprises meta-analysis of UIPs and government policies, bench-marked peer-reviewed grant-making organisations, studied the MIT model of commercialisation extensively along with the Cambridge University Model and worked with over 27 stakeholder groups that represented significant sectors of industry, top, world-class universities and government initiatives to improve economic development (Acworth, 2008). The author, Acworth (2008), presents a case study of Silent Aircraft KIC, an aircraft company that was selected by the UK government for funding and support under the KIC model. The Silent Aircraft goal was to *create “a commercially-viable next-generation aircraft with significantly lowered noise levels”* (Acworth, 2008, p. 1249). The stakeholder groups are listed in Table 2. The KIC model focused on short-term, medium-term and longer-term components regarding aircraft noise and safety. The eventual outcomes (Acworth, 2008, p. 1250) from the shared mutual interests are outlined in Table 3.

Table 2.

U.K. KIC Model Stakeholder Groups
• Aerospace industry
• Airport operators and service providers
• Airlines who buy and operate the planes
• University researchers in multiple disciplines
• Industry-based engineers focused on product development
• Government agencies involved in promoting economic development
• Regulatory bodies to ensure standards, safety and compliance
• Non-profits and trade associations in related areas
• Residents and community action groups that surround airports
• Local businesses who may experience positive or negative impacts upon their business

Source: Acworth, 2008.

Table 3.

U.K. KIC Aeroplane Successful Outcomes
• Short-term: noise decrease through operational changes at airport and with airlines
• Medium-term: noise reduction technology would be developed with current knowledge and applied to modifications of current aeroplane and airframe designs
• Long-term: a multi-partner project would be formed to develop a 'silent aircraft' acceptable to noise levels below those required for urban environments and minimal impact on the surrounding communities of air facilities

Source: Acworth, 2008.

This KIC model application to the silent aircraft was very successful and led to current advances in airliner aerodynamics, reduction in weight decreases in fuel consumption and stronger lighter weight aircraft that have increased safety. The original idea for the KIC was to refine the MIT model and transplant it to the UK as the Cambridge-MIT Institute (CMI), whereby the more profound science & technology engagement of UK universities could be enhanced. The CMI was established in 2000 by the UK government to build greater commercial links between academic researchers and industry research. This KIC-CMI model is instructive as it shows that with more extensive stakeholder involvement, advancement of multiple agendas can occur (Prigge and Torraco, 2006; Etzkowitz, 2008; Thursby and Thursby, 2011b; Engel, Fischer, and Galetovic, 2014).

2.6 High-Performance Construct

2.6.1 What is High-Performance?

The body of information in the field of high performance is large and varied across trade literature, business books, academic literature and corporate consultancy reports. The goal of this section of the literature review is to form a clear picture from the selected literature surrounding what constitutes high-performance regarding definitions, measurement systems, attributes, precursors, antecedents and elements that contribute to the design, formation, structuring, operating and feedback mechanisms for modifications. Also important are the softer aspects of the environmental considerations such as cultures, communications, rules or token systems that stimulate and reward best practices amongst members of a high-performance organisation. The literature review is explicitly exploring the individuals that are high-performing, the groups or teams and of course the organisational unit itself.

Although the definition of high-performance is varied, there are accepted elements that cover the definition of high-performance. Performance is beyond what is average or considered to be normal in a particular setting, society, business or organisation. High-performance is deemed to be above and beyond what is required or expected by some measurement system. High-performance is extraordinary performance or behaviors that exceed what is expected, what has been accomplished historically and sets a new pace, mark or definition of some expected result or creative actions that expand the current system of measurement, thinking, outputs, outcomes or generally expected deliverables (Fletcher, 1993; Owen, Mink and Owen, 1993; Nemiro, *et al.*, 2008).

As you can see from these three very high-level definitions of high-performance that individuals, teams and organisations exceed what is the norm or current standard of performance. This over-achieving of set goals, requirements or objectives is what makes the performance extraordinary. This over-achievement is also what allows for remarkable innovation through several paths such as trial and error, incremental goal designing, setting attainable stretch goals, or independent, but parallel development (Nemiro *et al.*, 2008). If UIPs can recruit, retain and reward high-performance with the individuals, teams and the organisations that form the UIP, the better chance that the UIP will achieve greater extraordinary performance and outcomes.

2.6.2 High-Performance Individuals

The first construct within the high-performance literature review is the high-performance individuals (HPIs). These actors form the basis of any team or organisation. The first notion of high-performance individuals is that they have high IQs, amazing memory or some other personal characteristic that makes they unique and above the standard or average person (Nemiro *et al.,* 2008). This characterisation of the HPI is not always correct. Yes, they may have unique talents or abilities that others don't have, but the majority of HPIs have common attributes that most of us have with some important exceptions. Tend to look at many options or actions when performing a task. Have a positive attitude and a strong orientation for learning from their actions. Have a high level of curiosity and seek to explore new things. Possess a collaborative nature when engaging with others.

Individuals must feel a high standard of trust, cohesion, socially engaging and a degree of reoccurring reciprocity amongst each who with each other. Ability to establish social contracts and agreements that are based deeply on trust and collectively supporting. As failures occur, HPIs see failure as a moment in time and just another data point in which to adjust their thinking and actions. HPIs risk-takers that weigh the odds of success and failure and deploy their resources and relationships according to this sense of planned progress. Some HPIs can have a sense of humility, empathy and nurturing personality, whilst other HPIs can have high and centered egos that are driven by the fear of failure, embarrassment of non-attainment or outcomes that are not considered extraordinary (Fletcher, 1993; Mink, Owen, and Mink, 1993; Ankrah *et al.,* 2013).

The actors that make up the individual members of any organisation are essential to the overall success of project or program outcome. In Ankrah, *et al.,* (2013), the authors discuss the reasons why critical entrepreneurial actors within academe are willing or motivated to engage with others in academe or more importantly why they would seek out industry partners. Any beneficial outcomes by academic players whereby they can have predictable relationships when everything else around them is unpredictable; this will drive HPIs to find like-minded collaborators in areas of most importance to the principal actor(s). In a higher risk and reward situation, an individual will engage in a high-risk, high-reward project and seek to share the stage with someone deemed to have similar interests regarding risk, rewards and impact of the eventual outcomes of that research (Crespi *et al*., 2011).

In fields of science and technology, there are more scientific unknowns, uncontrollable regulatory or governmental events. HPIs will seek out individuals who have proven themselves in terms of measurable yardsticks such as patents, citations, number of sponsored research or contractual research projects: all of which shows each engaging actor the importance of engaging with another HPI (D'Este and Patel, 2007; Crespi, *et al.,* 2011; D’Este and Perkmann, 2011; Perkmann, *et al.,* 2013). In summary, the HPI will work with all types of individuals and teams to further their goals, but HPIs will seek out individuals, groups and events that can allow them to experience the amazing thrill. An HPI and team that form and operate with a high-performance framework mentioned previously and most important is the overall environment for the HPI to work within. As HPIs gather and form groups or teams many of the characteristics found in HPIs do transfer to high-performance teams (HPTs) along with additional constructs, elements and attributes that come from the efforts of more than one individual The importance of breaking high-performance down into the individuals, teams and then the organization allows any researcher to identify the contributory components that each entity brings to the high-performance framework.

2.6.3 High-Performance Teams

Building an environment that encourages individuals who may have high-performance tendencies is important in stimulating that action of the HPT or HPI by the environment of the organisation (HPO). Evans (2004) motivating argument in the book is the importance of this perceptional viewpoint of seeking extraordinary events and being in an environment that supports those actions. Philippe and Vallerand (2009) showed that settings do affect motivation and psychological adjustment toward performance and belief in the ability to achieve greater than average outcomes. In the paper by Moultrie *et al.,* (2007) the author discusses this notion and bring forth the points that performance by top team members are driven by support from other team members, but also from the environment itself and other times by other circumstances that happen around them.

This shared situation will allow people who don't fear failure, have working support conditions and team members who will join in the action all enable them to feel free to act at the moment because of the support environment of the HPTs. These dormant tendencies can blossom, but the stimulus must be forceful enough or the environment accepting enough for the individual(s) to step up their behaviour and show their HPI tendency (Bradley *et al.,* 2013). In a paper by Brewster, *et al*., (2014) talk about the importance of distinct similarities of high-performing people who then come together and share their traits like a well-seasoned group. This is also discussed in the elite sports field from Cruickshank, Collins and Minten, (2013), the high-performance behavior can replicate and multiply quickly if the right contributions about the importance of peer-accepting influences that made acceptable the right to act by team members because they feel cohesion through social contract, positive reciprocity and association through alliances with team members. In most situations, this allows team members to feel and act on those items that everyone will feel is the right thing based on the norms of the HPT (Fletcher, 1993; Katzenbach and Smith, 1993).

The authors, Bradley, *et al.*, (2013) discuss how HPTs are HPIs operating within a high-performance organisational structure of processes, cultural elements and guidelines that allow HPIs to blossom on their own and with each other; thereby naturally forming HPTs. These suggestions from the literature of Nemiro *et al.,* (2008) is interesting as it constitutes the basis of the importance of individual recruitment and the guidelines for the establishment of organisational frameworks that allow the HPIs to apply their high-performing behaviour upon mutual acceptance and trust. Juxtaposed in agreement on the importance of the HPI attributes in the overall makeup of teams, some authors suggest that HPTs are the important construct in contributing to high-performance organisations (HPOs) and not each HPI (Fletcher, 1993). The nurturing theme comes from HPT structures that positively enforce behaviour that constitutes high-performance and extraordinary outcomes that ordinary individuals can achieve if given a chance to perform without obstacles that hinder high-performance.

In summary, HPTs are made up of HPIs who seek to co-mingle with other APIs whenever possible. The contract, policies, guidelines and natural boundaries all serve to offer the HPI the right to expand their interests, and when one or more HPIs come together, the forming of an HPT becomes easier. HPTs are entities that are supportive, active learning environments with distributed levels of leadership and decision-making. HPTs allow individuals to mentor and support each other through social reciprocity, trust and cohesive relationships that are built up over constant interactions. Some members of an HPT could be average, but if hidden talents exist in the ordinary members or the member has dormant high-performance potential, HPTs can bring out the best in an individual through group stimuli, positive reinforcement and supportive networks in times of uncertainty.

2.6.4 High-Performance Organisations

The high-performance organisation (HPO) is the aggregation of individuals and teams. HPOs exhibit characteristics that also reside within people and teams, but HPOs also have additional elements that make them truly unique such as in the case of one company that historically has been very highly innovative and produces extraordinary returns for its employees and shareholders (Fletcher, 1993; Fong-Boh, Evaristo and Ouderkirk, 2014). The highly successful Minnesota Mining and Manufacturing Company or The 3M Company. In a study of the 3M Company, the authors, Fong-Boh, Evaristo and Ouderkirk (2014), outline the story behind the story of 3M's operational and cultural variables that have allowed 3M to continually produce and reproduce truly innovative products over a very extended period. The significant findings were 3M as an HPO has a large number of inventors who have a vast breadth of experience, and when teams of these HPI get together with overlapping large scopes of experience, 3M allows them to explore and tinker towards a very high-level set of goals.

This high-level definition of targets to allow greater free thinking in solving a problem or need. Depth and breadth of expertise with HPOs as they strive to place HPIs into self-organising HPTs around topics of interest that HPIs find exciting and motivating. In the 3M study, Boh, Evaristo and Ouderkirk (2014) discuss the importance of placing HPIs with broad backgrounds together so each one can contribute to the overall knowledge pool of the HPTs that the HPI make up. 3M believes that HPTs, if made up of diverse, broad experiences and extensive technical backgrounds that the HPT's members will naturally overlap each other's disciplines and form new ways of thinking, defining and acting.

2.6.5 Sustainability of High-Performance

Sustainability is the measurement of the activity of a duration that is beyond the rational expectations of that performance of actions (Barnes, Pashby and Gibbons, 2002; Andersen and Kask, 2012). The literature was sparse regarding sustainability or long durational periods of success in UIPs. The long-term success of a series of continued actions is considered a sustainable level of output. The best channels (structures of UIPs) for long-term benefit in UIPs are those that have a robust central commitment to research that evolves. Major research programmes or co-development UIPs can provide a continuous flow of activity that is of a longer-term duration and if successful in outputs, can provide long-term benefits (DeFuentes and Dutrénit, 2012). Forging long-term partnerships centre on several factors that ensure the UIP was appropriately formed and can operate according to principles that won't change over time (Katzman, 1999).

The important factors discussed in the limited literature surveyed were 1) strong and clear objectives of the UIP's goals, 2) strong support from all levels of the organisations involved in the UIP, 3) processes and procedures that can handle intellectual property, daily operations and dispute resolution mechanisms, 4) a working environment that promotes innovation, learning, positive and collaborative interactions, 5) clear definitions of outputs and success, and 6) a feedback mechanism or system for improvements as the UIP operates so issues can be addressed (Katzman, 1999; Prigge and Torraco, 2006; Perkmann, Neely and Walsh, 2011; DeFuentes and Dutrénit, 2012; Jaksić, Jovanović and Petković, 2015).

In summarising the high-performance construct, one needs to understand the importance of the building blocks of high-performance as it relates to the organisation as the executor of the high-performance action and output (Garfield, 1986; Gilson *et al.,* 2000; Gelb and Cadicott, 2007). These building blocks are first in individuals where people are self-motivating, hungry for new challenges and willing to take significant risks to accomplish their objectives (Mink, Owen and Mink, 1993; Wills, 2009: Cruickshank, Collins and Minten, 2013). The high-performer is very smart and critically reflexive (Goldberg *et al.,* 2011). The high-performance from an individual comes from the person knowing their boundaries and capabilities (Fletcher, 1993).

Once you have a few of these types of people interacting with a group, the group starts to become like the high-performance people. This transference of individual traits to a group is an important element in building high-performance teams (Fletcher, 1993; Csikszentmihalyi, 1996; Nemiro *et al.*, 2008). The individual and their 'wholeness' sets the stage for the ability to build up an organisation that can be high-performing (Bessant and Tidd, 2007; Garfield, 1986; Mink, Owen and Mink, 1993). Once the synergy is present with the right individuals, the emerging collective of individuals become impactful as a team or group of high-performers (Bercovitz and Feldman, 2011; Fletcher, 1993; Gilson *et al.*, 2000; Isaacs, 1993; Katzenbach and Smith, 1993). The buildup from individual to team forms the last pieces of the multi-faceted high-performing organisation. An illustration of these dynamic components in their accumulation to an organisation, culture and operating environment of high-performance is depicted in Figure 10.

Figure 10. The High-Performance Construct
(Highlighted from the Literature Review)

2.7 Literature Synthesis

Chapter 2 is a selected synthesis of the literature concerning innovation, knowledge creation and the variables that make up knowledge-based economies. The complexity of this knowledge economy creates challenges in the system of management creation, diffusion and application of new knowledge. Successful systems of knowledge production supply actionable knowledge for both academic and professional use that provide value creation for further study, funding and partnership motivations (Agrawal, 2001; Siegel *et al.,* 2003). Understanding invention and innovation processes provide the initial considerations in whether to form partnerships through shared resources and knowledge exchange (Dodgson *et al.,* 2014). The author Jan Fagerberg (2006), explains invention as the first occurrence of an idea for new products/services; whereby innovation is the first action towards putting invention and new knowledge into practice.

Innovation is the entrepreneurial process whereby new and existing knowledge into practice. Innovative processes in knowledge-based economies are not so much singular in efforts but heavily weighted towards partnerships (Fletcher, 1993; Acworth, 2008; Dodgson *et al.,* 2014). Partnerships have been one of the mechanisms that organisations use to achieve mutually desired outcomes (Agrawal, 2001; VanGundy, 2007). UIPs have a long history of contributing to the knowledge economy through a mutually shared framework providing both parties with a process to achieve their goals (Tartari, Perkmann and Salter, 2014). The CMD UIP has had remarkable performance in successfully discovering NCEs. The key output from this research will be an actionable framework for innovation professionals in UIPs and to develop strategies for sustained success of their UIP.

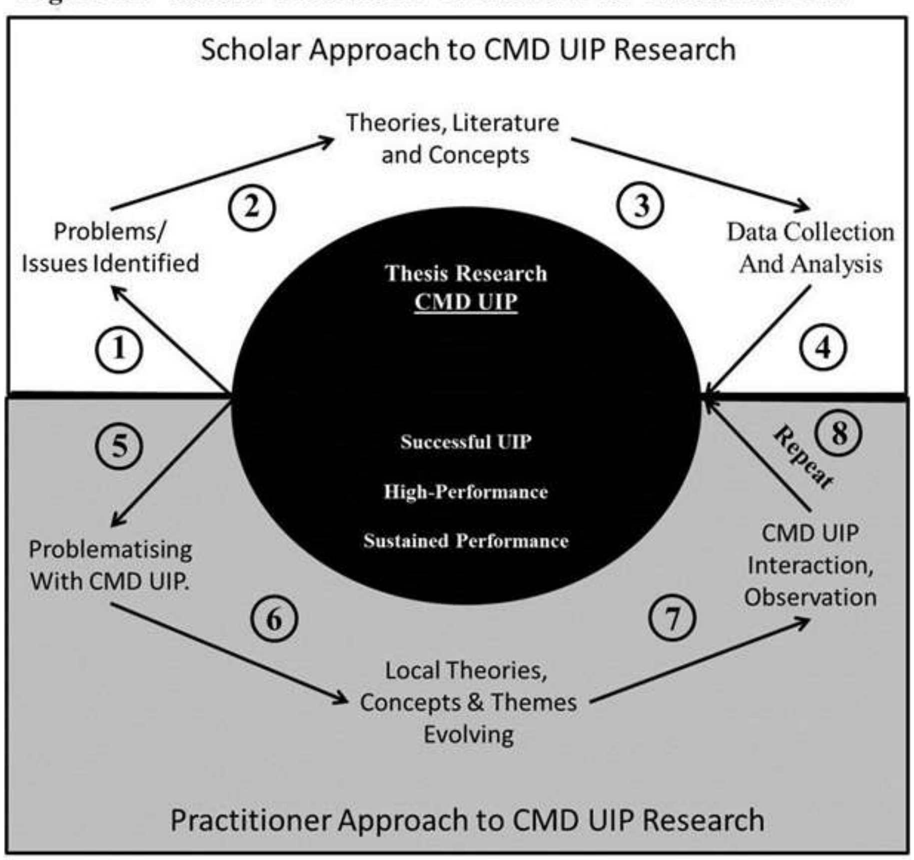
Chapter 3: Research Methodology

3.1 Introduction

In chapter 3, I introduce the research methodology study design, sample population, sampling technique, data collection and data analysis, protection of study participants and summary. What drove the main considerations for the methodological approach were the research questions posed. The focus is to understand the operational success of the CMD UIP, how the CMD UIP achieves extraordinary NCE outputs when most industries struggle to achieve higher than 3% and the literature is sparse on the factors that drive sustainability of performance. So there is a richness of data that I need to uncover in the research study on the CMD UIP. To broadly capture as much relevant data from the CMD UIP research, I chose a method that is designed to achieve broad and provide a richness of data sources. The research method choice I made was to conduct a qualitative research design with an ethnographic framework to study the essence of a people and environment.

The qualitative approach to inquiry is the case study method with an ethnographic framework. The sample population will be passed and current members of the CMD UIP who have worked in the CMD UIP over the various stages of the partnership's life. I will include in the sample population, CMD participants from the laboratory bench to the senior executive levels of both UoL and Unilever. I will collect the data through semi-structured, open-ended questioning in an interview process with each study participant. The data will be captured via digital audio recording and saved in an MP3 format for archiving. The audio recordings will then be manually transcribed to ensure a greater accuracy due to the highly technical jargon of computational chemistry and NCE discovery. The transcripts will be stored in both written and electronic formats. All materials will be secured in a locked box and on a password secured computer for storage and archive. The transcripts will then go through a two-step process of coding: 1) open coding and 2) axial coding. The raw data will eventually cluster and sort itself into emerging sub-themes and themes that will elucidate the factors behind the three research questions regarding the notable success of the CMD UIP. In this process, I will be critically reflexive in my sensing and problematising of the discovery of success factors that drove the CMD UIP. The process of scholar-practitioner approaches in my qualitative research study design is illustrated in Figure 11.

Figure 11. Scholar-Practitioner Framework for Thesis Research



3.2 Research Design

The study's research design is to conduct the study with a qualitative framework to unlock as much information as possible about the CMD UIP. The study design is emergent and interpretative. The research method is qualitative research with a single case study design using an approach to inquiry of an ethnographic framework of understanding a group of people, environment and culture of success. The ethnographic approach includes the participant-observer element of being part of the research study and environment. The participant-observer positionality creates an opportunity for me to live within the daily routines of the CMD UIP. In this participation role, I spent six months studying the CMD UIP with a consecutive six-week embedding in the CMD, UoL and Unilever.

As outside of the interviewing interactions, I both observed and participated in meetings and used observational field notes and legal/business documents surrounding the CMD and the CMD UIP. Despite the long history of UIPs, the factors that contribute to the sustainability of any single UIP remain unclear and are sparse in the literature. The aim of this approach provides me with a richness of data capture that will help me to uncover actionable findings and refine these emerging research insights into actionable knowledge. This actionable knowledge will provide the content for building a framework for innovation professionals to use in designing, forming, operating and exiting a UIP.

3.2.1 Qualitative Research Method

My methodological framework for this study will be qualitative research. There are two types of research methodological approaches to generating empirical research data (Yin, 1998; Creswell, 2005; Creswell, 2007). The first is quantitative research. Quantitative research is focused on characterisation and understanding through methods that emphasise objective measurements. These measurements can be statistical, mathematical, or numerical analysis of data collected through polls, questionnaires, and surveys or by manipulating preexisting statistical data using computational techniques. Quantitative methods are suitable when you have research findings that require more in-depth analysis. The second is qualitative research which seeks to expand the potential of data capture and richness of data insights:

> *Qualitative research begins with assumptions, a worldview, the possible use of a theoretical lens, and the study of research problems inquiring into the meaning of individuals or groups that ascribe to a certain belief system. Qualitative researchers use an emerging qualitative approach to inquiry, the collection of data in a natural setting sensitive to the people and places under study, and data analysis that is inductive and establishes patterns or themes. The final written report or presentation includes the voices of participants; the reflexivity of the researcher, and a complex description and interpretation of the problem, and it extends the literature or signals a call to action - Creswell, 2007, p. 37.*

Qualitative research is a process of research flowing from philosophical assumptions, to worldviews and through a theoretical lens, and on to the procedures involved in studying the problem stated. This approach provides a framework for designing the approach to inquiry that will make up the bulk of the qualitative research process. A comparison of topline differences are highlighted in Table 4 below:

Table 4. Differences Between Qualitative and Quantitative Research

	Qualitative	Quantitative
Conceptual	Concerned with understanding human behavior from the informant's perspective	Concerned with discovering facts about social phenomena
	Assumes a dynamic and negotiated reality	Assumes a fixed and measurable reality
Methodological	Data collected through participant observation and interviews	Data collected through measuring things
	Data are analysed by themes from descriptions by informants	Data are analysed through numerical comparisons and statistical inferences
	Data are reported in language of the informant	Data are reported through statistical analyses

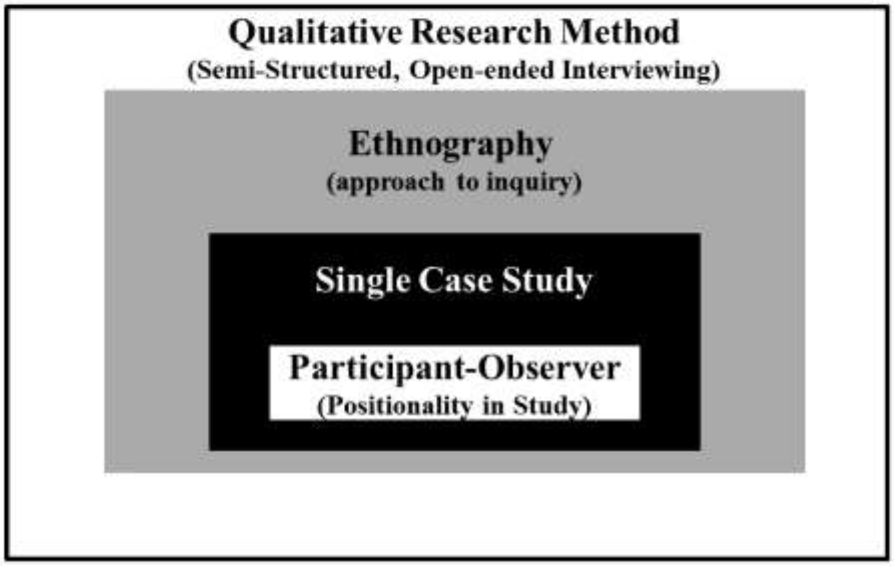
Source: Adapted from Creswell, 2007; Minchiello, *et al.*, (1990, p. 5)

Researchers use qualitative methods when an issue or problem needs exploring, and the elements of the subject of study are either not known, not well understood or the information presented is not clear (Creswell, 2007). According to Creswell (2005 and 2007), qualitative research designs provide a greater worldview and broader theoretical lens through which to view your subject target for research. Qualitative research methods seek to uncover a story or narrative that provides for discovery, and the essence of this qualitative approach is interpretive perspectives (Lin, 1998). When conducting qualitative research, you must allow for as much development of information to the surface to not leave any possible discovery untouched (Breathnach and Stephenson, 2011).

In qualitative research methods, the researcher strives to construct a view of authenticity by allowing individuals to share their observations and experiences as both an individual and collectively as an organisation through the common viewpoints of the people, observations and documentary evidence (Thorpe and Holt, 2008). In Cooper and Schindler (2002), the authors outlined three essential points that make up the reasoning and potential benefits of the open-ended and less structured nature of qualitative research. These three points were: 1) in-depth and repetitive interviewing, 2) direct interaction and observation of culture, environment, activities surrounding the study participants and 3) a framework for recording events to unearth, characterise, catalogue and postulate new constructs as they emerge from the research study.

My research interest and professional focus in this study are to understand how to design, form and operate UIPs to achieve sustainability. I wanted a thorough understanding of the key factors around successful UIPs and sustainability of high-performance. The literature is sparse about duration, endurance or sustainability in length of operational success in UIPs (BIS, 2003; Cummings and Teng, 2003; Bekkers and Bodas-Freitas, 2008; DeFluentes and Dutrénit, 2012). Qualitative research approaches can build a richness of data that provide more details in understanding and building knowledge around the topical area. There are six key elements of reasoning for the use of qualitative research for this thesis study to build a data repository about elucidating the factors of success in the CMD UIP. The six are: 1) as the researcher embedded in the environment of the CMD and the CMD UIP by interacting, observing and documenting the activities and observations, 2) the qualitative research is an inductive process whereby the empirical data emanates from the bottom-up and over time will present patterns, categories, themes and insights that should lead to sorting into key factors of the success of the CMD UIP, 3) the design is emergently allowing for a more flexible outpouring of data to occur than more tight and rigid processes that could be employed, 4) the theoretical lens is broader like a fish-eye lens and not so narrowed on just a few subjects, 5) qualitative research is an interpretive inquiry with ability to offer multiple views of the same problem or issue, thereby juxtaposing several perspectives that could be material. Lastly, 6) As the sustainability success remains unclear on how to achieve it in the CMD UIP, providing qualitative approaches allow for more holistic accounting in trying to capture the essence of the things achieved by the research methodology process (Alvesson and Skőldberg, 2009; Creswell, 2005; Creswell, 2007; Creswell, 2009). I summarise the research design for the thesis in Figure 12.

Figure 12. CMD UIP Research Design Summary



Rationale for Research Design

- **Qualitative Research –** **develop themes from richness of data capture.**
- **Ethnography –** **study the CMD venue, the people and the way they live at CMD.**
- **Single Case Study –** **understanding the CMD UIP's sustained high-performance.**
- **Participant –Observer –** **positioned within the CMD UIP, experience what the study participants do.**

3.2.2 Single Case Study

The approach to inquiry in my qualitative research framework is to use the case study method of inquiry. The study is comprised of a single case study method utilising qualitative interviewing techniques with former and current members of the CMD from both UoL and Unilever. The ability to build a theory and supporting constructs can be achieved from case study approaches Eisenhardt, 1989). The case study approach can allow themes and sub-themes to evolve and advance that can help to explain elements in the smaller end and also expand into theories in the larger end of the topical areas under study (Eisenhardt, 1989; Eisenhardt and Graebner, 2007).

I will be using a single case study approach. The single case study is the CMD UIP and its sustainable, high-performance success. Case study research is a qualitative approach in which the investigator explores a limited system (a case with limits) over time, through detailed, in-depth data collection involving multiple sources of information and reports a case description and case-based themes (Creswell, 2007). In selecting a case type and design, Yin (2009), outlined a decision-making matrix that sought to define the type of case study a researcher would need to accomplish their research goals. In Yin (2009), he finds that both quantitative and qualitative methods can be used in case study design, I felt that a case study approach was helpful to outline and bound the research subject environment which is the CMD UIP. Case studies need to have some boundaries that demarcate their environment for the research study (i.e. a setting, a context, an excellent outcome) so that a particular theoretical lens frames the degree of inquiry (Stake, 2005; Wolcott, 2009).

I found Authors, Robert Stake and Robert Yin to be helpful in deciding on a single or multiple cases approaches. The selection of the single case study approach was based upon four rationales and tied to objectives that I sought to achieve in the research. The four justifications were: 1) is the critical case and answers you seek in research potentially represented in this one case? The answer is yes as the CMD UIP is exemplary for sustainable success and unclear as to the factors surrounding this sustainability. 2) Does the study target you have to present an extreme case or unique case relating to your research question? Yes. The CMD UIP is an exemplary case and one that is rare in occurrence. As the literature is extensive on UIPs in general and very thin as it relates to the sustainability and high-performance of UIPs. 3) Is the research study target representative of the intended interest/topic you wish to research? Yes. The CMD UIP has verifiable outcomes and sustained success that defines my interest in what factors contribute to the sustainable, high-performance success of outputs from UIPs. The specific interactions and structured relationship between UoL and Unilever is a very specific, excellent and bounded venue for this thesis research study. Lastly, 4) does the research study provide a longitudinal perspective in studying the case? The answer is yes. The rationale and importance of the CMD would be to have the ability to research the case at different points in time. The chronological timeline helps to establish key timeline milestones that could provide diverse factors such as those in the pre-formation stage versus those from the operational stages. As this research is interested in the factors that contribute to high-performance sustainability, exploring activities that could change over time may shed insights into key points for understanding how sustainability is kept consistent.

The CMD UIP is a specific case illustration of a successful UIP. By pursuing a single case study approach, it will allow me to explore the factors behind the CMD UIP and move towards building theories and attributes that characterise the CMD UIP into an actionable framework for UIP design and operation. Case study approaches to inquiry can build theories and theoretical frameworks (Eisenhardt, 1989; Eisenhardt and Graebner, 2007).The multiple case study strategy of inquiry has the same intended result as single a case study, which is to explore a particular issue, problem or understanding of observations (Yin, 2009). Case studies can be a strategy of inquiry that I can employ in my research approach that weaves with an ethnographic intent to understand a group and their setting (Stake, 1995; Maxwell, 2005; Stake, 2005; Creswell, 2009; Yin, 2009).

In summary, single case studies are a common design whereby the choice is justified when the case represents a test of existing theory (e.g. sustainable high-performance outputs), is rare or exemplary (i.e. sustained duration above the normative) and the case is representative of the thing you seek to understand (i.e. factors leading to sustained high-performance in NCE discovery) and where the case has longitudinal elements that help to frame and validate repeating patterns, themes or other sources of information (over twelve years of successful discovery of NCEs on a relatively regular basis) that build a strong case and could contribute towards a UIP framework for sustainability for innovation professionals.

3.2.3 Ethnography

The term, ethnography, originated in the 19th century and had strong roots in anthropology. During this time, ethnography was used to describe field research that focused on exploring accounts of a community (CMD venue) or culture (CMD UIP) from a social science lens (NCE discovery by CMD UIP scientists (Hammersley and Atkinson, 1995; Wolcott, 2001). Ethnography has had a complex history and does not have a standard, well-defined meaning (Wolcott, 2001; Maxwell, 2005; Crang and Cook, 2007). Ethnography has played a substantial role in anthropology and social sciences and has evolved into a broader approach to inquiry within qualitative research frameworks (Atkinson, Coffey and Delamont, 1999; Atkinson *et al.*, 2001). I used ethnography studies as the inquiry approach to study the people and groups at the CMD, their environment of the CMD UIP framework and processes/activities (NCE discovery for new compounds for product development) in that environment.

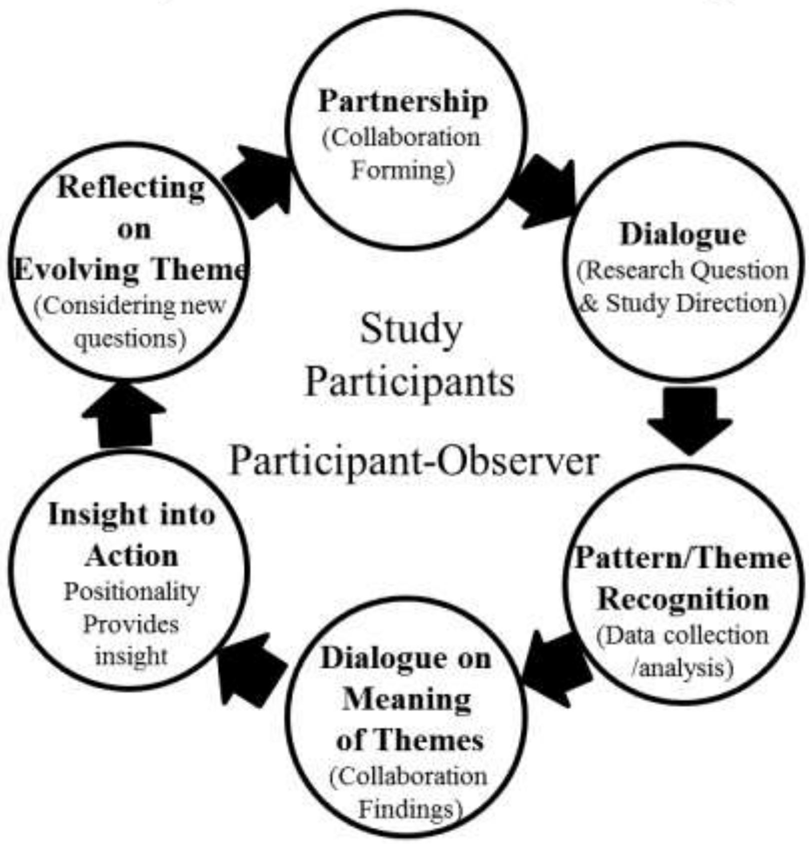
Interpretation is the objective of the ethnographic approach and turning that interpretation into something meaningful and significant such as actionable knowledge and a framework for the innovation professional to use. In ethnographic research, the researcher proposes to explain a framework with meaning and representative of the people or group under study (Rosen, 1991; LeCompte and Schensul, 1999; Lawlor and Mattingly, 2001).

The importance of ‘direct participation' in the affairs of people or group can allow the ethnographer to come to understand the actions and meanings of those who constitute the group (Madden, 2008; Daas and McBride, 2014). The ethnographer’s positionality is either through being an ‘employee’ of the group or approaching the group as observers of the participants (Moore, 2012). I chose to be temporarily embedded in the CMD for six months with a six-week continuous stay; This allowed me to have participation observation within the CMD and CMD UIP. The positionality of the researcher is important as you want to view all potential vantage points and perspectives to capture the full richness of the essence of what you are experiencing (Moore, 2012; Stephens and Lewis, 2017).

3.2.4 Participant-Observer

My positionality during the study was more of a participant-observer and part of the CMD UIP for a six month period. Participant-Observer involves the researcher being part of the study and view the study lens with a first-person perspective. The physical being within the group allows the positionality of the researcher to be potentially enhanced, broaden and provide unique insights into all actions (Cassell and Johnson, 2006; Forsey, 2010). Participant-Observers must be self-aware of their position within the study as their involvement may influence components of the study and create potential biases on the output of data (Spradley, 1979; Spradley, 1980; Stephens and Lewis, 2017). Participation with study participants can influence the researcher to lead the study into directions that unduly influence the process of the research study and acceptability of the outcomes (Lawlor and Mattingly, 2001; Moser, 2008; Moore, 2012).

Figure 13. Participant-Observer Problematising Framework



Adapted from Source; Pillsbury-Pavlish and Dexheimer-Pharris, (2012), p. xiii.

The importance of balancing the participant with the observer within the study was the challenge during the research study. The key issue is to know where your potential conflicts lie before commencing the study and the ability to remain vigilant during the study to potential conflicts (Creswell, 2007; Forsey, 2010; Pillsbury-Pavlish and Dexheimer-Pharris, 2012). The importance of sensing and living the study problem also provides a process in which to participate in the activities of the study venue actively. The problematising process and the flow of interaction within the study venue are presented in Figure 13. The participant-observer is an important technique in ethnographic inquiry as emersion into a study group allows the researcher to understand better in a first-person perspective about the events and issues within the study environment (Rosen, 1991; Lawlor and Mattingly, 2001; Madden, 2008; Forsey, 2010).

3.3 Sample Population

The sample population was recruited from two primary sources: 1) the UoL's CMD facility and 2) the R&D group for personal care and consumer cleaning products from Unilever in the Northwest of England at the Port Sunlight R&D facility. The aggregation of names was accrued from historical records within the finance department of the university that allocated time and financial remuneration to scientists associated with the UoL but directly assigned full or part-time to the CMD facility. The study population from Unilever was assembled from R&D records and from management of present R&D at Unilever who identified past and current members for potential inclusion into the study.

A purposive sampling technique was used to evaluate the potential study participants based on the following four criteria directly related to the CMD UIP: 1) scientists and executives that had worked directly within or had worked on the overall administration or operations of the CMD, 2) the scientists had to have been involved for at least 6 months of work within the CMD and were part of one or more research teams involved in the CMD, 3) the executives/researchers had to be involved in at least one or more of the distinct phases of the CMD maturation and have direct responsibility over or within the framework of the CMD, 4) the study participants had to be from either UoL or Unilever and the sample population involved some participants that had worked in both organizations.

The six hierarchical levels of the study participants were: 1) Foundation members**.** These participants were involved in the critical discussions about creating a CMD and UIP around the concept. These individuals also provided the vision, direction and support to continue the activities during the pre-formation and formation stages and if still present during the research data collection phase, they were responsible for continued operational and programmed support of the CMD UIP, 2) Staff and Consultants. The level of expertise necessary to support and direct operations of any UIP can be supplemented with domain experts and these participants, may expand the insights into the various phases of the maturation of the CMD UIP, 3) Researchers conducting science with UoL as employer. These study participants were main personnel who worked daily in the CMD UIP from the UoL side and provided the university perspectives, 4) Researchers conducting science with Unilever as employer. These study participants were main personnel who worked daily in the CMD UIP from the Unilever side and provided the industry perspectives, 5) CMD Directors/Managers from both UoL and Unilever. These participants were responsible for the daily execution and leadership of the main activities within the CMD UIP and were part of the steering committee of the overall CMD UIP for problem or project resolutions, 6) Senior Executives from both UoL and Unilever. As part of the senior leadership of the overall organisations of UoL and Unilever, these participants were involved in policy-making, high-level steering committee resolutions, and public relationships to the local, national and international members of society. See Table 5 for the stratification of CMD participants.

Table 5. **Sample Population# Screening Criteria (N = 28)**

	Maturation Phases of CMD UIP				
Hierarchical Employee Level CMD UIP	Venture Creation 1999-2000	Pre-Formative 2001-2004	Formative 2005-2007	Launch/ Operations I 2007-2012	Operations II 2013-Present
Senior Executive		#5 #28	#5 #13 #28	#5 #13 #15 #28	#5 #13 #15 #28
CMD Director/Management			#12	#8 #16 #11 #18 #24 #12	#8 #16 #11 #18 #24 #12
CMD Researcher - UoL			#26	#26 #23 #3 #6 **#22**	#26 #23 #3 #6 **#22**
CMD Researcher - Unilever			#17 #19 #25 #14 #21 #20 **#22**	#17 #19 #25 #14 #21 #20	#17 #19 #25 #14 #21 #20
CMD Staff/Consultant			#27	#27 #7 #10	#27 #7 #10
Foundation Member	#2 #4 #9 #1	#2 #4 #9 #1	#2 #4 #9 #1	#2 #4 #9 #1	#2 #4 #9 #1

Each # is Study Participant Masking Code. (e.g. Praxis #5)

3.4 Sampling Process

In qualitative research, the sample sizes of study participants are typically smaller than quantitative research sample sizes (Cochran, 1974). A typical qualitative study can utilise sample sizes from 5 to 25 or more participants, but there are no specific rules for sample size (Patton, 2002; Silverman, 2005; Small, 2009). The objective is to capture as much as needed to understand what may be occurring in the study venue (Maxwell, 2005). Determining the appropriate sample size for a qualitative, single case study using an approach of inquiry of ethnography/participant – observer is depended upon how much information is to be generated and is left up to the researcher for the most part (Patton, 2002; Creswell, 2005). According to Creswell (2005), a recommended sample size range of 1-25 people would most likely be appropriate while Seidman (2006) suggestions a sample size is one that eventually yields the researcher the necessary information they need to form themes or patterns from the qualitative interactions. Qualitative research requires a sampling approach that is representative of the population being studied. This population for qualitative analysis would be smaller in size as opposed to quantitative research which usually relies on larger sample sizes for more statistical quantification of results (Barlett, Kotrlik and Higgins, 2001; Creswell, 2005, Maxwell, 2005; Creswell 2007). The sampling framework for qualitative research involves gaining a number of participants in the study scene that would provide a representative sampling that would provide data feedback that would be most likely representative of the underpinnings of the essence of the phenomenon sought (Cochran, 1974; Creswell, 2005; Seidman, 2006; Creswell, 2007).

The overall sampling process drew from accounting records in finance of all associated individuals with the CMD, past and present and their level of standing with the CMD and CMD

UIP from both UoL and Unilever. A purposive sampling technique was used to evaluate the potential study participants based on the following four criteria directly related to the CMD UIP. The sample target was: 1) scientists and executives that had been employed directly within or had worked on the overall administration or operations of the CMD, 2) the scientists had to have been involved for at least six months of work within the CMD and were part of one or more research teams involved in the CMD, 3) the executives/researchers had to participate in at least one or more of the distinct phases of the CMD maturation and have direct responsibility for or within the framework of the CMD, 4) the study participants had to be from either UoL or Unilever, and the sample population involved some members that had worked in both organisations.

The initial screen consisted of over 75 individuals that had participated in the CMD, having been thoroughly recorded through payroll records. With the initial screen of CMD employment that lasted for at least six (6) months duration, the number was reduced to approximately 45 potential participants. The next step was to contact each potential CMD study participant with recruiting, consent and study overview documents through emails obtained from the CMD accounting/finance department. From this initial contact, the eventual number study participants representing both chronological and hierarchical positions during the maturation of the CMD UIP. The qualifying criteria of the study participant were re-verified through CMD records before final selection was completed. The minimum sample size initially during recruitment was set at 20 CMD participants to try to gain as large a sample size as possible. After conducting the field research portion of this thesis study, a total of 28 CMD UIP participants were studied. The chronological and hierarchical positioning of the study participants, as previously mentioned was illustrated in Table 5.

3.5 Data Collection

The qualitative interviewing approach was to sit informally in a quiet place near the CMD and conduct qualitative interviews for each of the CMD participants. For current CMD participants, the interviewing site was in or near the CMD. For past participants of the CMD, the interviewing medium was audio phone, video skype or meeting them at their current place of employment or in their residential area. Each study participant was asked the same semi-structured, open-ended questions. The interviews were allowed to free flow after introducing the question to capture as much new information as possible. As the responses were given, the semi-structured questioning, I would ask qualifying questions to keep the flow relevant to the questions asked. For each interview, the data was digitally captured and stored with MP3 audio files. These audio files were stored on a password-protected computer which was stored in a lockbox. Once the interviews were completed, each audio recording was manually transcribed. There are software packages that can transcribe audio recordings. I decided that I would manually transcribe each audio interview to ensure that the software did not miss any keywords, comments or the essence verbally of what a study participant said. There were twenty-eight interviews conducted in the first round and fourteen in the second round, and each transcription was reduced to both a paper copy and an electronic file. The transcripted interview records then went through coding, and the data was sorted and organised in keywords, concepts and other elements that made sense in the context of this study.

3.6 Data Analysis

The data captured was transcribed for each interviewee, and the transcription was the basis for coding. In the analytical phase of the raw data, I read and re-read the transcriptions of the qualitative interviews for the participant interviewee perspective from the open-ended questioning. After the first round interviews were completed, I contacted each participant and reviewed the interview notes taken to ensure that they were a close approximation of the interviews. I also followed up with the study participants for a second round of selected interviews to both clarify and gain additional richness of data from the first round of interviews. When completed I contacted each participant to make sure that I could still use the data obtained during the interviews and discussions while in the CMD. I also reminded them that I would publish beyond the thesis document and publish follow-on papers, books, etc. per the study overview and consent form (Appendix A).

In the coding phase of the analysis of the raw data, I used the technique of open and axial coding of the transcribed qualitative interviews. Coding is a process of assigning tags, labels or some nomenclature to a set of responses that help to form a greater trend or theme of categorisation (Saldaňa, 2009). Open coding is a process of breaking down, questioning, comparing and organising forms of data into larger more manageable sets of data for further analysis (Seidman, 2006; Saldaňa, 2009; Wolcott, 2009). Any repeatable actions, phenomenon, discrete events, reoccurring words, phrases are some of the ways that open coding can capture and organise what appear to be disparate elements upon first analysis (Saldaňa, 2009).

The process of coding the raw data came in several iterations of the reading the transcribed text of each participant. The first cycle of coding was for open coding to be used with the raw data.

Open coding was used to analyse and capture repeating words, phrases or other essence or nuanced sayings that provided a first high-level of organising of the data. This process was repeated over several times during the open coding cycle to organise clusters of repeating patterns into a smaller group of potential themes for follow-on second cycle coding. Once these high-level themes or points of interest were demarcated, the second level of coding approach was conducted called axial coding. Axial coding works to make more refined connections between open coded categories and curate the potential relationships between open-coded labels (Saldaňa, 2009).

I also decided to code the complete set of transcripts manually. My decision for manual transcription and coding was based on the need to understand a complex area: HTS chemistry fully. In HTS chemistry, there is a wide range of acronyms and functional language that can make understanding and coding more complex. I felt it was better to manually analyse the interviews and strive for both depth and breadth of understanding each participant's responses. This choice of manual was also driven by readings that I had made regarding qualitative interviewing and coding of responses (Basit, 2003). When there are possible errors or the chance of missing key elements because of highly specialised topical areas, it can be best for the researcher to do manual capture, transcription and analysis (Tesch, 1990; Basit, 2003; Vaughn and Turner, 2016).

3.7 Protection of Study Participants Rights

The potential candidates for selection into this research study were former and current workers within the CMD of both UoL and Unilever. The University provided pre-approval guidelines in the DBA Handbook and a Code of Conduct. A full proposal of research was submitted to the Committee on Research Ethics at the UoL that contained an in-depth review of the study, informed consent documents, recruitment documents for study participants (See Appendix A). The protection of study participants rights was administered through a classified listing of past and present members of the CMD through the finance group of the UoL for the CMD and the Unilever R&D division at Port Sunlight, England. All identifiable information was masked other than name, title, dates of CMD employment and contact information. To provide a comfort level of engagement with me, I asked both the UoL CMD administration and Unilever R&D CMD administration to notify the past and present members of the CMD that I would be contacting them firstly by email to allow them to reject participation in the research study. If the study candidates were ok with participation in the study, they would contact me or the department head that it was ok to participate. The next step was to email the study overview and consent document to each potential study participant (Appendix A).

After the email introduction to the study candidates and acceptance of willingness to participate in the study, I contacted each prospective participant either face-to-face or by phone. I explained the purpose of the study as the email recruitment documents had done. If the CMD member was satisfied with the study and their protection, I said that I would email to them the study summary, informed consent forms. The informed consent contained main objectives of study, who would be participating from type of position and organisational location, the research design used and how confidentiality would be administered and maintained. All participation in the study by participants that were cleared made them knowledgeable of the intent of the study, what to expect during the field work and corresponding requests for documents.

I explained that participation was voluntary and the participants could elect to remove themselves from the study at any time during or have their responses removed after the study completion. As I am required to publish the thesis, I asked for approval. I also intend to publish post-thesis. I asked for participant approval in allowing me to publish books, articles, make presentations and lecture relating to the findings of this thesis. I made it clear that all references to individuals, sensitive documents and other materials not in the public domain would remain confidential and not be disclosed to any party outside of my advisors and examiners.

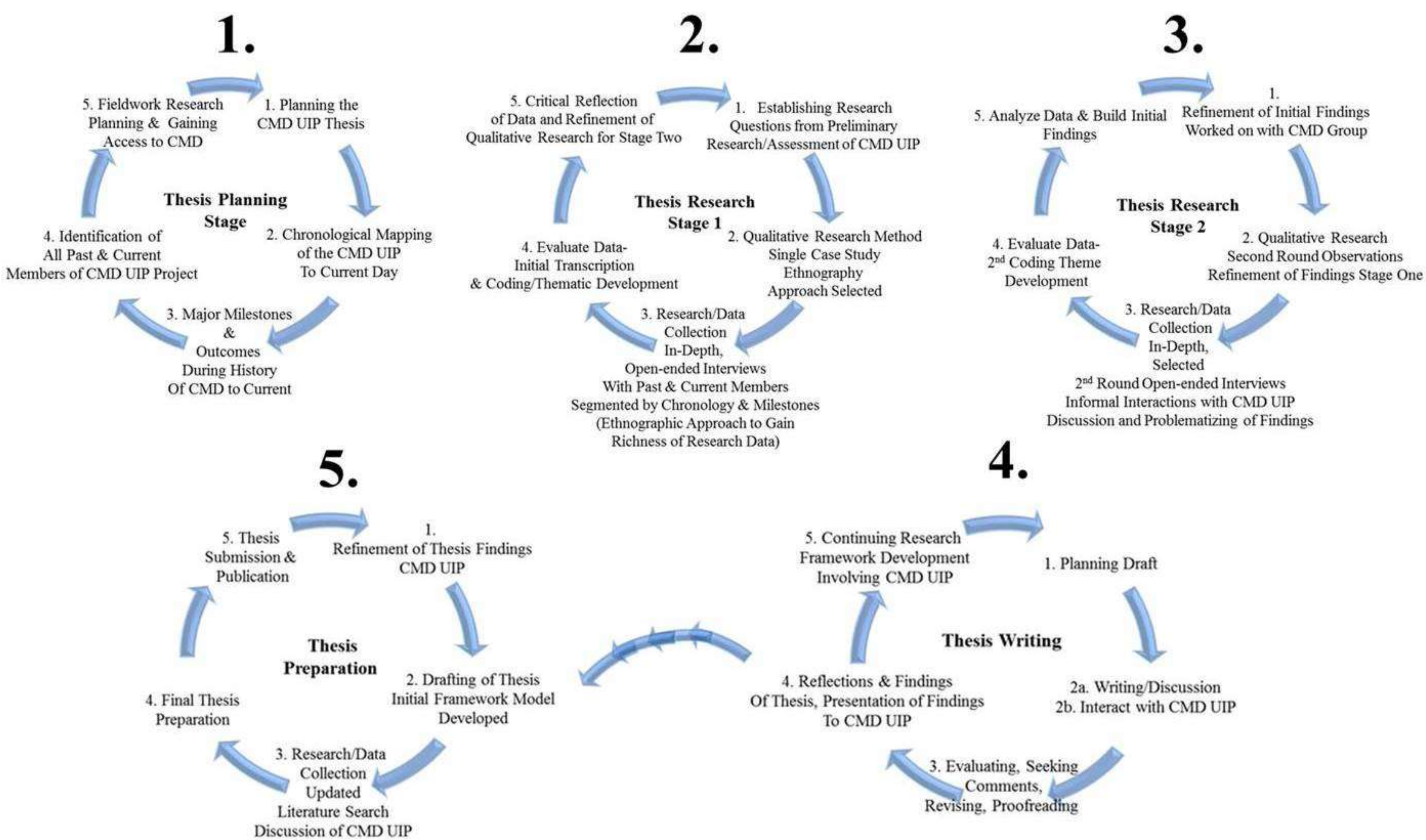
As part of the thesis study, I signed a non-disclosure agreement (Appendix D). I was asked not to disclose any detailed findings relating to individual product sales numbers, actual products on the market, the process or any particular R&D techniques and any confidential results of research per project or any specific chemical structures. For the university, the non-disclosure requirements were relating to the individual principal investigator's budgets, non-published research outcomes from NCEs or release of any of the operating, business or legal documents directly. I am allowed to provide general top-line summaries of the various confidential documents and findings as long as it doesn't provide public release of definitive information.

All participant materials developed or received during the study were kept confidential and that each participant's identity would not be disclosed (Wiles *et al.*, 1995). I employed a code system to guarantee the anonymity of participants and data generated. I assigned a unique identifying code word (PRAXIS) and number to each participant (e.g. PRAXIS 11). All raw data including the digital audio recordings, field notebooks, documents belong to UoL and Unilever, and any other work product were kept secure in a password-protected computer folder if electronic and under lock in a box if materials were in paper copy format. As under the NDA that I signed, all confidential materials supplied to me were marked as such and stored in a locked cabinet. After the award of the degree, I will retain the materials for an additional two years for further publication of papers. At the five year point, I will destroy all forms, documents, electronic files and other digital media storage devices.

3.8 Summary

This chapter highlights the approach to the thesis study of CMD UIP's successful operations and the ability to generate sustainable high-performance in a difficult area of NCE discovery (Farrant, 2012). The research strategy is to utilise a qualitative research framework that will allow emergent sources of data to flow about the CMD UIP. Within the qualitative approach, my approach to inquiry is the ethnographic single case study structure. Ethnography is about observation and interpretation while being immersed in the research study venue through being a participant-observer (Rosen, 1991; Madden, 2008;). I am using a single case study approach as my study is focused on one specific UIP and the notable and rare performance of the CMD UIP. The sampling approach is to select past and present members of the CMD UIP. In the sampling process, I want to capture the hierarchical elements of the CMD UIP to capture differences from the bench-level scientists up to the most senior executives in both UoL and Unilever. To understand if there are maturation elements, I also want to select participants that have been involved in each phase of growth of the CMD UIP. This would be from pre-formation and creation to the operating phase of the renewed contract regarding the first CMD UIP. Finally, in Figure 14, I illustrate the complete research methodological approach taken with the DBA research and the thesis process.

Figure 14. DBA Thesis Process Flow of CMD UIP Study



Chapter 4: Case Study Overview

4.1 Case Study Introduction

In Chapter 4, I present the case study background and set the stage for the research setting. I will introduce and discuss the critical actors in the CMD UIP: 1) the University of Liverpool and, 2) Unilever. As the case study is set within the CMD, I will re-introduce and delve deeper into the Centre for Materials Discovery (CMD) at the University of Liverpool. I will finish with a discussion regarding the processes I had undertaken to research the CMD UIP as it involved the analytical processes of sample selection, sampling, data collection and analysis. The city region of Liverpool served as a backdrop for economic regeneration.

As part of the UoL strategic plan, the University looks to become a co-leader in the redevelopment of the city region of Liverpool. The city of Liverpool suffered extensive job loss and poverty in the 1980s as the heave industries started to move towards Asia. In the early 2000s, Liverpool began a historical and economically amazing rebirth (Bell, 2013b). Part of the success of this redevelopment was setting up a development company to bring together public and private interests, monies, universities, industry and regional/national governments to work together to provide Liverpool with a vision of the future through redevelopment investment in knowledge systems, education, and employment schemes (BIS, 2006).

This economic development effort was referred to as ‘The Liverpool Vision’. Liverpool Vision is an Economic Development Company based in Liverpool, England. Set up in 1999, Liverpool Vision was the first Urban Regeneration Company to be founded in the United Kingdom and was tasked with leading the physical transformation of the city into the new millennium. In 2008, a re-organisation of Liverpool Vision saw its operations as a URC merged with both the

Liverpool Land Development Company and Business Liverpool to form a single Economic Development Company within Liverpool (Liverpool Vision, 2017). A multi-billion pound investment in economic regeneration has transformed Liverpool in the last two decades. From science to manufacturing, digital technology and maritime we attract global brands and companies wanting to invest and benefit from our infrastructure and expertise.

4.2 University of Liverpool Background

The University of Liverpool was founded as a college in 1881. The university gained its royal charter and degree-granting capabilities in 1903 and was known as one of the original six ‘red brick’ universities. The university is somewhat unique in that it has over 35 schools and one of the few to possess a medical, veterinary, dental, tropical medicine, allied health and schools in each of the major areas of science and technology, all on one campus setting. The university is currently ranked in the top 1% of universities worldwide (ARWU, Shanghai Ranking Consultancy). The annual turnover of the university at last reporting was over £500 million, including over £200 million in research money (History of the university, 2015).

The University of Liverpool has a strategic growth plan entitled, Strategy 2026, which sets out an ambitious plan for the economic advancement of the Northwest of England through the actions of the University. The University’s main objectives in this plan are advancement of knowledge creation and utilisation, learning and enablement for the local population, creation of new employment, ennoblement of impacting the new knowledge-based sectors of the 21st century, and establishing new beachheads in the region around new industrial sectors that emanate from new sciences and technologies (University of Liverpool Strategy Plan: 2026).The focus of the University about the strategic planning is being recognised in several categories as amongst the top 100 research universities in the world (University of Liverpool Strategy Plan: 2026). The U.K. government had expanded its programs in supporting the advancement of science and technology centres of excellence around the U.K. This support was financial as well as policy influence.

In most of the OECD countries, R&D is historically the most cited metric of innovation in an economy and measures of success again that R&D spending is usually critical to any decision-making or policy change considerations (NAO, 2013, p.7). The focus of the UoL in the 21st century was about leveraging new areas of research and the contribution these new fields would have on knowledge-based sectors such as nanotechnology, biotechnology, nanomedicine, nanosensors, sustainable energy and food security. All of these segments in the industry were going through tremendous growth in knowledge creation and utilisation (Owen and Hopkins, 2016). The other distinct factors about these new fields were the increasing rates of successful research knowledge creation and material outputs (Alder, Shani and Styhre, 2003).

The direct benefit associated with these new fields was economic and job growth (Balconi and Laboranti, 2006). As these sectors were comprised of integration of several science and technology fields such as computer science, mathematics, biology, chemistry, physics, material science, engineering, business and industrial design (Bartlett, Kotrlik and Higgins, 2001). This integrative scientific approach is contributing more exponentially to knowledge generation, diffusion and applications than the more traditional linear growth curves seen in the 20th century (BIGT, 2003; Van Looy, Debackere and Andries, 2003; BIS, 2006; BIS, 2010; OECD, 2010; BIS, 2011; NAO, 2013).

As part of this strategy, UoL was part of the Russell 20 group of universities. The Russell Group is a self-selected association of research-based universities with academic prestige all of whom are situated in the United Kingdom. This grouping has now expanded to 24 universities. The importance of the Russell Group is that the members receive approximately two-thirds of all university research grants and contract income in the U.K. The Russell Group can also garner a very large amount from E.U. pools of funding. The Russell Group objectives were to: lead the research efforts of the United Kingdom; maximize the income of its member institutions; attract the best staff and students to its member institutions; create a regulatory environment in which it can achieve these objectives by reducing government interference; and identify ways to co-operate to exploit the universities' collaborative advantage. It works towards these objectives by lobbying the UK government and parliament; commissioning reports and research; creating a forum in which its member institutions can discuss issues of common concern; and identify opportunities for them to work together (Russell Group Homepage, 2015).

4.3 Unilever Corporation Background

The beginnings of Unilever started with aspirations of a one William Lever. William Lever, later the 1st Viscount Leverhulme, was born in 1851 in Bolton, Lancashire, England. Lever, the son of a grocer, was made a lord. Lord Lever's approach was as much environmentally sustainable as it was paternalistic in striving for a better world. In 1884 William decided to specialise in selling individually wrapped bars of soap so everyone would have their own and not have to share with others for hygienic reasons. The business grew quickly and by 1887, a site near Birkenhead was chosen. The site provided for direct access to Liverpool, a great maritime city at the time. The factory site later became known as Port Sunlight, named after the first brands of soap, Sunlight. Over the years, the factory site became a village that comprised over 221 acres and eventually was recognised as one of the most advanced operationally and comprehensive company towns devised (Unilever, 2003).

Unilever prospered through the late 19th and 20th centuries and built a global consumer brands business. By the late 1990s, Unilever had lost it edge and business were constantly under pressure (Reitsma, 2001; Jones, 2005). During the early 2000s, Unilever sales were under pressure, and new product development wasn't yielding the new product discoveries necessary to fuel the traditional growth of the food, cleaning and personal care product divisions (Jones, 2005). The world's economic expansion (emerging countries like China, Brazil, Asia, etc.) grew the growth in the consumer goods industrial sector, and expansion of marketplace needs drove requirements (i.e. globalisation) for new products. This created a large void as many of these new products needed to have product properties to perform new requirements.

These requirements could not be met with existing products. New products with new ingredients needed to be developed which put larger amounts of pressure on internal R&D capabilities. (Jones, 2005; Smith, 2009; Strategic Direction, 2009, Strategic Direction, 2012; Bell, 2013a; Bell, 2013b). Unilever started a process of internal reviews and audits of all its business units to decide on the future direction of the commercial operations of the company (Bell, 2013a, Bell, 2013b; Strategic Direction, 2013). The progress was lacking that in the period from 2005 to 2008 Unilever started an aggressive reorganisation. This reorganisation would focus on out-sourcing a majority of R&D through open innovation programmes. (Jones, 2005; Strategic Direction, 2009 Jopson, 2013). The partnership with the UoL would be one of the largest in the early stages of Unilever's open innovation strategy.

The open innovation programmes were designed to find new ways to become more innovative in new product development. Unilever was not as big as Proctor and Gamble (P&G) regarding R&D capabilities or scientists (Jopson, 2013). Unilever had to find another route to increase its R&D capabilities and industrial outputs (Jones, 2005). Compared to P&G, Nestle and other consumer goods companies, Unilever had a relatively smaller scientific and technical capability. The overall numbers of employees in the R&D areas of Unilever were a fraction of those from P&G and Nestle. This made new product development and incremental product improvements a real of challenges and impacted the direct bottom-line of the balance sheet (Bell, 2013b; Jones, 2005).

In 2009, Unilever hired a new CEO, Paul Polman, who came from Nestle and P&G. As part of this redevelopment of the company, Unilever chose to sell-off many of its food brands and reshaped the overall consumer goods portfolio into more sustainable and competitive products. Unilever also wanted to move into the emerging markets where little sales had been historically generated from any of the consumer goods companies (Jopson, 2013). Unilever believed its new strategy would provide it access to the emerging markets for growth while at the same time provide for new stimulus into the more saturated markets it already served (Evans and Fukase, 2014; Gelles, 2015). The original focus of Mr Polman's growth strategy was a set of plans he called The Sustainable Living Directives (Bell, 2013a; Bell, 2013b; Evans and Fukase, 2014; Gelles, 2015).

Through Polman’s efforts, Unilever is now one of the main leaders in sustainable production and have mandated to cut its environmental footprint in half by 2020 (Gelles, 2015, p. 10). Today, Unilever is a global producer of over 1,000 soaps, cleaning products, personal care products, ice creams and spreads that sell in 190 countries (Gelles, 2015). Open innovation R&D partnerships have created savings of €400 million or USD 430 million, since 2009 (Gelles, 2015, p. 12). The commercial outcomes, so far, are nothing short of amazing. Many of these newly launched products serving the emerging markets are individually-packaged products that are environmentally friendly and provide sustainable product offerings. Many of these products are derived from new chemical compounds discovered through the CMD UIP.

As an example, Unilever introduced Comfort One Rinse, a fabric softener meant to use a third as much water as usual. In Nigeria, it has replaced its Sunlight dishwashing detergent paste with a new concentrated powder that requires less energy to distribute and less water to make the product work. In Brazil, it is selling a new, more energy-efficient 'Omo' laundry detergent" … "according to Unilever's calculations, 90% of the environmental impact of the making and using of its products comes from the consumers. … *"there is simply no easy way to heat a gallon of water in developing countries with half as much fuel or half as much water, so the product must make the difference in that sustainable change in use"…* as Mr Polman sees it, [the hardest part is to impact the environment through new science and technology]. *"Unilever must make new products that change the habits of consumers through innovation. Unilever should not try to change the habits of consumers by changing cultural elements that are impossible to change"*Mr Polman says, *"A lot of water usage in our value chain comes from cooking, cleaning and showering, from heating up water.* (Gelles, 2015, p. 12.

Figure 15. Unilever is a Global Fortune 500 Company

4.4 The Centre for Materials Discovery (CMD)

The CMD opened in 2006, following a £9.6 million investment from the UoL, the Northwest Regional Development Agency (NWDA), and Merseyside European Objective One Funding. The study is a UIP between UoL and Unilever. The study venue for the UIP is the CMD on the campus of the UoL is the School of Sciences and Engineering. The CMD enables industries to move rapidly into the next generation of manufacturing novel materials. Its high-throughput chemistry technology accelerates research by enabling scientists to produce and test large numbers of new materials in parallel. The capabilities that later became the CMD were operated informally (with very limited instrumentation and resources) for about four years, and then in

2006, the CMD was structured into a more formal and self-contained operating facility that was named more formally, the Centre for Materials Discovery (CMD Documents, 2016).

The total operating life cycle of the CMD and the CMD UIP has been close to 11years and is currently operational in 2017.The CMD is a basic and applied research facility that serves a wide range of chemistry and material science needs for Industry Collaboration. Unilever was developing new polymers – large molecules of repeating units – with improved properties in a wide range of home and personal care products. The new materials (NCEs), when discovered, have enabled Unilever to improve the structure, feel and flow of products as well as their ability to bind to surfaces. This has created a competitive advantage for Unilever.

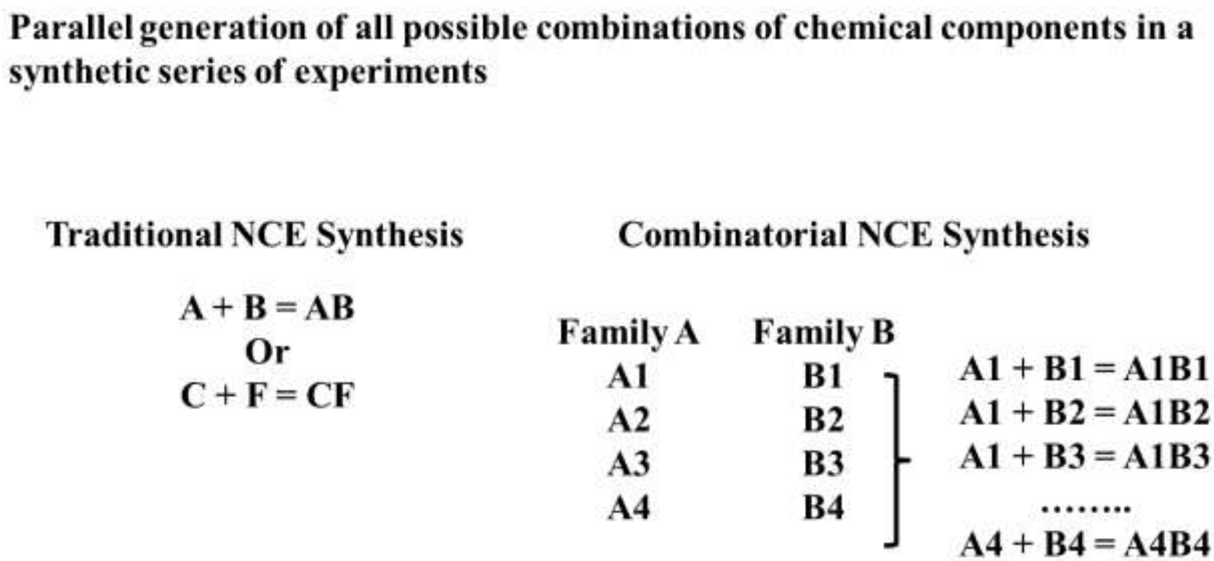
The scope of research conducted at CMD is broad, but can be grouped into four areas: 1) HTS method development: the development of new or improved techniques to enhance expertise and capability in the field of HTS material science research, 2) New materials discovery: the use of automated synthesis and characterization to discover wholly new materials with step-changes in performance, 3) Material optimization: "scaling-out" the development of existing products to improve performance, reduce costs or strengthen IP claims and lastly, 4) Property/behavior investigation: automated or parallel experimentation to facilitate detailed mechanistic investigations, kinetic studies, reproducibility studies.

> *We aim to double the size of our business while reducing our overall environmental impact so identifying new materials which are highly effective is crucial. Companies are increasingly looking to develop more sustainable alternatives which have similar or enhanced properties and the technology*

available [CMD] at the University [Liverpool] make it well-placed to support Unilever - Unilever Director for Structured Materials.

The original goal of the CMD was to provide scientific capabilities in the medium to high-throughput chemistry compound discovery and development arena for industry and to complement the research efforts of the university in the advance chemical discovery area (Barr *et al.,* 2013). The CMD is focused broadly on material science with a large range of applications within academe and industry where it utilises state-of-the-art instrumentation, computers and mathematics. The CMD Center operates as a stand-alone entity within the structure of the university and engages with both inside researchers at the university as well as outside researchers located at government-sponsored labs and industry companies. The CMD operates on its budgets and funding comes from partnerships with industry, other universities, government programmes and grant funding organisations (Business Department, 2013).

Figure 16. What is Combinatorial Chemistry Synthesis?



The importance of material science has been extraordinary for the past several decades and has resulted in a wide range of products that have an advanced society in many facets such as manufacturing, textiles, healthcare, communications, transportation, agriculture (Devlin, 1997; McClellan and Dorn, 2006). With the advent of advanced computing, mathematics and material sciences, the field of computational chemistry is extremely dynamic, globally positioned and continues to change dramatically in both scopes of science and technologies (Bruneel, D'Este and Salter, 2010). New market applications are driving a greater need for new products with unique attributes and functions. Many of the consumer packaged goods (CPG) market sectors are requiring new chemical compounds with new functional characteristics to replace older less functional products (Keserù and Makara, 2006; Marcarron, 2006).

Average rates of NCE discovery have been dropping down to under 2% on average in the late 1990s and early 2000s (Borchardt *et al.*, 2004; Barbolla and Corredera, 2009). In a selected group of published papers regarding the performance of discovery of an NCEs can range from

0.01% to <10% of total chemical output processed (Devlin, 1997; Keserü and Makara, 2006; Macarron, 2006; Posner, Xi and Mills, 2009; Hansson *et al.*, 2013). In industry, the NCE hit-to-leads ratio of the number of potentially successful compounds can be highly confidential to most companies (Walters and Namchuk, 2003). From my own experience within the industry, to have more than one or two discovered compounds in a three years' time would be out of the ordinary for most projects. The rate of commercially successful NCE output by the CMD UIP (has been orders of magnitude greater than published rates of success (Devlin, 1997; Borchardt, *et al.*, 2004; Fox, *et al.*, 2004; Macarron, 2006; Posner, Xi and Mills, 2009; Hansson, *et al.*, 2013). The duration of successful outputs of commercially-viable NCEs has lasted over nine years and continue to be a large source of revenue growth for Unilever in their emerging market sectors in consumer products.

> *The University has enabled a transformation in the way Unilever approaches a traditional and established field such as chemistry, enabling a dramatic uptick in speed and quality of output. The success of this partnership has been instrumental in boosting our innovation funnel, and so we are delighted to be extending our collaboration with Liverpool - Unilever Vice-President for Open Innovation*.

4.5 Case Study Analytical Process

The literature surveyed for this thesis included professional and academic publications, professional books, academic textbooks, government reports, manuals, databases and confidential documents relating to the CMD and the CMD UIP. The confidential documents surveyed were correspondence, impact reports, grant funding tables, internal budgets, U.K.

funding tender responses, legal documents and strategic plans relating to the development of the CMD centre and the UoL-Unilever UIP. My position in the thesis research was as a participant-observer within the CMD. I was allowed participatory access to both the university and Unilever facilities and the people. This positionality was instrumental in observing, participating and capturing key elements of the activities of the CMD operations and the CMD UIP.

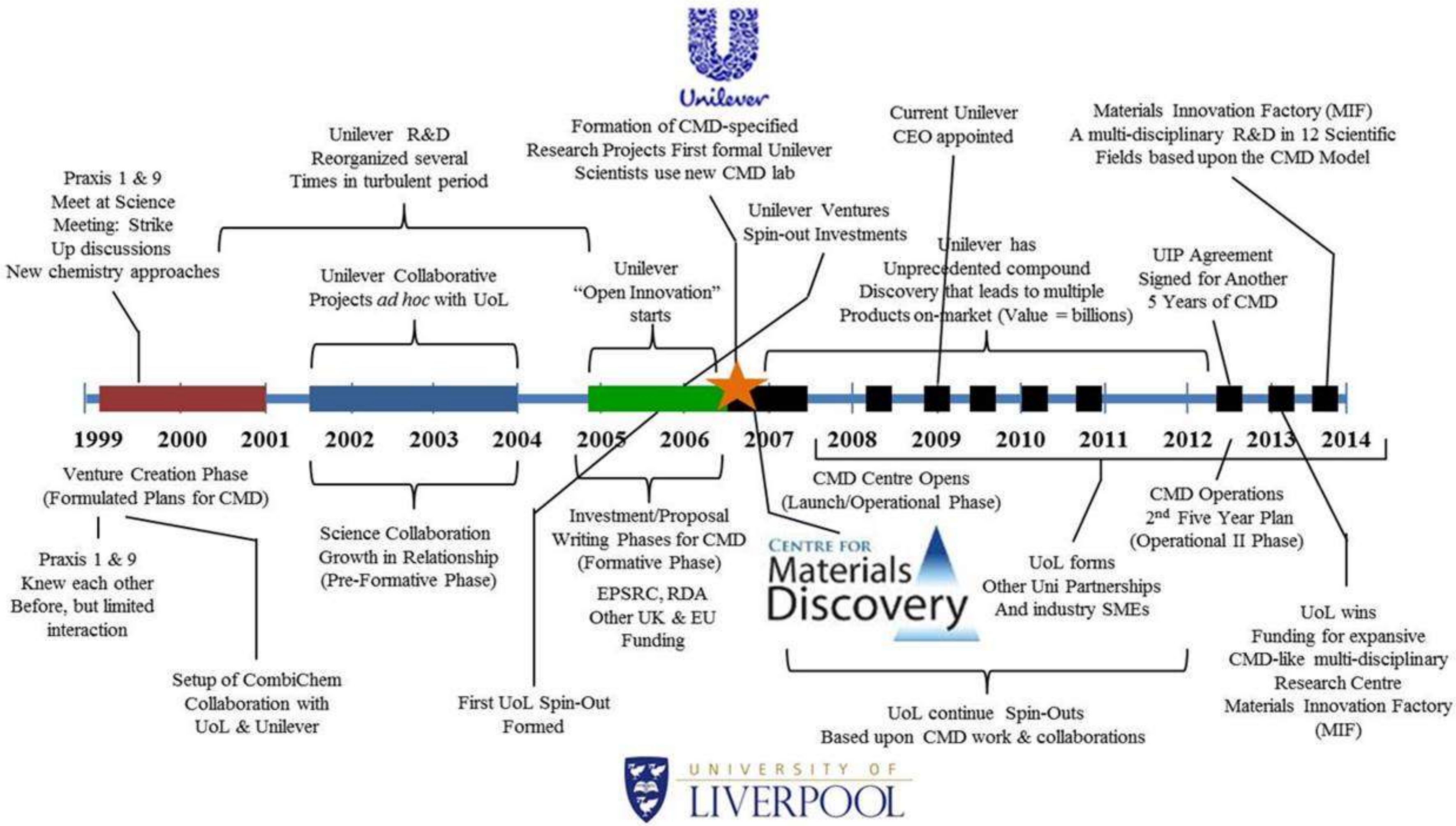
The major elements were 1) formation of the CMD, to understand all of the elements and activities that went into the formation of the CMD including the initial vision, champions and stakeholder actions that allowed the CMD to become an entity, 2) chronological order of material milestones and to capture the major points of distinction. The stages were the pre-formative, formative, early operations and later operational stages of the CMD, 3) document the principle reasons behind CMD that would help to understand why this UIP was formed, 4) engagement with participants from the pre-formative period up to present day participants of the CMD to understand the durational aspect of the operations over time. The identification of CMD participants was an important part of the study. Many researchers would access the CMD instrumentation for brief periods of time and the infrequent nature of this particular group was a reason for delimiting members of the CMD. The CMD members sought were those with at least six months or more of time spent working in the CMD. The CMD participant must be working directly with the CMD relating to UoL research or by Unilever scientists conducting research directly related to programs of Unilever.

The sampling framework for qualitative research involves gaining a number of participants in the study scene that would provide a representative sampling that would provide data feedback that would be most likely representative of the underpinnings of the essence of the phenomenon sought (Cochran, 1974; Creswell, 2005; Seidman, 2006); Creswell, 2007). According to

Creswell (2005), a recommended sample size range of 1-25 people would most likely be appropriate while Seidman (2006) suggestions a sample size is one that eventually yields the researcher the necessary information they need to form themes or patterns from the qualitative interactions.

For this thesis study, the projected sample size was in the 20 to 40 range of potential candidates who had worked in the CMD for more than six months and were materially part of the CMD from either the UoL or Unilever (Cochran, 1974). The minimum sample size initially during recruitment was set at 20 CMD participants to try to gain as large a sample size as possible. After conducting the field research portion of this thesis study, a total of 28 CMD UIP participants were studied.

Figure 17. Key Chronological Events of the CMD UIP



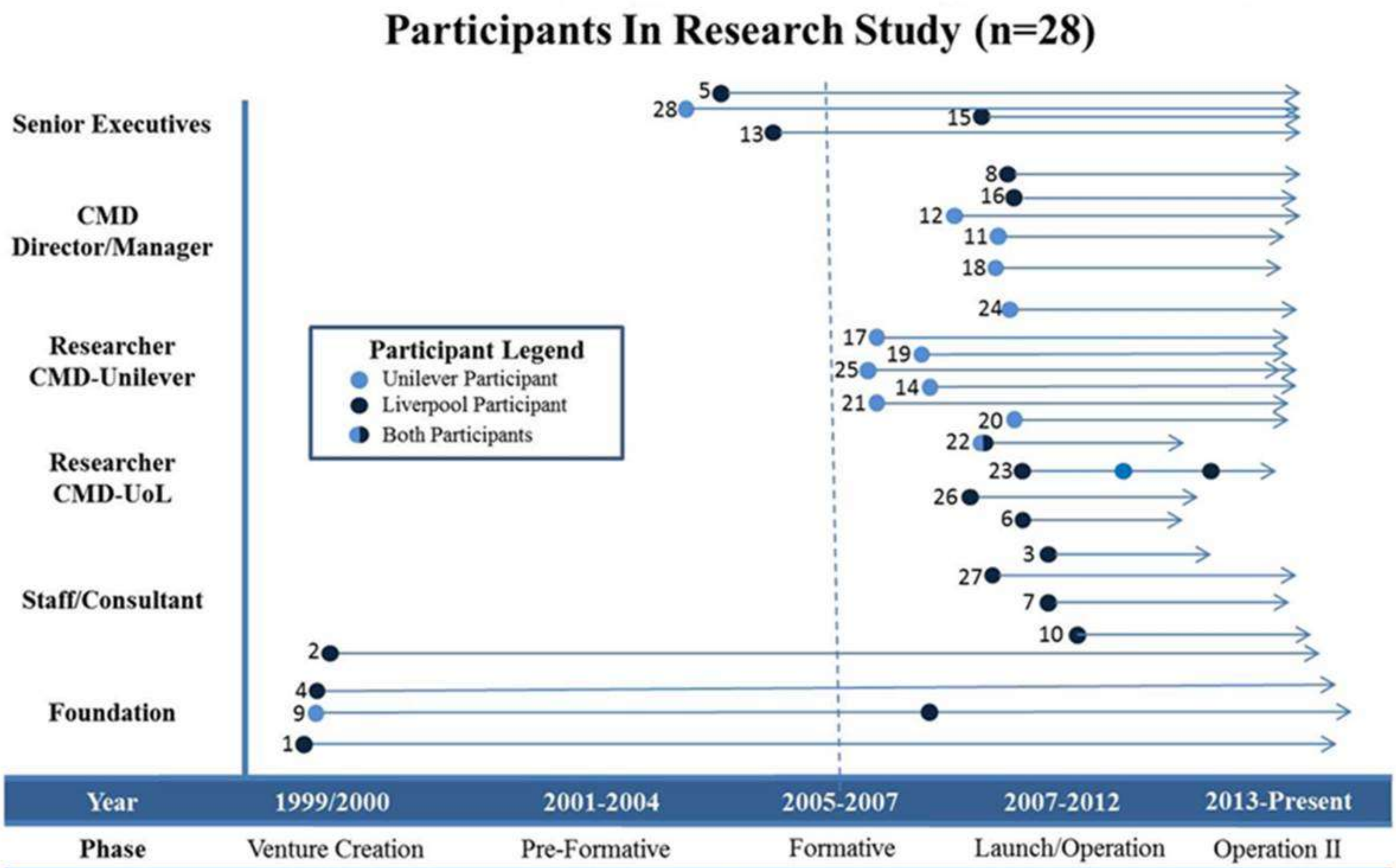
Source: Adapted from records of UoL, Unilever, The CMD and CMD UIP.

The study population was recruited from two primary sources: 1) the UoL's CMD facility and 2) the R&D group for personal care and consumer cleaning products from Unilever in the Northwest of England at the Port Sunlight R&D facility. The aggregation of names was accrued from historical records within the finance department of the university that allocated time and financial remuneration to scientists associated with the UoL but directly assigned full or part-time to the CMD facility. The study population from Unilever was assembled from R&D records and from the management of present R&D at Unilever who identified past and current members for potential inclusion into the study.

A purposive sampling technique was used to evaluate the potential study participants based on the following four criteria directly related to the CMD UIP: 1) scientists and executives that had worked directly within or had worked on the overall administration or operations of the CMD, 2) the scientists had to have been involved for at least 6 months of work within the CMD and were part of one or more research teams involved in the CMD, 3) the executives/researchers had to be involved in at least one or more of the distinct phases of the CMD maturation and have direct responsibility over or within the framework of the CMD, 4) the study participants had to be from either UoL or Unilever and the sample population involved some participants that had worked in both organizations. As a participant-observer in the research process, the two-level coding process has been influenced by the participating observations and interactions that I have had with CMD UIP participants. This was a benefit for the thesis study as I uncovered elements within the raw data and coding process that could have been missed by not having a first-person perspective on the CMD UIP through a participant-observer lens (Bartunek, 1993; Bradbury-Huang, 2010).

The six hierarchical levels of the study participants were: 1) Foundation members. These participants were involved in the critical discussions about creating a CMD and UIP around the concept. These individuals also provided the vision, direction and support to continue the activities during the pre-formation and formation stages and if still present during the research data collection phase, they were responsible for continued operational and programmed support of the CMD UIP, 2) Staff and Consultants. The level of expertise necessary to support and direct operations of any UIP can be supplemented with domain experts and these participants, may expand the insights into the various phases of the maturation of the CMD UIP, 3) Researchers conducting science with UoL as the employer. These study participants were main personnel who worked daily in the CMD UIP from the UoL side and provided the university perspectives, 4) Researchers conducting science with Unilever as the employer. These study participants were main personnel who worked daily in the CMD UIP from the Unilever side and provided the industry perspectives, 5) CMD Directors/Managers from both UoL and Unilever. These participants were responsible for the daily execution and leadership of the main activities within the CMD UIP and were part of the steering committee of the overall CMD UIP for problem or project resolutions, 6) Senior Executives from both UoL and Unilever. As part of the senior leadership of the overall organisations of UoL and Unilever, these participants were involved in policy-making, high-level steering committee resolutions, and public relationships to the local, national and international members of society. See Figure 18 for the stratification of CMD participants.

Figure 18. CMD UIP Sampling Population Map



NOTE: The figure represents the chronological ordering of participants by phase of maturation of the partnership, level of position within the partnership and the organization to which each participant belonged during the partnership with a few having both. It was also important to show through the (use of arrows) the length (duration) of participation within the CMD as part of the partnership. It should be noted that one participant (foundation member) started as a Unilever employee and switched to a University of Liverpool employee/researcher during the partnership and remains with the university today as a senior researcher/manager.

The six hierarchical levels of the study participants were: 1) Foundation members. These members participated in the critical discussions about creating a CMD and UIP around the concept. These individuals also provided the vision, direction and support to continue the activities during the pre-formation and formation stages and if still present during the research data collection phase, they were responsible for continued operational and programmed support of the CMD UIP, 2) Staff and Consultants. The level of expertise necessary to support and direct operations of the UIP. Domain experts and these participants may expand the insights into the various phases of the maturation of the CMD UIP, 3) Researchers conducting science with UoL as the employer. These study participants were primary personnel who worked daily in the CMD UIP from the UoL side and provided the university perspectives, 4) Researchers conducting science with Unilever as the employer and, 5) CMD Directors/Managers from both UoL and Unilever. These participants were responsible for the daily execution and leadership of the principal activities within the CMD UIP and were part of the steering committee of the overall CMD UIP for problem or project resolutions, 6) Senior Executives from both UoL and Unilever. In the context of the senior leadership of the overall organisations of UoL and Unilever, these participants were involved in policy-making, high-level steering committee resolutions, and public relationships to the local, national and international members of society.

The Key five phases of the chronological timing of the CMD UIP were: 1) venture creation of CMD UIP also known as foundation stage (1999/2000). This phase explored the precursor elements and interactions that may contribute to the formation of UIPs and to see what, if any, enduring elements exist that potentially could help the longer-term success of the CMD UIP, 2) pre-formative that were involved in planning and inter-operational projects (2001-2004). The insights from this phase potentially could provide insights and the very essence of how enduring successful UIPs get formulated and set in the right direction for start-up operations, 3) formative start-up and limited operational projects (2005-2007). The formation of the CMD, this phase potentially could elucidate those elements that had endured over the previous five years that allowed the perseverance of both sides of the CMD UIP to set-up operations with new funds, equipment and personnel, 4) launch/operations I with full capabilities (2007-2012). This phase provides initial project selection and research focus for the larger CMD UIP effort and takes into account the broader mandate issued to the CMD from the Triple Helix stakeholders of UoL, Unilever and the U.K. government. This initial selection of projects upon full-scale launch of the CMD UIP was of ultimate importance as to whether success had been achieved., 5) operation II, a renewal of the CMD UIP contract and expansion to other projects (2013-Present). This current phase has had a renewal of commitment to the CMD UIP between UoL and Unilever due to a mutually acceptable definition of research and commercial development success. In reviewing these variables that led to renewal is important in exploring these underlying elements of initial success of the CMD UIP

This choice of manual was also driven by readings that I had made regarding qualitative interviewing and coding of responses (Basit, 2003). When there are possible errors or the chance of missing key elements because of highly specialised topical areas, it can be best for the researcher to do manual capture, transcription and analysis (Basit, 2003; Saldaňa, 2009; Seidman, 2006; Tesch, 1990; Vaughn and Turner, 2016). From the digital audio recordings and transcripts that were analysed, the goal was to determine emerging underlying themes, nuances, coalesced meanings and last sub-themes that could create more defined thematic categories relating to the CMD UIP (Basit, 2003; Saldaňa, 2009; Seidman, 2006; Yin, 2009).

In the analytical phase of the raw data, I read and re-read the transcriptions of the qualitative interviews for the participant interviewee perspective from the open-ended questioning. The process of coding the raw data came in several iterations of the reading the transcribed text of each participant. I wanted to make sure that if there were any important elements exposed, I would be able to capture them properly and be able to analyse them appropriately from this first-person perspective. As mentioned before, the analysis of the raw data was done manually versus computer software for coding analysis. I am glad I decided on this approach as emergent sub-themes did present themselves that I'm not sure would have been captured with more automated means.

In the coding phase of the analysis of the raw data, I used the technique of open and axial coding of the transcribed qualitative interviews. Coding is a process of assigning tags, labels or some nomenclature to a set of responses that help to form a greater trend or theme of categorisation (Saldaňa, 2009). Open coding is a process of breaking down, questioning, comparing and organising forms of data into larger more manageable sets of data for further analysis (Saldaňa, 2009; Seidman, 2006; Wolcott, 2009). This process was repeated over several times during the open coding cycle to organise clusters of repeating patterns into a smaller group of potential themes for follow-on second cycle coding. Once these high-level themes or points of interest were demarcated, the second level of coding approach was conducted called axial coding. Axial coding works to make more refined connections between open coded categories and curate the potential relationships between open-coded labels (Saldaňa, 2009).

Chapter 5: Research Findings

5.1 Introduction

In Chapter 5, I present the results of a thematic analysis of the study. The method was a single case study involving an ethnographic approach to inquiry. The empirical data capture was through semi-structured, qualitative interviewing of executives, staff and researchers of the CMD UIP. From this study emerged empirical data that elucidated factors relating to the success of the CMD UIP partnership. Also present were the factors relating to the science success of the CMD UIP to achieve extraordinary output performance for NCE discovery, and key factors related to the sustained high-performance of the CMD UIP. This chapter focuses on the discovery of five key categorical themes that emerged during the study. These five categorical themes capture the elements that contributed to the overall success of the CMD UIP.

The five categorical themes were very distinct and separate. The five categorical themes in the study were 1) *people*, 2) *environment*, 3) *instrumentation*, 4) *communication* and 5) *business and legal*. The chapter structure is an introduction contained in Section 5.1. The CMD UIP specific analytical coding approach is covered in Section 5.2. In Section 5.3, I present the five categorical themes that emerged during the study. In section 5.4, I will introduce two cross-cutting emergent global themes that permeated throughout the five categorical themes. These two global themes played an important relational influence on the certain themes and together can be used to explain the success of the CMD UIP. In Section 5.5, I provide a summation of the chapter.

5.2 Analytical Approach to Research Findings

Using an open-ended approach to the coding process, I started examining the raw data transcripts and utilised preliminary 'descriptors' to sort and orientate the clustering of key descriptors. The coding processes sorted the raw data and helped me to establish emerging patterns. The filtering and clustering reiterations provided emerging sets of descriptors that could be organised into small coded groupings or sub-themes. This repetitive cycling provided a set of codes for further analysis and sorting. I continued this process until a more coherent definition of coded groupings emerged. Eventually, these sub-themes were clustered into major categories of themes. The sub-theme development and new categorical coding developed during the final analytical iteration. This final cycle of coding created the five major categorical themes noted above. The iterative and emergent nature of this coding process is not easy to represent, but the following paragraphs (and associated tables) aim to present the overall data structure generated by this thematic analysis (Gioia et al., 2013).

In Table 6, to the far left column titled '*1st Cycle Open Coding'*, codes and descriptors of a repeating nature are captured from the interview transcripts. As these fragments increased in frequency, they were re-sorted into new sub-groupings. Through a process of filtering these early codes, new repeating codes started to suggest early sub-themes. In the next column labelled '*Open Coding Emergent Themes'*, the sub-categories and repeating key words build up into more definitive descriptors. These grouped descriptors help to form a link with key words and concepts that build into major labels that categorised key attributes. The development of these key sub-themes is in the third from the left column titled '*2nd Cycle Axial Coding Themes'* the five *categorical themes* that resulted from this process are illustrated in Table 6 and Table 7.

Table 6. Open and Axial Coding and Thematic Linkage for Categorical Themes

1st Cycle Open Coding	Open Coding Emergent Themes	2nd Cycle Axial Coding Themes	Categorical Themes
• Preselected participants 'best of best' • People driven to do science only • Supportive, positive & mentoring types • Inclusive club of people in CMD • Independent-minded people • Entrepreneurial oriented attitudes • Focused, single-minded approach • Tenacious, perseverance, soft rebellious • Collaborative-in-nature, tightly bonded • Motivating, self-starting behavior • Broad organization levels of support • Top level support from both sides • Affinity for risk-taking	• Pre-chosen entry • Entrepreneurial orientation • Positive, can-do attitude • Tightly bonded group • Strong, single focus mission • People drawn by chance to do science only • Highly supportive & collaborative • Risk-taking, pushing the edge	• Hand selected • Risk-taking • Collaborative • Supportive • Broad organizational support	**People**
• Must be certified on all CMD aspects • Scheduled access to CMD • Highly structured operations • CMD participants hand-picked • Credit/token system for access equip. • Science only work allowed in CMD • Removed from general UoL or Company • Self-contained operations within Univ. • Access to Univ. common areas/labs • Company only labs for confidential/IPR • Free to be a scientist when at CMD • Positive, open and learning environment • Ability to mingle with univ. scientists, events. • Cross-collaboration discussions of general chemistry nature	• Prequalified users • Highly structure environment • Removed from Univ. or Company • Management system for operations • Exclusive use by scientists with state-of-the-art facility • Separate, but equal access to CMD • Confidential work separated, protected • Open access to Univ. resources and general collaboration with faculty/staff	• Structured environment • Separate, but equal access • Controlled, managed • Focus on scientific work only • Collaborative, learning • Compartmentalized for Univ and companies	**Environment**
• State-of-art-equipment • Comprehensive offering • Controlled access to equipment • Common shared equip/sole supplied • Always being updated equip/software • Always access, but scheduled • Always properly maintained/upgraded • Don't have to buy (company) equip, so don't have to amortize accounting • Full service training on equip and experiment set-up assistance • Clean and fully operational	• State-of-art • Allows leading-edge science work • Large equip offering for broad work • No CAPEX for companies, constant updates • Training and experience leading-edge • Cross-collaboration with Univ faculty equip	• Controlled access • Clean not messy • No CAPEX, great for companies • Broad assortment of equip • Updated, state-of-the-art	**Instrumentation**

Table 7. Open and Axial Coding and Thematic Linkage for Categorical Themes

1st Cycle Open Coding	Open Coding Emergent Themes	2nd Cycle Axial Coding Themes	Categorical Themes
• Daily communication on lab status • Problem reporting daily • Training & development frequent • CMD staff always available • CMD users have access to broader Univ. • Univ. events open to CMD companies • Monthly meetings: steering committee, operating groups, lab operations • Quarterly updates between Univ and Companies • Top executives frequent meetings with CMD management • Documented and managed communications within CMD	• Positive, open communications • Frequent interactions amongst CMD • Reporting systems for daily events • Structured action/corrective systems • Top-down, bottom-up communications • Open discussion environment about major issues & challenges • Frequent promotion of CMD • Business development promotion	• Comprehensive communication systems • Broad participation within, between CMD members • Regular communications, especially Executives • Open, positive and collaborative	**Communication**
• Comprehensive discussion of major points right at the beginning of negotiations • Experienced people both sides who deeply understood key issues & operating challenges • Key end goals laid out at beginning, clearly • Operating structure laid out beginning • Access systems discussed, limited participants • Intellectual property needs laid out in beginning • Representation, communication and problem resolution were key points upfront • No lawyers or documents for first 4 months • Total time for CMD legal was 7-8 months • Full business development staff in CMD • Cross-collaborative working relationships between Univ and Company	• Discussions of end-goals, outcomes first • Business first, legal second • Measured discussions • Each major area discussed before any contract • Very experienced people • Shared and bonded vision between CMD groups • Top executive participation • Blank sheet of paper type of working relationship • Creative clauses to deal with uncertainty	• Business first, then legal • Thoroughly laid out in beginning • Shared & common goals • All sides wanted to make it work • Intellectual property dealt with upfront and creatively with CMD • Daily to twice weekly meetings to keep momentum during early phases • Agreement was about quality not speed	**Legal & Business**

5.3 The Five Categorical Themes

This section presents the key findings from the study organised by each categorical theme that emerged during the thematic analysis. Each theme is described in turn drawing upon constituent elements in the data structure (Tables 6 & 7): 1) People: training, skills, their characteristics, attributes and personalities, 2) Environmental: were cultural, organizational and operational elements that existed within the CMD facility and relating to the support functions of the environment of the UIP, 3) Instrumentation: how instrumentation played a role as tools of a trade to impact the work that members of the CMD did; unique and enabling scientific capabilities of the CMD lab that were created through the use of specific instrumentation, 4) Communication: the role of communications in the CMD and the CMD UIP; the style and systems of communication within the CMD and the UIP, and the way communications as a theme impacted decision-making and leadership; and 5) The importance of business and legal constructs in the CMD UIP.

5.3.1 Categorical Theme: People

The first categorical theme of the CMD UIP study was People. The people from the study are the staff, faculty, and researchers working the CMD UIP. The theme of people played prominently in the CMD UIP during all stages of maturation for the partnership. The findings suggested that the role of people in the pre-formation, formation and operation stages of the partnership was the largest factor influencing the other categorical themes due to the mutual shared vision and purpose that both partners wanted in the UIP. In the literature regarding important success factors in UIPs, people make up the greatest intellectual resource in the organization (Hinds *et* *al.*, 2000; Jaksić, Jovanović, and Petković, 2015). People can also be the stimulating factor in creating high-performance outputs (Katzenbach and Smith, 1993; Hilzik, 2000).

The process of how people interact and work with each other and as part of a system can be quite important in high-performance organisations (Katzenbach and Smith, 1993; Kupers and Weibler, 2008). In the pre-formation and formation stages of the CMD UIP, people were instrumental in the founding principles of the centre and partnership framework. The three key champions from the chemistry department had nurtured relationships with outside industrial scientists with hopes of some form of collaboration between them. The UoL had other industrial partnerships in place, but the majority of them centred on sponsored or contract research. The contract research focus can be short-term duration projects with a small actionable outcome. Once that outcome was achieved or if it failed to be achieved, the relationship was over. The time and resources necessary to gain partnerships was a large commitment to the UoL.

The senior executive management at the UoL was interested in more long-term relationships that would build over time into more than a project orientation. During the research phase, one senior executive at UoL I interviewed stated that ..*"I had as my remit for some period, the goal of orchestrating a major partnerships with a large multi-national companies that could provide longer, more expansive types of partnerships".* One particular faculty member had a vision for creating a chemistry centre that would bring together the varied areas within chemistry with computer science. This same academic was the passionate champion of the vision of the CMD to advance the chemistry school at UoL.

The range of personal interactions between this academic was bench-level scientists (who would later form the initial group of UoL CMD members) up to the Vice-Chancellor of the university. This academic researcher would also have frequent interactions with research executives at two companies in the Liverpool region. One of these executive R&D scientists shared the same visions of advanced chemistry capabilities, but with an eye towards the development of new products which Unilever struggled to achieve with their in-house R&D efforts.

Each level within the UoL at the pre-formative years (1999-2005) was looking for options for growing the scientific, research and industry collaborations through various forms of open innovation. During the interviews and in subsequent discussions as a participant-observer, the members of the CMD were very strong in their opinions of the importance of a hand-full of people that had a vision, fortitude and the stamina to see the process through to building the CMD. The importance of not just early champions, but persevering and committed people to see a vision through was one attribute of high-performance individuals cited in the literature review (Fletcher, 1993).

This extraordinary level of commitment, risk-taking and perseverance were descriptors that many of the study interviewees used to describe the pre-formation and formation days of the CMD. During the interviews, the names of the founding group of members were often invoked, and full acknowledgement of their perseverance was stated as key to keeping the interest and momentum going during the pre-formative years. Champions or sponsors of ideas are important to any project. The heterogeneity or varied multiple experiences of the individual is an important distinction as they are more capable of lateral thinking and doing (Deakins, 1996; Corsaro, Cantù and Tunisini, 2012).The makeup of the people involved in the CMD during the various maturation stages still exhibits this type of behaviour. In the study, it was often mentioned that the CMD was not a place for more normal or routine people, but for people who wanted to make a difference in materials science. The labels associated with people of the CMD were *'visionary'*, *'passionate'*, and *'highly motivated'*. The abilities and mission commitment of the key people in both partners of the CMD UIP was a large part of the sustaining vision and hard work that allowed the CMD UIP to be formed and operated the way it was.

> *The importance of management to encourage people to do big things. That is the biggest learning point, senior people backing these big visions; you need two types of people, the people at the bottom wanting to do this and have a vision and the senior people supporting and encouraging the organisation to keep doing it. - Senior UoL and Founding Researcher.*

It is these types of people who drive themselves for success and the need to succeed when others can't or won't do what is necessary (Hiltzek, 2000; Salkind and Israel, 2004). The early CMD Unilever researchers showed similar traits as Unilever began to reorganise the way R&D was conducted. The recruitment of more *'entrepreneurial'* and '*forward-thinking'* scientists also changed how Unilever viewed outside partnerships. Unilever became more reliant on open innovation schemes externally to produce R&D outputs (Bell, 2013b). Interestingly there was one very important scientist at Unilever who was very similar to his counterpart at the UoL. These two scientists interacted greatly and jointly on proposing ideas to both the UoL and Unilever very senior management.

At the end, when the topping off ceremony of the CMD was completed, the shared vision of the early champions of an advanced centre for chemistry compound discovery and development did become a reality. The eventual CMD that would grow from this early stage would make greater impact than anyone would envision when the process started. Having key people around you who become champions of that vision is important in making things become a reality (Deakins, 1996; Hiltzek, 2000; Nemiro *et al.*, 2008). This focus on recruiting the *"best of the best"* as one UoL senior executive interviewee stated was to guarantee that the people recruited would fully utilise the capacity of the CMD when it was formed and opened operations.

Throughout the life of the CMD UIP, the *'pre-chosen'* aspect had been prevalent. It is people doing leading-edge work with a very keen entrepreneurial attitude towards risk that continues to motivate those around them. These CMD people were highly entrepreneurial, self-starting, and visionary and had a strong work-ethic. They stated in the interviews that they would see work as play and everyone in the CMD wanted to work together to achieve what others wouldn't on their own... "*The importance of getting people together who want to do something special in chemistry is important. One important thing I learned about from this is you can't force people together to do this [CMD UIP]" - Senior UoL Founding Researcher.*

This multi-level management support was frequent interactions through more formal communications and meetings. The depth of interest and continued support by the Vice-Chancellor of UoL and the CEO of Unilever was quite surprising. When I interviewed the VC, he was very animated in his style of communications and very sincere in his support of the CMD partnership with Unilever. On the Unilever side, I interviewed senior executives that were leading the open innovation strategy that Unilever had been employing since the mid-2000s. The over-arching sub-themes that emerged were about how the people of the CMD were and how they ‘recruited’ or ‘prechosen’ future members of the CMD. This adherence to this element has stayed with the CMD in their selection of people who work in the CMD on a regular basis. Although I did not interview people who occasionally visited the CMD for a small experiment or two, I did get the sense from observations as a participant-observer that the full-time members of the CMD did self-police who used or interacted in the CMD.

The importance of the right people in the right jobs doing the right type of scientific work was often mentioned in the research interviews. When I asked about the selection process of members of the CMD on both UoL and Unilever sides, the general comments were *“each member of the CMD was the best in their field or topical area”... “All of our scientists share a common vision of the future of chemistry”, and who “wanted to do just only science in the most singular way” - Unilever Senior Research Manager.* This collaborative engagement and processual interplay helped to stimulate larger thinking, problem-solving and strengthen the bonds of engagement in innovation situations. The CMD’s design and operations were heavily dependent on the right type of people recruited, trained and given special access to the CMD. The policy at the CMD was to recruit people who would be inclined to: *“stimulate intellectual challenges”, (Unilever CMD Scientist)* and, whilst at the same time group-oriented enough to *“be collaborative so that the team’s outputs would be enhancing through cross-collaboration projects and interaction”, (UoL CMD Scientist).*

It also was highlighted in several interviews that [paraphrased into this one quote]

> *I like the CMD because everyone here is like me... a very good scientist in their right, but willing to still share and help all of us- the group" - Unilever CMD Researcher.*

As a participant-observer, I further explored these comments and found that people in the CMD were considered [according to their comments] creative, better at problem-solving and could focus on very complex problems. What I found was a positive and proactive environment of change through members of the CMD. The interactions with members of the CMD UIP seemed to thrive on the constant need to keep things moving and changing within the CMD itself.

> *One of the key things for me about the CMD is the people who inspire your work in the synthesis [chemical compound making]. It's about having the people to work within the CMD regarding expertise, mentoring and troubleshooting. - Unilever CMD Innovation Executive.*

The people theme emerged as the key enabler that brought the other categorical themes together. The environment and instrumentation themes emanated from the proactive direction and leadership of people. The importance of this interaction amongst members and the broad support given to each other helped to keep people in the CMD UIP motivated and focused on the scientific problems they faced. The CMD made People more willing to take on greater risk in the scope of the projects. These mechanisms found in creative teams can be quite powerful stimulators of this type of behaviour (Bercovitz and Feldman, 2011).

The findings relating to the categorical theme of people are summarised in Table 8. Each major finding that was sorted into the theme people were captured and illustrated in the middle column of Table 8 entitled '*key findings'*. The key findings are highlighted as they have an impact on each partner to the CMD UIP. The UoL perspective of the people and their impact/influence was captured in the left column under '*academic perspective'* and the Unilever perspective in the far-right column.

In summary for the people categorical theme, the role was very pronounced as people make up the key intellectual resource as well as the key resource of execution. This was not a surprising finding, but the level of involvement from the people was extraordinary relating to the commitment, time involvement, patience in the long durations felt in the pre-formation and formation stages of the CMD UIP. The key factors on the success of the CMD UIP relating to the people were the ability to find highly motivated scientists who had a strikingly shared vision and purpose in the objectives for the CMD UIP. This strong vision was an important linkage to establishing the CMD UIP and having a strong clarity of operational relationships and performance measurements of failure or success. The key people would be forever committed to a multi-level perspective, and this strong bond of partnership would grow stronger as time went on and successes continued to mount.

Table 8. Key Findings of Categorical Theme: People

Academic Perspective	Key Findings	Industry Perspective
	People	
Recruit key faculty, post-docs, entrepreneurial scientists who want to publish, make name. Formed special teams around certain projects. Used the CMD to recruit Post-Docs and Ph.D. students. Used the CMD people to bid on other tender schemes, and used same scientists for other proposals for new institutes like the Nano, MIF and Bioprocess.	Pre-selected participants. Hand-picked recruitment for specific work projects. Vetted Throughout life of CMD UIP. Used current CMD scientists and executives to recruit new CMD members. CMD members served as foundation members for new initiatives in UoL institutes and for larger specialized Unilever programs based upon success of CMD	Used as promotion. Develop high-potential employees. Selected long tenured and high experienced scientists. Kept project team's together year after year to build bonds. When special projects were initiated, current Unilever CMD scientists would recruit new members and put best people on complex problems.
Identification and selection of entrepreneurial faculty would increase research contributions for publishing, patenting and engagement with industry.	Participants were very driven and focused people. CMD participants exhibited soft rebellious attitudes, tenacious, self-motivating behaviors.	Strong, single focus on complex problems, no distractions. Move highly entrepreneurial employees into singularity of focus assignments for greater success.
University scientists seeking to gain entry into the CMD were mostly non-tenured and highly self-motivated to work hard together to advance each other's careers.	CMD participants were highly collaborative, positive attitudes, mentoring amongst members and would team troubleshoot lab situations.	Chemistry project teams assigned to the CMD UIP were highly collaborative and worked together for years and in certain technical areas.
Top university support for economic development, community prestige, access to government funding schemes. Success in knowledge-based industries allow for CMD expansion.	Broad organizational support. Both sides of management proactively worked on new schemes/tenders for joint benefits. Frequent participation from all key levels in each organization	Support from CEO downward made CMD top priority. Top employees strived to gain entry. Exclusive club mentality brought high motivation to CMD participants.
NCE discovery was important, but the increase in publications, patents and research funding was top priority. Access to industry was accepted along these attributes. Won several big tenders.	Output was HPIs, HPTs performing extraordinarily on consistent basis relating to discovery. CMD members serve as experts for new science initiatives.	Assignment of HPIs and setting up HPTs around key science projects was strategy of Unilever R&D in CMD UIP. Led to massive investments in new programs: MIF, Sensor City and Sustainability.

5.3.2. Categorical Theme: Environment

The CMD was located on the campus of the UoL in the large complex that was known at the time as the School of Physical Sciences. A separate and controlled operating environment was put in place to ensure that both academic and corporate scientists would take the mission of the CMD seriously. The CMD UIP was to work in partnership with industry to further academic research gains and publications while giving access to a larger group of intellectual knowledge resources of the university. The industry would benefit as the CMD, and any partnership would leverage the UoL talents, but the CMD was always meant to stand alone as a creative centre for materials science. An excerpt from an interview about the early operating stages with the CMD stated…

> *The facility [CMD], I remember the double doors and researchers wanted to come into the lab but were told that it was closed access, it wasn't an academic research facility that academics could walk in, and it was controlled access. The academics were outraged because of the brand new shiny equipment was locked. -UoL Senior CMD Scientist.*

The CMD members mentioned that their goal was to eliminate the distractions of the modern day university or company. The problem was spent time addressing needless distractions that would not allow any true focus on the science and the problem at hand. The CMD environment was set apart for all the scientists involved in CMD work. This was a strongly discussed element in the pre-formation stage of the partnership. The partnership agreement has mechanisms to reinforce and legally enforce the importance of the centre of the CMD's capabilities as the reasoning for the partnership to exist. The CMD has allowed these Unilever science-only employees an environment to use their skills and creative discovery while maintaining their independent streak.

> *I think it is an unusually good commercial - university relationship that over a five year period, with Unilever's prompt, the university created a place, a physical location which is a unique combination of laboratory, equipment and expertise that allowed Unilever researchers to go and use that facility to create what they needed to create in a way that was never done at Port Sunlight. – Unilever Senior CMD Research Executive.*

Unilever CMD scientists stated during interviews and informal interactions of having a strong loyalty to each other with a strong affinity or cohesion used to describe the bonds. There were high levels of trust amongst CMD members, and it was stated that the current group did a high level of vetting before allowing others to join their group. Sometimes the Unilever CMD scientists had been able to overrule corporate decisions relating to staffing at the CMD, citing their common bonds and performance records. Each member of the Unilever CMD project teams stated in related terms that the real success of the people at the CMD had an environment that fostered the science only focus and supported by outside senior managers as the CMD matured. A UoL senior executive the negotiated the original CMD UIP summed up the purpose of the laboratory environment being treated differently*…" true scientists doing true science"*. The Unilever scientists stated that their group was more entrepreneurial than the full-time corporate R&D scientists located back at Port Sunlight because each member was *"allowed to do science all day"* (Barr *et al.*, 2013).

The environment is also one of prestige and limited access. The CMD and the way the CMD UIP is operated within the environment are very structured regarding the laboratory set-up and instrumentation access. The CMD is comprised of main common use research labs that are used by both university and industry scientists, and confidential work is not usually conducted within these labs. The possibilities for mentoring or expertise interactions occur in these areas and also informally in the cafes that surround the CMD on the campus setting. Having a more commercial lab facility co-located within a university campus setting was mentioned by all of the Unilever CMD scientists in their first and second interviews as being important. The academic setting or environment was cited in over 75% of the Unilever CMD participants as being one very important reason for "feeling detached from corporate life" and "stirring more free-spirit attitudes" towards their focusing on the science-only part of the reason for being in the CMD.

For highly specialised or confidential work, there are sub-laboratories that have been set up to be used by university and industry scientists with pre-arranged and sorted time slots for no overlap between UoL and Unilever. For the mainstay of the confidential work conducted by Unilever, there were labs set up and operated solely by Unilever employees with no access to them by UoL personnel unless an accident or reoccurring inspections were taken place. These are access-controlled labs within the CMD to the parties who pay for them as part of the UIP. As stated by one of the operating managers of the CMD:

> *There was a good reason for controlling through separate access. We needed controlled access so only the partners could use, we had confidentiality to keep in place, and we needed to run it like a business and give a commercial feel to the laboratory. - UoL CMD Business Executive.*

The cultural aspects of the CMD UIP environment were described as being highly supportive. Depending on the problem, many CMD researchers would use mentoring and positive collaborative support to offer to other CMD UIP colleagues. In interviews members of the CMD UIP stated that when problems occurred, members would lend a hand, troubleshoot a design of experiments, or help to evaluate raw data. When problems arose, the person closest to the problem would act and support their colleagues. In over half of the responses during interviews, this positive styled collaborative interaction provided a unique support system within the environment of the CMD. This support system was stated as being part of the reasons that CMD members felt strongly aligned, will collaborate more, willing to take risks and share work closely with others because of built-up trust and support.

> *I think amongst ourselves we look out for each other. We are also not afraid to teach each other and ask stupid questions. I feel there is a strong community here [CMD], only one thing to do, science. – UoL CMD Scientist.*

This support system helped to keep projects on time and according to interviewees is one of the important differences of working within the CMD and the CMD UIP. The first-floor coffee lounge was a favourite place for laboratory meetings in secluded areas if discussions were confidential. If not confidential, the ability to be in an academic setting made the CMD scientists from Unilever feel more creative and uninhibited according to the interviews conducted and my informal interactions and discussions by being a participant-observer.

I think we are freer thinking. Entrepreneurial always means taking risks, and Unilever is an adverse risk company. CMD has allowed us to do things we haven't been able to do – Unilever Senior Researcher CMD Haircare Products Team.

For Unilever scientists, being able to take breaks and discuss with academic faculty broader issues in chemistry, experimental design, etc. offered an enhanced way to troubleshoot or think bigger about experiments than when they were in more confined and regimented surroundings like the corporate R&D facilities. When at the CMD, they could have lengthy discussions about basic chemistry issues or strategies in chemical design. When back at the corporate facilities, they only free time to think and discuss was over lunch and coffee breaks, both of which were brief and usually consisted of corporate topics.

The environment of the CMD and the CMD UIP made these situations disappear and was often stated by the Unilever scientists as a great benefit for them. Unilever scientists also frequently stated that many co-workers back at the corporate R&D facility thought that the CMD members were not part of the company. Being out of sight and out of mind was mentioned in a transcript excerpt above. In capturing the raw data and emergent themes during cycling of coding, many potential characteristics of higher performance environments from the literature started to surface.

In looking at the possibilities of the high-performance environment contains key elements that are common to environments and the environment processes such as open sharing of information, positive reinforcement of risk-taking, promoting a learning and collaborative work environments and the removal of as much noise (distractions) as possible to gain clarity of thoughts were some of the common thematic elements exposed in this study and related to selected literature reviewed (Fletcher, 1993; Jo and Joo, 2011; Katzenback and Smith, 1993; Mink, Owen and Mink, 1993; Nemiro *et al.*, 2008). The Unilever scientists exhibited a more animated façade when working in the CMD UIP.

> *I would say we are bolder in our experimentation. I would do things that I am not necessarily tasked to do. So the Friday afternoon experiment still exists here whereas in [Corporate R&D], I am not so sure it does. (Unilever CMD Scientist).*

People in these environments tend to embrace the positive inclination for risk and risk-taking as no more than learning situations (Jo and Joo, 2011) and that the environment itself, a core competency to leverage, (Fletcher, 1993), can be the difference in high-performance behavior such as risk-taking, fear of failure, willingness to work with others, sharing of new knowledge and diffusion of ideas in problem-solving; the health of the people is heavily surrounded by the CMD environment (Deakins, 1996; Glynn, 1996; Hiltzik, 2000; Isaacs, 1999; Katzenbach and Smith, 1993; Phillipe and Vallerand, 2008).

In summary, Table 9 presents some key highlights for the categorical theme of environment. Academic perspectives and benefits from the environment theme are presented in the far-left column and the Unilever perspective in the far-right column. The key highlights of the theme are contained in the middle column and provide the key sub-attributes that constituted this major theme. Some of the key highlights for environment were structured operating environment with controlled access. The environment had both common and specific areas that were equal in capability, but very separate in access to the resources.

Table 9. Key Findings of Categorical Theme: Environment

Academic Perspective	Key Findings	Industry Perspective
	Environment	
Opposite the typical university lab. Made entry into lab very prestigious, competitive. UoL general scientist vied for membership. University labs usually messy, instruments down and not efficient: this allowed for more lab production than most general UoL lab outputs.	Highly structured and controlled access to ensure 24/7 efficiency. Access controlled for pre-selected CMD scientists could maximize use of labs Use of state-of-the-art instrumentation was strict scheduling basis for optimal research lab use.	Protection of IPR, know-how and confidential activities. The environment also shielded Unilever scientist from all non-science activities so lab days were spent doing science. Constant training and immediate access allowed for very efficient use for conducting experiments.
Access to state-of-art equipment allowed for faculty recruitment regarding top PIs, Post-docs and collaboration with industry. Resource planning by top PIs for their people was made easy and allowed for more publishing and patenting.	Separate, but equal in access. Specialized equipment was in dedicated lab space and access tightly controlled, but available to all CMD. More general, state-of-art equipment was in dedicated, but shared space in CMD.	Allowed access to state-of-art resources equally, but the separate parallel environment allowed for protection of IPR and strict scheduling to maximize researcher time at bench.
UoL scientists and CMD personnel had access to industry scientists to understand what industry was like. The labs in CMD were more like industrial R&D labs and this helped to organize UoL scientists in their experimental work.	University campus access provided to all CMD UIP members. Use of non-lab . facilities permitted.. Campus access created more relaxed and productive environment for CMD scientists.	Unilever CMD scientists felt like they were back at university with more freedom to think and relax from the corporate daily grind. Scientists found a lot more time for creative thinking and planning of experiments.
Full-time laboratory focus and released from all other university duties when in CMD project mode.	Singularity of focus on science only	When in CMD, only science. No distractions with email and company meetings.
Mentoring of younger HPIs in the university by older or more experienced HPIs or PIs in the CMD.	Highly team oriented, positive, collaborative culture within the CMD between UoL and Unilever.	Teams were rewarded for CMD output by the Unilever R&D. teams would have longer assignments and greater support for success at CMD.
University researchers gained more access to people through the CMD events and projects. Faculty had more appreciation for industry perspectives and access to future project supporters.	Broad access to university environment for members of the CMD. The lure of creativity of a university environment influenced CMD members.	Provided a greater creative feel to work and knowledge spillovers through informal discussions and attendance at university events.

5.3.3. Categorical Theme: Instrumentation

As with any tools of the trade, the better the tools, the better the potential outcomes could be. At the time of the formation and early operating phases of the CMD UIP, materials science was still nascent as a major contributor to new chemical compounds. NCE discovery techniques were rudimentary and the computer science behind the processes crude (Devlin, 1997; DiMasi and Grabowsk, 2007; Adams, Brantner, 2006). As *'instrumentation'* contains both science and technology resources, they must work together. The CMD includes equipment that can take raw chemicals and run a process that will make new chemicals on a variety of size scales. Smaller size scales for initial proof-of-concept work. Larger scales for working out process development problems along the way to a full manufacturing process once the compounds are commercially-viable and ready for sale.

The processes also require a lot of computer science work (mathematical modelling, 3D computer visualisation). The initial NCEs developed are early manufactured small bulk chemical compounds. The small bulk NCEs are later tested and analysed for their chemical properties to assess whether they are suitable for use in the desired applications or products. These chemical manufacturing processes are known as chemical synthesis, and the process of making the NCEs is as important as the designing of NCEs for synthesis. This makes NCE discovery a very slow, expensive and high-risk process (DiMasi and Grabowsk, 2007; Owens and Hopkins, 2016).

With the advent of these new tools for synthesis in the laboratory, chemists can now produce what would take weeks or months of work to maybe yield 4 or 5 potential chemical compounds and do dozens of compounds in a week. This is why one CMD participant in their interview stated that *"Playing with instrumentation that is state-of-art and not widely available to most scientists will make all the difference in success or failure"* - UoL Senior CMD Scientist. The instrumentation of the CMD allows for leading –edge material science to take place. This instrumentation is the top tools one can use to make chemical compound discovery, and this can translate into new papers to publish, discoveries that lead to new funding schemes and research status recognition by other top-class research universities. For industry, access to this type of instrumentation means that risk of discovery and development may be lessened and the ability to stay competitive in R&D.

To have the leading-edge capabilities, you need these state-of-the-art instruments just to start to compete. So it is not the instruments alone that seem to make a difference in this CMD UIP, but other elements that I discovered during the study. One of these features that I believe is more unique to the CMD UIP was the way in which both the facility environment and instrumentation were used.

> *The CMD partnership was built around the physical assets almost as much as the intellectual assets. Those intellectual assets are closely associated with the physical assets, the labs and the equipment. That's what Unilever has accessed. We were happy separating various labs based on functions and levels of commitment and confidentiality. – Senior CMD Unilever Scientist.*

They were placed in common area laboratories and also in Unilever-only restricted laboratories. The CMD UIP and centre were setups as key laboratory areas that served as a series of platforms of instruments. These 'platforms' would allow for more flexibility of use and gain more utilisation. The CMD UIP became a place of collaborative partner capabilities. These capabilities were used for different reasons by the partners but had the same desired outputs, NCE discovery. Unilever's key new businesses were diverse from a chemical compound discovery viewpoint. This materials science difference made NCE discovery different for the products groups within Unilever. The key benefit of the CMD UIP setup and instrumentation was the versatility of the capabilities and use of the instrumentation contained within the CMD. One of the key UoL business executives who negotiated the CMD UIP said during their interview:

> *I think the reason CMD worked well is that it was a facility which is platform technology in the true sense of platform technology. I could turn up and use the robotic platform for fuel cell technology, and someone else could turn up and use it for paint; someone else could use it for cosmetics, perfume, washing powder. The platform allows you to control chemical environments for characteristics of new materials. And because of that, all of the types of companies could participate (UoL Senior Business Executive).*

I also discovered that the instrumentation used in the CMD UIP was modified to meet certain needs that were designed into the overall workflow of the chemical discovery and characterisation processes. These proprietary modifications were part of the research work by the partners. This highly structured and regimented approach to instrument usage allowed the supporting personnel to keep the instrumentation up and running more than average industrial or academic laboratories.

The last remaining factor contained within the instrumentation theme was the benefits of industry partnering with academic institutions as they related to corporate finance and accounting treatments. The instrumentation contained within the CMD UIP was the property of the University. The University was a non-profit entity with access to government funding. The government funding came through grant tenders that promoted economic development and advancement of sectors of knowledge. These 21st-century sectors were keen areas of government support. The sectors also were young, and their growth was yet to blossom. The funding for the CMD UIP over time established the CMD as a centre where foundational science and technology would originate. The creation of knowledge for commercial gain would come from the COE

The acquisition of the instrumentation was key to keeping a competitive advantage in science and NCE discovery. The process of keeping the resources current is of great importance. How instrumentation is acquired and paid for is different for the UoL than it is for Unilever. When this highly expensive instrumentation is acquired, it will require constant upgrading to remain current and provide state-of-the-art capabilities. In the university setting, instrumentation is usually acquired through some form of a tender where the equipment is paid for with grants, endowments, other types of gifts or government economic development schemes. In all cases for the university, the cost of the capital of the equipment is usually at the time of acquisition. This presents some very important advantages for the university-based UIP.

In this case, this became a very big motivator and differentiator for Unilever. With companies, usually, instrumentation of this magnitude will consume budgets, so these expenditures are usually treated separately from the daily operating budgets. These less many budgets are sometimes referred to as capital expenditures or CAPEX. This CAPEX requires companies to amortise or write-off the value of the instrumentation over some years. Companies are also more profit driven and require their departments to adhere too tightly controlled budgets. For Unilever to stay always at the top competitively with the ability to perform HTS research and development and to constantly upgrade to keep that advantage would not be operationally or financially feasible. Universities, on the other hand, do not recognise profits the same way and through the use of both private and public monies can acquire needed instrumentation and also keep it up to date. A selected excerpt from a higher level executive at Unilever outlines the mutual benefit for both the university and the company when a UIP can structure its partnership to be a 'partnership of capabilities' not just a' partnership of intellectual know-how':

> *However, the investment atmosphere within companies into scientific equipment is not ideal. Because what you have is this dual problem – you have financial depreciation and a scientific depreciation, and the two of them don't run in parallel. So financial depreciation is 'well we spent these million pounds on this NMR [Nuclear magnetic resonance spectroscopy] machine, and it depreciates over 14 years, and in 14 years' time you go and buy you a new NMR machine. From a scientific point of view, after three years you are wiped out.' So that's why you don't do it in-house. So, which organisations have a completely different model for capital depreciation? The universities do. Because they get a lump sum of money to go and spend on their better kit and that's job done, that's finished, right? Completely different model. So they don't have to worry about economic depreciation because they bought the thing outright. So, what happens is, you go into a different environment, you go to a university and say 'hey why don't we co-create this capability where you're going to buy the capital equipment and effectively, so that means for Unilever, zero depreciation problem, you are going to invest in capability*

development around that and you are going to staff it up, the bits are common to what you need and what we need, and we will, next lap, put our own laboratory and our own staff and will get access to it. From that point of view alone, that's probably worth doing. - Unilever Senior Innovation Executive.

That senior executive of innovation at Unilever summed up the success of the CMD UIP for Unilever R&D NCE outputs regarding the use of the strategy of laboratory capabilities of research over just intellectual ones.

Well, in the first five years of the CMD we doubled the patent output per researcher. Ten times the speed of activity, seven innovations to market, and two significant platform technologies in polymer science by what we've done. That, by any stretch of the imagination, is a fantastic output. On top of the investment that we've made and the kind of local government, or local EU government investment, there has been great leverage of additional grant from into that. So the CMD has been a fantastic set of results. - Unilever Senior Executive.

In Table 10, I present a summary of the instrumentation certain theme. The key findings are interesting in that the use of the instrumentation was similar from a science standpoint, but how the instrumentation was set up and accounted for was different for each partner. The science knowledge factor depreciates much faster than the financial business depreciation: it more like months for science than years for the CAPEX financial write-offs.

Table 10. Key Findings of Categorical Theme: Instrumentation

Academic Perspective	Key Findings	Industry Perspective
	Instrumentation	
Goal with the formation of CMD was to expand the chemistry, physical and material sciences offering for the UoL. Founding scientists envisioned building a large combi-chem capabilities for leading-edge work and publishing. Senior UoL executives viewed the CMD as growth of the redevelopment of Liverpool and worked to establish centers of excellence for chemistry. Since the CMD, the success has spawned other institutes like the MIF, Bioprocess, Stephenson Iinstitute. With leading-edge equipment, ability to perform top level experiments increases odds of better papers, more potential patents and increases recruitment probability of top researchers.	State-of-the-art equipment that is regularly updated with government-backed technology and economic development schemes. The latest kit is always available with on-going training. The instrumentation was physically set-up in a footprint that allowed more common work to be done in one place and collaborative discussion. The more confidential work had restricted access. The types of equipment allowed other related areas of the Universisty to access and collaborate with CMD scientists.	Allows Unilever R&D scientists to access the most up-to-date and state-of-the-art equipment a chemical scientist could have. Allowed for no limitations on lab capability, but shifted the challenges of experimental designs to the mind of the scientists. Very important point is the instrumentation of the CMD is a partnership of capabilities and not as much a partnership of intellect with UoL scientists. The access is there, but the main focus is more enabling and seminal science.
Utilizing the CMD UIP as a center of excellence for HTS chemistry compound discovery was first tender mandate. With the success of CMD came greater government funding and lessen the CAPEX burden for the UoL and allowed the university to gain greater competitive advantage.	No CAPEX burden for initial acquisition and regular updating to stay current with marketplace. Government funding schemes provide for continued advancement of laboratory instrumentation capability through creating center of excellence based upon early operating success of CMD.	Equipment in industry has to be amortized over years and limits the purchase of new equipment regularly. Access to top-level equipment lessens the risks of obsolescence, and allows greater risk-free projects to be undertaken if CAPEX issues not present.
Key university projects and collaborations were part of CMD and had access to best equipment on campus. CMD laboratories were more efficient in costs and operating scheduling.	All instrumentation controlled access, frequent updates and periodic maintenance. Users have strict access requirements and equipment is top shape versus normally limited academic lab equipment.	Schedule researches experiments weeks in advance and guarantee to have uptime access and follow-on scheduling for additional research back at Unilever R&D. Maximize resources and use of project timelines.

5.4.4 Communication

The communication system/processes of the CMD UIP were one of the first areas of discussion when UoL and Unilever sat down to design a CMD and the corresponding UIP. Both parties agreed that communication was very important and without good communication policies, systems and dialogue at all levels the partnership would be doomed in a few years. This was based on experience on both sides with other UIPs they had been part of and failed. Communication is critically important for harmony, trust and relationship building. Further communication is the simplest form of building common understandings and connections. These common elements lead to building trust and commitment for the current, but also for the future. Communication was an important categorical theme throughout each stage of the CMD UIP's maturation (Fletcher, 1993).

Communications has two direct benefits in a UIP: 1) The role of human interactions over time will build trust and interpersonal relationships that form will drive better interactions and, 2) communication amongst all members of a UIP will create more operating efficiency and more informed decision making (Fletcher, 1993; Katzenbach and Smith, 1993; Barbolla and Corredera, 2009; Ankrah, *et al.*, 2013). During the discussions on the business issues before entering into the legal drafting of the final agreements that would form the CMD and formalise the CMD UIP, both UoL and Unilever laid out several areas in which communications would have to be the primary driver of UIP interface. The main areas of focus was 1) governance and dispute resolution, 2) Strategic communications that would be used for new project initiatives, new funding schemes and communication to other interested stakeholders who could support and grow the CMD UIP, 3) operating communications that oversaw the daily operations, access policies, training and updates communications and 4) scientific communication policies between scientific members of the CMD to ensure confidentially, protection of IP rights.

To accomplish these requirements, communications was written into the legal and business agreements. There would be a senior steering committee that would comprise top executives from both organisations who would deal with more complex and strategic issues relating to the CMD and the UIP. As new funding tenders were identified by the principal investigators, the senior steering committee would meet on a regular basis to discuss and decide how best to continue improving the CMD. At the operations level, all parties to the UIP are engaged and working together for the benefits of the UIP. An operations team made up of both parties would meet weekly to go over operational issues in the CMD and in running the UIP. This weekly meeting would be where issues or suggestions would be made to improve the CMD.

During the normal course of daily operations, there would be problems relating to equipment operations, scheduling conflicts, personnel issues and other operating issues. In these situations, a joint advisory board and an executive committee were set up to operate and settle disagreements between members if they could not be addressed properly in the weekly meetings. On a quarterly basis, the steering operating committee would meet to discuss issues and potential additions to the CMD and the UIP.

In instances of stalemate, an executive committee was formed with the senior executives of UoL and Industry to discuss and negotiate compromises and satisfactory outcomes. The role of communications has been instrumental in building a cohesive working environment. During the interviews, it was mentioned frequently how the open and positive nature of the CMD led to a building up of trust and open communications. The large extent of the system of communications should also be noted in the CMD UIP. With every level of the two organisations involved in some form of team or committee, the ability to genuinely improve the CMD UIP led to both a very successful operating environment and also to the sustainability of the working relationships. As each member who was working in the CMD was personally recruited by the CMD UIP management, you could screen out potential problems that would negatively impact the CMD.

Teams that produce extraordinary outputs tend to be very similar regarding personal attributes and relational processes (Hinds *et al.,* 2000). As the CMD functioned as a unit, the decision-making was done by those closest to the situation. The trust and positive working relationships built through the honest and open communications allowed for an exceptional distributed leadership to form inside the CMD. One of the positive attributes in high-performance groups is the ability to have distributed leadership and decision making by those closest the situation at-hand (Fletcher, 1993; Katzenbach and Smith, 1993; Nemiro *et al.,* 2008). Each member of the CMD would make decisions that would help the CMD improve, and these interactions were daily and very timely. It is noted that the members of the CMD felt like they could share any information with the other members of the CMD. In Table 11, I present key finding for the categorical theme of communication. The University perspectives as it relates to communication are presented on the left and Unilever on the right side of the table.

Table 11. Key Findings of Categorical Theme: Communication

Academic Perspective	Key Findings	Industry Perspective
	Communication	
Partnership management was streamlined. Small and large issues were dealt with quickly through regular and open communication channels. CMD was highly supported from senior management. Problem/dispute resolution was handled through joint operating committee. Operational issues handled by joint laboratory operations team and interacted on a regular basis.	Comprehensive communication systems put into place with CMD stakeholders. Communication was at CEO – Vice Chancellor level for top-level performance and management of large issues. Communication was daily, organized and reviewed to ensure all issues were address in timely manner. All communications from CMD groups were jointly shared between UoL and Unilever.	Partnership management was streamlined. Small and large issues were dealt with quickly through regular and open communication channels. CMD was highly supported from senior management. Problem/dispute resolution was handled through joint operating committee. Operational issues handled by joint laboratory operations team and interacted on a regular basis.
Universities can be very vertical in relationship building and silo-oriented in collaboration and communications. CMD university members understand the importance and benefits of collaborative sharing of work and ideas. Very proactive communication across the UoL and with industry	Executive and Steering committees were setup to lead the UIP. Operating Committees were setup to ensure daily efficiency. These group meetings were used to resolve disputes, plan for new projects and to eventually plan for the expansion of the CMD UIP concept.	Broad company support for the CMD and the general operations. After first five year operations were successful, a renewal of UIP occurred in 2012. The CMD has been used an example for other UIPs. Unilever and UoL have launched greater UIP called MIF and opens in 2016. UK Plc success.
The general labs of the UoL were like most labs, messy, not well organized and resources not maximized. The communications, policies and operation promotions of the CMD make it special.	There were policies for every aspect of the CMD and the CMD UIP relationship. The polices had to be followed or CMD members would not be allowed access to the facilities.	The structured nature of the policies ensured everyone knew their place and how to run efficiency. The center was considered a privilege to work in not a right. Communications were that way.
A very supportive and collaborative tone between all parties and members of the CMD UIP. This allowed for candid discussions about problems and also allowed for more future planning.	All communication was open channels, positive, supportive and collaborative when issues arose. The frequency, candor and overall relationship in communications were very high.	A very supportive and collaborative tone between all parties and members of the CMD UIP. This allowed for candid discussions about problems and also allowed for more future planning.
The positive nature of the overall communications and relationship has allowed the UoL to leverage the success of the CMD and gain other tenders for new UIPs. The research element has been enhanced with new impact papers.	There was a very proactive and full effort to make aware what the CMD was doing for UK PLC, the Merseyside Region and for the science & technology sectors of the UK	The CMD has been a success for Unilever in NCE output and commercialization. The open innovation model Unilever is employing requires more of these type of CMD UIPs.

5.3.5 Categorical Theme: Business and Legal

Some of the greatest issues that UIPs face concern both legal and business issues that are not well defined during negotiations in the pre-formative stage, and which then create the main reasons for failure of UIPs other than the science or core technology deficiencies (Reams, Jr. 1986; Cummings and Teng, 2003; Wesser, 2003b; Fontana, Geuna and Matt, 2006; Steger, *et al.*, 2008; Smith, 2009; Thursby and Thursby, 2011a; Thursby and Thursby, 2011c; Thune and Gulbrandsen, 2014; Wilson, 2012). The issues that are frequently reported that contribute to UIP failures are: lack of scope or definition of the work of the UIP; levels of commitment in terms of financing, science contributions or resource allocation; control, decision-making and tie-breaker voting to settle decisions or disputes; continued funding scopes, competing interests, breach of confidentiality, patents rights, indemnification and hold harmless provisions and potential conflicts of interest with university researchers (Reams, Jr., 1986; Gray, 1989; Prigge and Torraco, 2006; Boardman and Ponomariov, 2009).

Interesting the legal and business aspects of the formation of the CMD were conducted completely different than most UIPs. The attention to detail with the business issues would be was sorted out long before lawyers become involved. The joint UoL and Unilever teams met without lawyers to walk through and discuss every possible facet of the CMD that was envisioned. The length of time would have forced many discussion to dissolve, but both parties had a vision (HTS chemistry discovery), a motivation to succeed (UoL was built a chemistry center of excellence and Unilever was outsourced chemical compound discovery to yield better results for new product development) and people on both sides who liked each other, believed in the CMD vision and had the patience to sort through all the potential issues.

Some of the greatest issues relating to UIPs with legal and business are around intellectual property rights and confidential information and know-how (D'Este and Patel, 2007; Perkmann and Salter, 2012; Prigge and Torraco, 2006). All legal work regarding operating structures, access, intellectual property (IPR), dispute resolution, and distribution of revenues, ownership and other administrative issues were dealt with in a very comprehensive and fully engaged process between UoL and Unilever. The legal strategy for the CMD UIP was to work through, exhaustively, all business issues before engaging lawyers in drafting documents (Business Department, 2013). The importance of this planning before doing is very important as it allowed the CMD and the CMD UIP to operate more efficiently.

This approach also allowed a well-thought process to be put in place to handle any issues that would come up. This process was used for both tactical as well as strategic issues and decision-making. Both UoL and Unilever met on multiple occasions to discuss the concept of the CMD and how it would function technically. To deal with the IPR, the CMD was structured to control access to working laboratory areas. With very specialised lab work, the laboratory would be set up for either Unilever or the UoL and used by those scientists only. In a separate, but equal way access was controlled and organised so that highly confidential work could be conducted while other groups worked alongside.

The process before lawyers lasted for seven months, and an exhaustive list of potential issues was drawn up. A mutually agreed upon process for addressing the issues has been laid out as well. With the positive and open communications between both parties, it now is much faster to make changes to the operating plans than when it first started in 1999.

From one of the early founding negotiators of the CMD… *"Looking back, it took 7.5 months to negotiate this, and it was not because we were not paying much attention to it. That was with full focus" (UoL Senior Business Executive).* The depth of the focus on both sides of what was needed for the CMD to operate successfully was quite surprising from the field research. An excerpt from an interview with another one of the early founding members of the CMD who negotiated the UIP and is still with the university and involved with the CMD said…

> *Because we put so much time and effort into planning it, at the very start, getting the contract right, getting that access agreement right. Everyone knew what we had to do. When you got the people on the ground [after it was formed and started operations], they were relaxed, and how things needed to be operated. - UoL Senior Business Executive.*

Operating governance, a structured operating environment, strict policies and procedures were all put in place to ensure restricted access, consistency of services and quick resolution of potential or actual problems with the CMD. The business teams from both UoL and Unilever work very closely together to make sure all facets of the CMD facility and the CMD UIP function properly and the maximum is extracted from the CMD for both sides. A top-level executive committee and governance committee govern, guide and financially support the future mission, vision and directions of what the CMD is and how the CMD UIP model can be made ‘portable' to other UIPs that UoL and Unilever want to pursue.

The current CMD operating committee and strategic board oversee jointly the CMD UIP and this has allowed all problems to be addressed and all opportunities to be discussed. An excerpt from one of the executives in the CMD UIP:” *What has followed from CMD is we have a partnership agreement with Unilever, which has a strategic board with three members from them and three from us. What are you going to do in 5 to 10 years' time? If we can align and it makes sense, then we will" (UoL Senior Business Executive).*

To handle any administrative issue or to address items that needed to be decided upon, various joint teams or committees were setups to address a particular situation. In each case, the business and legal issues were laid out, discussed and then put into either a tactical plan document or in the annual strategic review document. All legal issues or potential disagreement areas where listed with a business process and outcome protocol. For very strategic issues, a joint steering committee was set up that included the Vice-Chancellor of UoL and the CEO of Unilever along with the senior staff of both organisations. In Table 12, I present the key highlights surrounding the categorical theme of business and legal. The perspectives of both partners are also presented in the table. The key for the business and legal was the ease of pre-formation and formation of the CMD UIP as there was a deep understanding of what both sides wanted through mutually shared vision, purpose and clarity of objectives and outcomes.

Table 12. Key Findings of Categorical Theme: Business & Legal

Academic Perspective	Key Findings	Industry Perspective
	Legal & Business	
Key issues addressed were access to equipment, full utilization of CMD capabilities to retain and access new government funding. UoL required Unilever to fund and support during life of UIP and support new tenders for expansion of CMD UIP.	Shared common goals were well thought out and thoroughly discussed as part of very first discussions. No rush to get deal done. Both UoL and Unilever saw the CMD UIP as a serious and long-term obligation in open innovation.	Key issues addressed were IPR, access to equipment and key PI university personnel. How UIP would be maintained was important as this was Unilever's R&D open innovation Strategy.
University had numerous milestones to meet based upon government funding programs to establish the CMD. CMD needed a key industry partner to secure necessary funds to form CMD. The partner had to be in the long-term relationship as part of the UIP. Key elements that had to be in contract were laid out as part of the CMD founding and made clear to participant if entry was granted. Business issues were first to be presented, in plain English.	Business first, then legal discussions. All business issues were worked out before any lawyers became involved. Initial CMD agreements took 7 months to finish with first 4 months only discussions with business people. Each side worked daily on sorting out all potential issues with all facets of science, operations and governance. This agreement contained special and original legal provisions that most agreements don't contain. Many of these provisos are protected under NDA and can't be disclosed in this thesis. The elements will be discussed.	Outsourcing of R&D through Open Innovation initiatives created a greater need to control the work conducted off-site. Access to capability and know-how was important along with protection of new discoveries and the building of new IPR. The business issues were critical to get right and dispute resolution was paramount. Unilever was risking its market competitiveness if the NCE output didn't improve.
Separate, but equal access structure allowed for Unilever to feel comfortable on IRP. This allowed Unilever to contribute substantial money for CMD and this stimulated UK government support for CMD. Operating efficiencies were also gained in the UoL.	IPR and confidentially dealt with upfront, creatively and used CMD environment, operating structure and access to protect IPR under the 'separate, but equal' approach. The form of the UIP as a partnership of capabilities with some UoL interactions made this easier to also control.	Key HTS chemistry work was setup in a separate CMD lab to ensure that IPR and confidentially of work would be protected. Efficiency of putting to work resources was gained with the separate, but equal structure.
Each section laid out with both sides requirements well throughout. Discussion was collaborative on both sides as 'legalese' language, sometimes creatively drafted.	Agreements were about quality not speed in negotiations. Creative and original language and mechanisms were put into as much about 'intellectual' resources.	Each section laid out with both sides requirements well throughout. Discussion was collaborative on both sides as 'legalese' language, sometimes creatively drafted.
The seriousness of the CMD project was supported from the top of both organizations. Very senior people teamed with key middle-level people made sure all issues were addressed and correct decisions made early-on. The success of the CMD and the way it was formed, operated and leveraged has spawned several other massive science and revenue-generating programs with UIPs.	Very experienced people involved who had full authority over decision-making. Every level of both organizations was involved in the formation, operations and future planning. The frequency of interactions was daily for mid-level and below and one to two times a month minimally for the senior executives of UoL and Unilever.	The seriousness of the CMD project was supported from the top of both organizations. Very senior people teamed with key middle-level people made sure all issues were addressed and correct decisions made early-on. The was part of the Unilever CEO's open innovation and sustainability company mission to growth the revenue of the company.
Open, positive, collaborative, frequent communications established great relationships	Daily to twice weekly meetings to keep momentum during early phases and establish group bond.	Open, positive, collaborative, frequent communications established great relationships

5.4 Cross-Cutting Global Themes

There were five categorical themes that emerged during the study. These categorical themes provided insights into success factors for the CMD UIP. For example, an insight from the categorical theme environment was the importance of having controlled access. This controlled access allowed the physical CMD setup to be used to address how people work, how instruments were accessed and how the scientific experimentation was controlled through the use of the environmental aspects of the CMD UIP. The categorical themes also helped to orientate key components that made up each theme. An example of this orientation was the key finding that the use of the instrumentation was state-of-art, but in of itself, this didn't provide any tangible benefits to the UIP that other UIPs could have.

The orientation discovered was the importance of positioning the University as a growing globally competitive top research university that needed to stay current with the rapid pace of advancement in the field of materials science. This keeping pace with instrumentation and funding came from the COE model and standing the CMD had developed. The COE was the way the UK government looked at the city region of Liverpool as an emerging leader in chemistry, materials science and nanotechnology. As part of this coding process, several underlying sub-themes evolved. The process of coding is very dynamic and not linear process. Upon each cycle of coding and refinement through clustering, certain elements continued to present themselves in each refinement of the development of the categorical themes. From the early stages of open coding to the more refined axial coding, certain cross-cutting emergent themes developed that permeated through each of the five categorical themes. In Table 13, I illustrate an example of this new global theme development. In the far left column titled 'Cross-

Cutting Emergent Themes Development' are excerpts from the raw data of the interview transcripts. In this far-left column you will see threads of key descriptors that lead to instrumentation or people in the categorical themes such as ‘instrumentation key to top research work' or the transcript comments regarding restricting access like ‘more structured than typical university spaces' or partnership access rather than ‘buying instrumentation' and risks associated with building capabilities and funding gaps. This progression from the larger sections of the transcript to the refinement process can be seen in the middle column of Table 13. These global themes cut across the five categorical themes and provided greater richness, insights and refined definitions of success factors for the CMD UIP.

Table 13. An Example of Coding and Clustering of Global Vertical Themes

Cross-Cutting Emergent Themes Development		Global Vertical Themes
• Separated resources, but sometimes shared • Each has own space and instrumentation • Common areas for sharing capabilities • All CMD access is separate, but equal in use	→ Separate, but equal → Sharing common resources	**Separate, but equal**
• Equal science capabilities, separate access • Structured environment, dedicated resources • Collaborative interactions between partners • Instrumentation key to top research work • Access rather than buy instrumentation provides access to state-of-the-art, lower risk/cost than buying for Unilever • University more structured than typical university spaces	→ Separate, but equal → Collaborative → State-of-art instruments → Recruited, dedicated staff	
• Quality, richness of science time (6-8 instead of 1 daily) • All CMD like me, medicinal chemists • No distractions with other ‘corporate duties like Port Sunlight	→ Science only focus	**Singularity of Focus**
• Allowed to be science creative • No distractions from industry staff • All day spent on chemistry structures • CMD experience different than Company • Structural chemistry resources everywhere • All day spent doing chemistry design, reading and designing	→ Science only focus → Allowed to do science only → Structured & focused environment → Results/outcome focused	

5.4.1. The Global Theme of 'Separate, but Equal'

In the phase of the engagement, both partners gained from the use of a shared facility. This advantage was the leading-edge capability to create chemical materials as good as anywhere in the world. This capability comes from the continued advancement and upgrading of the instrumentation that is used by the CMD UIP. The *'separate, but equal'* theme provided both partners complete access, benefit and leverage from the CMD and managed the downside risks of science, technology, finance and marketplace. The separation is an enabling feature of the global theme as it demarcates, positively, those items that usually create great problems in UIPs. Some of these problems were confidentiality, creation and diffusion of IP and sharing of financial costs and burdens. The *'separate, but equal'* was also a key strategic tool for policy considerations for governments funding COEs and for academic institutions seeking to gain COE status and capabilities.

In Table 14, I illustrate the ring-fencing of resources, processes and capabilities of the CMD UIP. This demarcation was sole to give each partner equal access and capabilities. The separation was to ensure that when researchers in the CMD conducted their research, they could maximise the quality and quantity of time spent working on just their chemical compound issue. This provided a situation whereby the CMD UIP researcher could acquire as much as six to eight hours daily of structural chemistry-related work if they chose to. This created situation by this thematic approach would be impossible to do in a more traditional R&D lab where there would be a myriad of distractions and limited time spent doing work by the cross-sharing of resources.

Table 14. The 'Separate, But Equal' Global Success Theme of CMD UIP

UoL Researchers

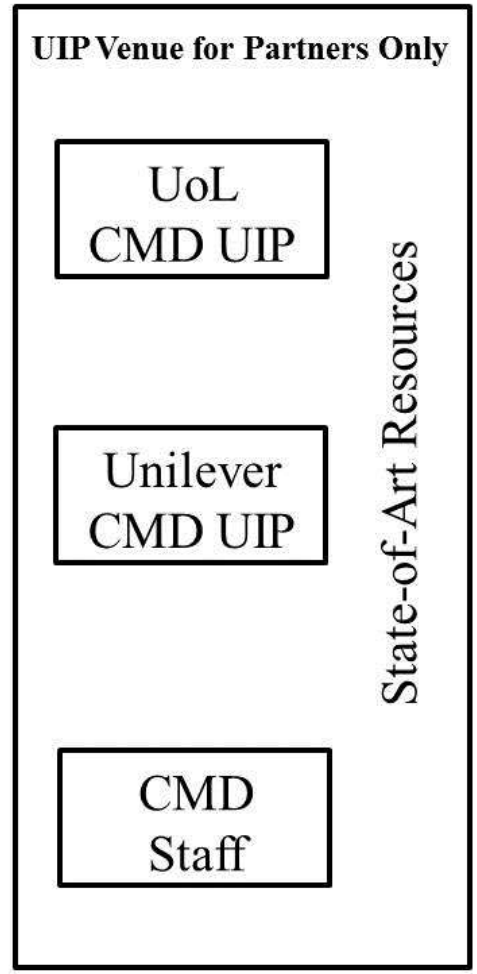
- CMD dedicated work
- Highly trained
- Specially recruited
- Focus: chemistry only, one project

Unilever Researchers

- CMD dedicated work
- Highly trained
- Specially recruited from senior R&D chemists
- Focus: chemistry only, one project task at time

CMD Professional Staff

- Full-time, dedicated workers
- Executive researchers background in laboratory operations, materials science and computational chemistry
- Managed CMD operations, scheduling and problems
- Worked like project mentors and general collaborators



The separation of efforts supports the needs and operations issues of both partners by allowing equal access, but under physical demarcation and processual guidelines. This is a highly important distinction and allows venues (environment and instrumentation) to become COE and provide additional capabilities to more than one industrial partner. Government funding schemes in the past have provided funding to individual companies and not an academic COE partnered with an industrial company. The funding of individual companies cost more, is more inefficient and harder to manage because of the redundancy of the governmental efforts. In the case of the CMD UIP, the establishment of the CMD and UIPs from the CMD allow for greater use of the COE and the capabilities of the CMD. The establishment of the CMD as a COE also utilises the public funding schemes more effectively.

5.4.2. The Global Theme of 'Singularity of Focus'

The *'singularity of focus'* allowed all the CMD scientists to focus solely on their work. The singularity theme permeated through the categorical themes of people, environment, instrumentation, and communications and business/legal. The people that worked together in the CMD were grouped by the type of chemistry being pursued according to the type of NCE compound characteristics being sought (i.e. the hair care products researchers were together and not working with the cleaning product detergent researchers at Unilever). In Table 15, I illustrate the key themes interplayed with this global theme. All the CMD researchers were structural design chemists, but the compound family structures they worked on had distinctly different chemical properties. This would force the different R&D groups at Unilever to conceptualise and design experiments differently as the hair care NCEs would function differently than the detergent products. This provided a relationally focused and singularly common perspective of the chemistry problems and functional elements being sought.

There were issues of useable NCEs coming out of Unilever's R&D facility at Port Sunlight. The potential negative impact of a typical R&D environment without some separation of research and researcher functions is not readily obvious. In Port Sunlight, the researchers in chemistry had very different backgrounds in science and new product development experience. Like most industrial R&D companies the research projects were formed into multi-faceted teams with a varied background in science. This is done mainly to have some *'team synergy'* in the various components of developing a new product such as haircare shampoo. The chemical researchers would comprise the early and more creative design structural-oriented researchers teamed up with chemists for compound characterisation, process development chemists working on scale-up issues for manufacturing. Combining these types of chemists to focus on NCE discovery would not have the same approach, feel and think that only a group of design organic chemical trained researchers would have regarding NCE discovery. One reason in industry that this singularity of focus is not done is the financial increases in costs and redundancy of efforts as viewed by some industrial executives.

Table 15. Global Theme: 'Singularity of Focus' Processual Influence on NCE Discovery

Categorical Theme	Global Theme Influence on NCE Discovery
People	• Very senior, entrepreneurial and collaborative scientists • Only one type chemist: structural design chemist to create NCEs • Dedicated to the CMD for all their research work, no dilution of effort or workplace • Rewarded with extra perks for being at CMD, treated special
Environment	• Science-only focus, no other activities but NCE discovery related • All laboratories focused on being restricted access, structured research operations • CMD researchers were allowed to spend six to eight hours a day on NCE work • All work spaces were designed to fit common or special lab work, separated to allow the CMD researcher to devote as much time as necessary to NCE work without interference of others
Instrumentation	• World-class capabilities via state-of-art equipment • Separated common and specialised labs for key NCE work segments • Constant updating of instruments, software and CMD to stay competitive • Equal access by partners and each partner could upgrade when neeeded • UK government funded and supported through COE scheme to stay world-class
Communication	• Only one-on-one personal interactions in CMD science work • Structured design chemists talking to same type six to eight hours a day in CMD • Communication structured and separated in CMD from rest of the organisations • Multi-level process (both partners) to address strategic/tactical issues immediately

'Separate, but Equal' Global Theme Influence Relationally with 'Singularity of Focus'

Cross-cutting global themes helped to demarcate the CMD physically and cognitively to focus only on structural chemistry activity for NCE discovery

The intended purpose of the CMD was strictly materials science. Discovery and characterisation of these new compounds was the sole process outcome for the CMD and researchers. The second global theme seems obvious from the standpoint of the science only important nature of the CMD and the work of each partner in the field of materials science. This obvious feature is not so obvious to the typical industrial researcher or industrial R&D Company. The notable fact that the CMD housed and conducted science only, but also was organisationally structured only to allow the science work to occur. Another example was the second global theme of *'singularity of focuses* applied from the beginning of the CMD UIP in the pre-formation and formation phases. These two phases set the stage for the daily operational aspects of the CMD UIP that were put into place upon the opening of the CMD and have continued through today. The problem pathing that was introduced by Unilever related to other partnerships that failed to produce the desired results. One element attributed to these failures was the distractions that the work environment created, especially in more matrixed larger organisations.

The typical workday of the Unilever researcher at Port Sunlight (approximately 30 mins away from the CMD) would be consumed with management and product team meetings, email sorting and responding, interactions with other groups within R&D at Port Sunlight, but not scientifically related to the same type of discovery chemistry. An example of this given during the interviews was a researcher from the hair care products discovery team interacting with a consumer detergents researcher. The haircare scientist was working to develop compounds that would reduce oily proteins in the hair. These hair discovery compounds were distinctly very different than the consumer detergents compounds. The interactions between these two researchers were very inefficient due to different scientific needs and the materials they were working with.

In the CMD, Unilever scientists in the detergent area worked on the same parent family compounds and sought to design and functionally test derivatives to find new NCEs. At Port Sunlight, you may have a project team made up of chemists working across product areas and the same knowledge being created was not helpful to be used by a chemist working on another unrelated project. The idea behind this approach at Port Sunlight was to have serendipity in activities if multiple groups worked across different chemical structure families. At the CMD, the work and chemical family focus were more homogenous than the Port Sunlight heterogeneous NCE discovery approaches.

From the study findings, one such project was the cold water detergent household cleaning product line being developed for emerging markets that couldn't access heated water for cleaning. The goal of these detergent cleaning teams was to develop new products using new NCE surfactants that could clean textiles effectively with the use of cold water to release the dirt. In the current product line of Unilever, the detergent products would use surfactants that synergistically worked with heat to activate the chemicals in the detergent to clean. The generation and use of heat were not practical in emerging markets, so new surfactants had to be discovered. During the interviews, Unilever researchers developed the global theme of ‘singularity of focus' as it relationally interacted with the categorical themes of people, environment, instrumentation and communications. These categorical themes were influenced greatly by the global theme of the singularity.

The study highlighted the influence that the global theme of singularity of focus had upon the categorical themes. The categorical themes provided key insights into the learning and knowledge creation capabilities within the CMD UIP. From a senior Unilever CMD researcher working on the haircare products team the benefits of researching the CMD were the following… *"When in the CMD, the science imperative was the only reason for being there"* (environment and business), and *"The science was the only thing we did all day"* (environment and communications), and *"When I interacted with other chemists, they were working on the same type of chemical compound problems that I was"* (people, environment). As the global theme of *'separate, but equal'* provided more physicality to organising the CMD UIP and the operational aspects of conducting the NCE work. The other global theme of *'singularity of focus'* provided a more critically reflexive and science-only approach from a cognitive and psychological approach.

The quality of time spent and not quantity of general time spent is a reflection of the ability to generate potentially more NCE compound possibilities. As one Unilever CMD researcher commented, "*My days at Port Sunlight were caught up in mixed activities, like management meetings, other types of research activities and I spent very little time on the real problems I had to solve"* (environment, instrumentation, communications, and business). This appeared to be a common thread of the interviews as another Unilever CMD researcher quoted, *"Most of my daily actions at Port Sunlight were useless and distracting from my department's only goal of generating new compounds for haircare products"*. Another said*: "The CMD is calming and helps to concentrate on the chemical science only"… "But a lot of the discussions here [Port Sunlight] get bogged down in mundane, prosaic things that constantly distract you".*

For those who are not familiar with chemical structure or medicinal chemistry discovery, there are several steps in the process of designing, making, testing and then characterization of the seemingly functional chemical compounds being made. At the CMD, the researchers were focused on the designing and making (synthesis) of the NCE compounds. Initial function testing was done at the CMD, but follow-on more extensive characterisation was done back at Port Sunlight's R&D labs. During a typical R&D day at the Port Sunlight facility, a researcher could spend only a few hours and not at all some days on the compound designing and make components of NCE work.

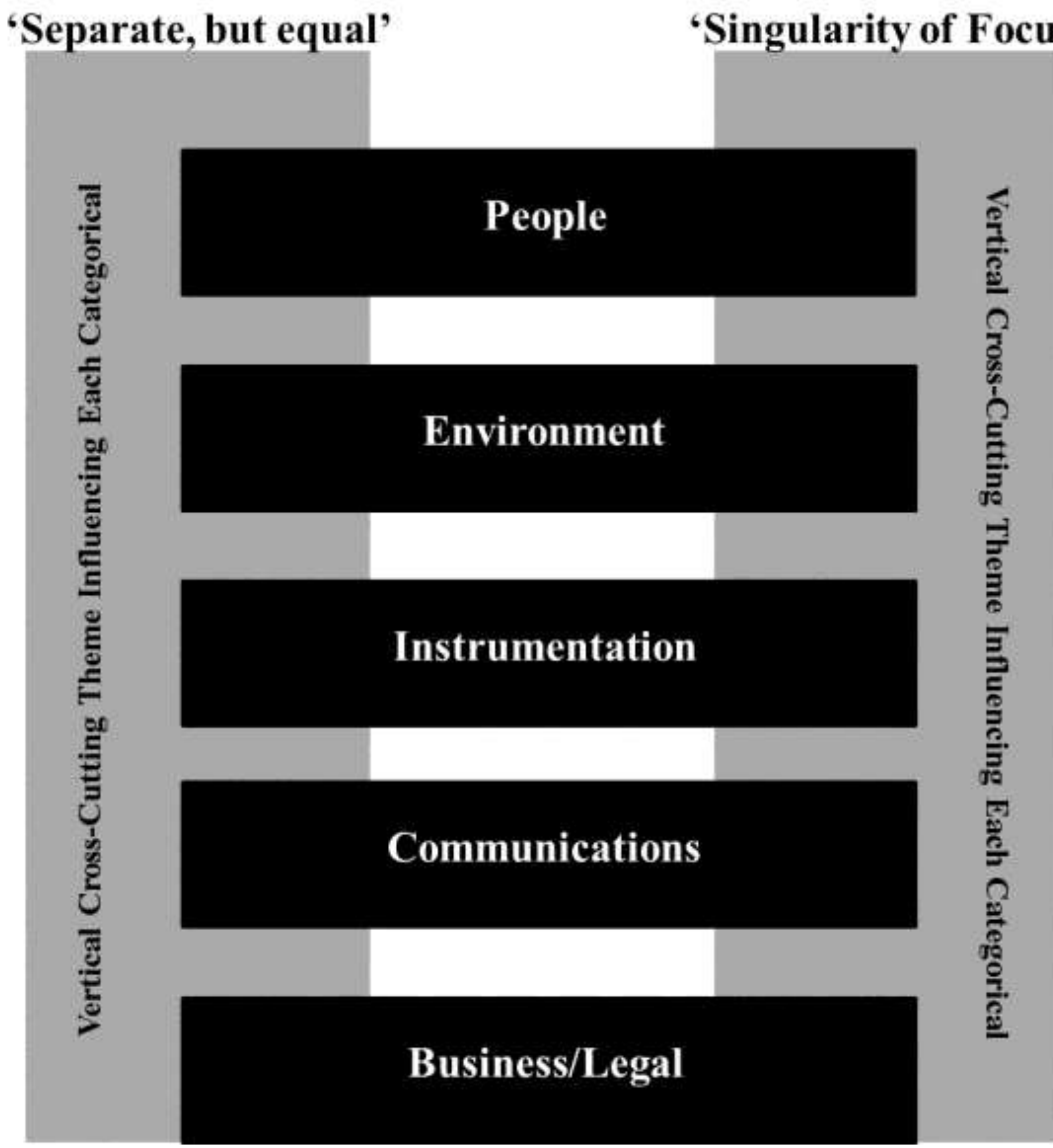
These non-NCE discovery activities had a profound impact on the capabilities, efficiencies and final outputs from the Port Sunlight R&D groups. One CMD Unilever researcher in the detergent's group said: *"Everyone in the CMD is focused on just their chemical science work, nothing else".* This global theme of singularity of focus I believe provided a much higher quality of critical thought through greater homogeneous time spent on a single or singularly focused problem. The lack of distractions meant that the typical CMD researcher was spending an average of 6-8 hours, uninterrupted, each day on a singular issue or approach to addressing a problem. The Unilever team lead researcher in the haircare products group discussed the need for no distractions *"There are a lot of scientific discussions around our problem when you are in the CMD, not the type of useless distractions or types of office talk we have back at Port Sunlight".*

5.5 Summary of Findings

The research findings provide insights into the CMD UIP as a successful partnership. The CMD UIP effectively utilised five key resources during the pre-formation, formation, and operation stages of the UIP. These five key resources were the categorical themes that emerged during the study. In designing, organising and operating the CMD UIP, it was critically important to efficiently utilise people, the CMD environment and facility, the design, application and management of world-class instrumentation for materials chemistry, communication systems that effectively were multi-level and action-oriented in addressing strategic or tactical situations. Lastly, the exhaustive planning and discussions between UoL and Unilever provided a very clear shared vision, clarity of purpose and a sustained commitment to the objectives of the CMD UIP. In ending this chapter, I offer the interplay between the five categorical themes and the two cross-cutting themes into a system of relational influences to organise, manage and direct the future of the CMD UIP.

The two global cross-cutting themes help to advance the capabilities of the categorical themes through building an operational boundary for the CMD UIP and a scientific boundary for the way the NCE discovery is conducted. In Figure 19, the graphic illustrates the enabling relationship the two types of themes have upon each other. I present the five categorical themes as "horizontal" themes whose enactment is influenced by "vertical" global themes. In chapter 6, I will make use of this inter-relationship between categorical themes and global themes to answer the research questions posed for this study. All the themes developed in this chapter will be used to construct an actionable framework for innovation professionals interested in organising their UIPs in their professional practice.

Figure 19. Categorical Themes Relationship With Global Themes in the CMD UIP



Chapter 6: Research Discussion

6.1 Introduction

In Chapter 6, I will answer the three research questions posed in the thesis from the findings of the study. The chapter discussion will also draw upon the insights from the literature review and my experiences in professional practice involving open innovation with UIPs. I will finish the chapter with a synthesise of the research findings into an actionable framework for innovation professionals who wish to work with UIPs that have sustainable extraordinary successful outcomes.

The structure of the chapter is as follows. An introduction to the chapter in (Section 6.1); The synthesis of these findings (Chapters 4 & 5) and discussions will be structured according to the original research questions posed regarding factors that: made the CMD UIP successful. The UoL's objectives for success increased in funding for programmes in the materials science, the discovery of NCEs for patenting and licensing, increase citations for new literature, the attraction of world-class faculty and the attainment of being in the top one (1%) percent of the globally ranked research universities. Unilever's objectives for success were an increase in commercially viable NCEs for inclusion into new products for Unilever's new corporate strategy of environmentally sustainable products for emerging markets in developing countries (Section 6.2); delivered extraordinary NCE discovery outputs from the CMD UIP (Section 6.3); and allowed the CMD UIP to have sustained high-performance (Section 6.4). The chapter concludes with the building of an actionable framework for the development of sustainable, high-performing UIPs (Section 6.5).

6.2. Research Question #1: What Factors Contributed to the Success of the CMD UIP?

The first research question focused on the factors that led to the successful design, formation, operation and outputs of the CMD UIP. These factors will be discussed by drawing upon the qualitative analysis (Chapter 5) of data collected during the study, and the interactions between the main themes to emerge from that analysis (cf. Figure 19). In the pre-formation phase of the CMD UIP, the importance of the people was paramount. The roles of people in UIPs are critical to gaining strong involvement of all key members from each partner. In the case of the CMD UIP, the people factor was critical to not just championing the potential relationship, but to driving it over a two year period into a strong vision and mission for NCE discovery. The impact factor for the people was two-fold in the CMD UIP.

One crucial factor was multi-level support from the UoL and Unilever. Having a top-down executive commitment and active support through participation in the meeting and on conference calls displayed the importance of the relationship and created stronger bonds of trust and honesty. The laboratory bench level researchers would push up information to higher levels knowing that something would be acted upon because of the detailed system the CMD UIP had in resolving issues. During the pre-formation stage of the CMD UIP, support from both UoL and Unilever during these two years of discussions was paramount in gaining the eventual trust and commitment for such a complex UIP. The other people factor in the success of the CMD UIP were the hand-picked recruitment approach to acquiring the 'best of the best' researchers from both UoL and Unilever. The rationale was only the best should apply to join the research teams at the CMD. The senior executives of both UoL and Unilever wanted a certain type of researcher only in the CMD. The vetting process for the researchers and staff of the CMD UIP were defined by the entrepreneurial traits of perseverance, positive inclination and achievement. As one Unilever Innovation Executive stated: *"we want researchers who know where they want to go and have the intellectual capabilities to handle the assignment"* this was further echoed by another senior executive at the UoL: *"the best researchers are the ones hungry and not starving. The best researchers know the endpoint and will achieve it at all cost necessary"*.

The environment was set up to focus only on science related to NCE discovery. The laboratories were equipped with state-of-the-art instrumentation to allow these 'hand-picked' researchers the capability to create the most enabling computational chemistry that they could dream up. To operate the CMD UIP smoothly, there was a myriad of operating policies and procedures. If there were problems, a resolution process and team were standing ready to intervene. To ensure that the overall CMD UIP could be controlled, the laboratories and offices of the CMD UIP were separated from the general university labs and offices. The access was restricted and heavily controlled by the full-time staff of the CMD. This highly structured environment within a usually more relaxed university campus was unusual but allowed the partners of the UIP to operate in their world.

The protracted length of time (2.5 years) of the pre-formation phase was a key factor in the UIP's success as it allowed for frequent discussions on what each potential partner wanted from the CMD UIP. In the last months of the pre-formation stage, it was decided that both sides would engage in more formal discussions centred on creating a COE for materials science. The two sides spent seven months discussing the pros and cons of various setups and operating principles for the CMD UIP. The motivations for successful partnership were driven by the need for more open innovation and NCE discovery success for both partners. This led the partners to a shared vision that would help to organise the various components of a partnership. An example of this benefit of shared purpose was problem resolution. If something occurred that would impact daily operations in the CMD UIP, one of several teams would intervene. The problem resolution team would identify the problem, determine the best course of action and then implement the changes to address the problems encountered. This involved many people communicating regularly according to sets of policies and guidelines. The five certain themes illustrated in Figure 19 represent the constituent elements of such daily routines.

Another success factor that evolved from the pre-formation negotiations and in the formation stages was the work of the business and the legal teams on adopting a *'living, flexible and enabling'* set of documents that would guide, address and fix most things that would stop success from happening. If a performance gap were discovered, the partners would use their early work to define and address a new problem that had not been envisioned. Once both sides found an acceptable resolution, the new item was put into the CMD UIP operational policies. In the end, the hard work upfront to establish a shared vision also produced a mutual clarity of operational relationships and problem resolutions. The five certain themes relationally helped to establish a larger operating system for the CMD UIP.

In addition to the five certain themes, two cross-cutting themes also emerged from the qualitative analysis (Figure 19)These global themes were evident in each of the five categorical themes and represented operating principles critical to the UIP's success. These two global themes were *'separate, but equal'* and *'singularity of focus'*. They cut across the categorical themes providing a (metaphorical) *'glue'* that explains the interrelationship between all of the categorical themes. The researchers could mingle and interact with others outside their closed group when they wanted. The open or closed group access was the people hallmark of this global theme and helped to enable new scientific thoughts without jeopardising intellectual property. The second global cross-cutting theme was 'singularity of focus', and it influenced the people, environment, instrumentation, and communications directly. The ability to have a highly contained and intense environment of science only helped to increase the quality of scientific work. This theme also helped to provide a richness of interactions as the same type of researchers were intermingled. These types of researchers were more design or medicinal chemists who were doing more of the creative side of chemical design and not the more linear approach of characterising the NCE after it was designed, synthesised and functionally tested.

These two global cross-cutting themes helped to strengthen the level of commitment and engagement in the CMD UIP on both sides. These feelings and actions led to finding ways for advancing the relationship and grow the capabilities further to increase the impact that the CMD UIP was having on NCE discovery. In summation, the success factors of the CMD UIP were strong mutual and shared visions, purpose and mission of NCE outputs. This combined positive vision helped to motivate both sides to articulate, delineate, organise and operate a set of guidelines, policies and processes that would address the CMD UIP.

Once the decision was made by the University and Unilever to build the CMD and operate the UIP, a process of detailed operational planning ensued before lawyers became involved with structuring the UIP legal agreements. From the literature review and my professional experience, most parties to a UIP rush into the negotiations stage and don't critically reflect on the key elements of the structure of the UIP.

When the agreement was completed for the UIP, every major element had been discussed, organised and assigned a *'process'* for addressing daily operations or when problems arose. An example of this was the form of 'support system' that was developed to handle the *'processes*. The support system would comprise both strategic and tactic groups and formats for discussions. The strategic elements were a senior executive steering committee that met regularly and decided on the more important issues that needed to be addressed such as next funding goals, tenders to government or key strategic scientific programmes. The tactical elements were laboratory operations, instrumentation upgrading and approach to recruiting and hand-picking top researchers to work in the CMD. There were teams for every facet of the CMD.

One example of this was the categorical themes of people, instrumentation, and communications. These three categorical themes acquired a new synergy that may be explained concerning the two global themes of *'separate, but equal'* and *'singularity of focuses*. When the CMD facility was being laid out physically during the pre-formation phase of discussions, the question of intellectual property came up. Intellectual property is always a large issue in UIPs (Reams, 1986). The protection of new knowledge can be a key distractor and barrier in forming a potential UIP. Intellectual property protection usually drives the particular model used and can limit the ability of a UIP to do its job really (Fontana, Geuna and Matt, 2006). Sponsored research, for example, is one-sided and usually contractual (Bekkers and Bodas-Freitas, 2008).

The loss of knowledge creation and translation synergies occurs because the partnership is a one-way generation of knowledge (Reams, 1986; Etzkowitz, 2003). During the long discussion phase for the CMD UIP, both parties would highlight key problem areas for detailed discussions. These were referred as '*problem paths'*. These problem paths were then organised into various groupings that would be addressed regarding the mutual interests or concerns.

An example of this problem pathing was the protection of intellectual property (IP) for both partners. For the UoL, the IP objectives were to patent any unique processes of synthesis, manufacture, discovery processes or the original chemical structures. The goal of the IP strategy at UoL was to license out the technology in a transfer to industry. The other main objective was to publish in high impact science peer-reviewed journals. The IP Objectives of Unilever were to discover new NCEs and any derivatives of the parent compound structures and patent them for protection from competition. The new product would have patented and hence commercial protection for a large number of years. The NCE discovery process method itself or the compounds that resulted were key intellectual property and concerns for protection. Some of the elements discussed in the problem paths were actual laboratory bench space for the confidential work, access to the leading-edge instrumentation, protection of communications either by a computer, phone or laboratory group meetings.

The access to the CMD would be an issue as well as the time spent in the laboratory conducting the research. Because the CMD had state-of-the-art instrumentation in a separately confined set of laboratories (the CMD setup) researchers from both partners would be intermingled and risk disclosing confidential secrets. The University wanted to publish, patent and license the discoveries. Unilever wanted to patent and commercialised the NCE discoveries. Protecting and generating IP is always an issue for discussion in the pre-formation stage of a UIP (Reams, 1986; Etzkowitz, 2002; Etzkowitz, 2003; Smith, Collins and Clark, 2005).

The practices that controlled the IP situation were nuanced by the global theme of *'separate, but equal'*. The influence of this global theme explains how the categorical themes of people, environment, instrumentation and communications influenced the protection of the new IP. The CMD was comprised of common lab areas that used the same state-of-the-art instrumentation. These common areas were contained with equipment that would be used on a more routine basis. The CMD was access-controlled so only authorised CMD researchers and staff could enter the CMD. This access provided some protection from general university staff but did not address within the CMD. The people who worked in the CMD were described as more 'business-like', 'mature' and professionally driven by what the CMD could offer them. This made, according to the many interviews, a higher level of seriousness about the business of chemistry being done in the CMD. The 'separate, but equal' theme provided unlimited access to all of the CMD laboratory facilities and any range of instrumentation needed. If a researcher needed to schedule a long series of experiments to make sets of chemical compounds and then do follow-on design of new chemical structures, they could schedule the CMD for up to eight hours each day. After hours scheduling could also be done. This allowed the CMD researcher the ability to work for long and very productive periods of time on just one problem. The combination of controlled access, dedicated instrumentation that was state-of-the-art and very motivated researchers made scheduling and utilisation of the CMD for long periods of time a more routine habit for researching. This would be nearly impossible to do at the UoL general chemistry laboratories where time was in small blocks, often interrupted and not with the best of instrumentation. The CMD dedicated researchers could work six to eight hours a day on just one problem. Whereby the typical day spent at Unilever's Port Sunlight R&D would be lucky to get more than one to two hours into the laboratory to work on just the same thing.

To control the access to the common labs, each partner had to sign up in advance to schedule their time on the common lab equipment. This would allow only the University or Unilever researcher to be present. This boundary of the workspace was a very important distinction that had frequent training on CMD researchers. The scheduling was done with software, and the access was controlled through daily lab review meetings to ensure that no overlap occurred. Every facet of the work day, routines and access to instrumentation were highly controlled and monitored. Any discoveries or conversations amongst the scientists would be controlled through this 'separate, but equal' philosophy. To ensure an even higher level of IP protection, there were laboratories built that housed only Unilever or University researchers within the CMD.

These partner-specific areas were developed because the particular actions of each partner warranted daily use of the instruments because of the need for frequent access. For less frequent access, the common controlled lab areas were used. These 'protected' areas would be for use by only the one partner and sometimes additional state-of-the-art instruments would be acquired through national tender schemes. The *'separate, but equal'* global theme cuts across several boundaries to provide very distinct benefits to the relational categorical themes. Let us take each categorical theme and cross it with the global theme of *'separate, but equal* 'or (SBE). Regarding the first categorical theme of people, the global themes of SBE there are distinctions between the researchers in the UoL general chemistry labs and the UoL researchers in the CMD UIP. The same is true for Unilever researchers in the CMD versus at Port Sunlight. The best hand-picked and highly motivated researchers are separated from the general population of chemical scientists and put into a highly controlled and demarcated laboratory setting. The researchers are now distinct and can make their mark if they have the tools to succeed. This is the relationship to the other categorical themes. Once we have separated and motivated scientists, they then have the ultimate in instrumentation for world-class experimentation. They also have a controlled access facility that is controlled by the individual scientist who wants to use the CMD as much as possible. This high-quality exposure to the best-in-class instrumentation with all the time you need on the specialised laboratory areas give the CMD researcher a very high-quality experience. The SBE global theme also reinforces the science-only imperative in that the CMD researcher cares nothing about the corporate or academic life. The mandate of the researchers assigned to the CMD is to conduct science only and only think about your structural chemistry problem. You are not to worry about your emails, departmental meetings, you social media chats or any other activity that would take you away, dilute your attention or cause you to divide your time spent. The only way left was for public disclosure by an individual either within or outside the CMD. The hand-selection of CMD researchers and their greater professional, business-like behaviours made this disclosure less likely to occur.

The success of the CMD UIP stems from several factors (categorical themes) that manifest both individually and through interaction between categories. These interactions are informed by two global themes that act as overarching operating principles in the CMD. I believe the following is the contribution to professional practice from the CMD UIP study. The strength of the CMD UIP emanated from the strong, well-defined mutual shared vision that both University of Liverpool and Unilever had regarding the focus and outcomes of the UIP (communication, business and legal themes). The mutually shared vision brought together many items for discussion in the pre-formation phase for both parties to consider. The mutual vision provided a strong starting point in discussions by forming a strong bond of common ground. Each item had an equal weighting for discussion.

A success factor that contributed to the CMD UIP that came from the mutually shared vision and resulting partnership agreements and operating guidelines were the straightforward ‘clarity of purpose'. This clarity of purpose set the organising structure to operate the CMD UIP for each partner’s separate, but equal benefit. The CMD would be globally structured (separate, but equal) and solely focused (singularity of focus) to deliver a venue environment of NCE discovery without distractions for each partner on their own time with their instrumental capabilities (‘separate, but equal' and ‘singularity of focus'). These two global themes would be used as operating principles to organise, control and direct the activities of the five categorical themes that were the controlling factors of CMD UIP success.

The CMD as a COE is an important milestone in the CMD UIP life cycle. The COE designation provides for a large amount of flexibility and increases in stature. The UK government has always supported schemes that added to a region's foundational strengths. In the case of the UoL, the city region of Liverpool was already receiving large amounts of money that were destined to be used for the regeneration of the city as well as the city region. Utilising a venue as a COE allows the caretaker of the COE to improve upon the current situation. The capabilities and stature can always be increased and kept up to date through funding of programmes and recruitment of key opinion leaders from academe and industry. In the factor of engagement, both partners gain from the use of a shared facility that is leading-edge capable of creating chemical materials as good as anywhere in the world. This capability comes from the continued advancement and upgrading of the instrumentation that is used by the CMD UIP. For the

University, the ability to use the non-profit tax structure to leverage governmental funding stimulates a process for continued improvements. The CMD as a COE provides a funding and legislative scheme to continue the advancement of the scientific capabilities to keep the status of the COE, but also to ensure that local parts of the UK continue to be global leaders in their selected sectors of science and technology.

Unilever, like most companies, has certain corporate finance and accounting rules it must follow the law. Public companies have an even higher standard of accountability. The CMD represented the opportunity for Unilever to access world-class capabilities (instrumentation) and utilise the most leading-edge, state-of-the-art processes to design and synthesis NCEs for new product development. Unilever had a strategic decision that would have a great strategic impact on its future when it partnered with the University with the CMD UIP. That decision was a ‘make or buy' decision on how Unilever would establish its open innovation programmes for NCE discovery. The risks to Unilever was building a new R&D capability (environment and instrumentation) in a field that was still nascent, but rapidly emerging in various dynamic forms. In summary, the key factors that provided substantial benefits to both partners from the CMD operations and the CMD UIP are presented in Table 13 by categorical theme. Each of the five categorical themes is delineated by the benefits derived to each partner of the CMD UIP. The UoL has very key benefits for each of the five categorical themes as did Unilever.

Table 16. Key Categorical Themes in CMD UIP with Top-Line Benefits

Key Categorical Theme in CMD UIP	UOL Benefits	Unilever Benefits
People	• High-performance faculty attract like-minded individuals	• High-performance scientists are recruited to riskier, bigger impact projects
Environment	• Special access to CMD draws more entrepreneurial and higher performance faculty • Separate, but equal operating structure allows for co-mingling of collaborative thinking, but also allows protection of confidential information for UoL and doesn't interfere with IPR generation for Unilever • Top facility have top access and this is a big recruitment and retention tool for UoL	• Singularity of focus and full-time thinking about science produces better outcomes • UIPs provide venues that take away all the distractions from the company environment • Co-mingling with academe helps keep the creative edge flowing: keeps older scientists young again
Instrumentation	• State-of-art allows for leading-edge research: follows publications and patents • CMD attracts industry and government funding to move UoL up the research rankings • New sub-schools form from influences of CMD UIP such as nanomedicine and materials science, eventually chemical engineering	• Access to state-of-art without having to purchase, setup and take risks that projects don't work out and left with millions of pounds of equipment • Constant access to latest science allows Unilever to advance R&D faster and cheaper; don't have to amortize CAPEX • R&D scientists get upgraded training and scientific skills by working with latest equipment: outsourced R&D leveraged
Communication	• Allows UoL to engage with government (THM), increase value to community • Top-down support drives new thinking, gains greater access for Vice Chancellor with other industry UIPs	• Part of Unilever CEO Polman's strategy of outsourced R&D through Open Innovation schemes with financial support from government: leverage funding • Good corporate citizen by engaging with UoL; can leverage a lot more than on Unilever's own
Legal & Business	• CMD UIP has served as a model for other, larger, more complex UIPs (MIF, Sensor City and Precision Medicine) • Many UK and EU universities come to UoL to learn about the CMD UIP	• Business development has new models for university engagements that gain more value through less efforts from CMD model, can this now be made to be portable?

6.3. Research Question #2: What Factors Allowed the CMD UIP to Achieve High-performance in High-throughput Computational Chemistry for NCE Discovery?

The new NCE effort would require building a large number of new resources over several years (the categorical themes of people, environment, and instrumentation). This ‘makes' decision for NCE R&D expansion would also add to the costs and finances of Unilever (business and legal). If Unilever chose this ‘make' decision for NCE discovery, it would have to buy, maintain and upgrade the laboratories, supporting facilities and instrumentation to keep vitally current on the science and technology. This would involve huge sums of money and risks. The greater negative impact to Unilever of this ‘make' decision was the need to amortise the cost of the instrumentation over seven years. This issue of writing down the capital instrument costs would mean that the value would have to be written down for some number of years before new instrumentation and facilities could be built or bought.

This would inevitably limit Unilever's ability to stay current with the rapidly developing science and technologies around NCE discovery. The option of partnering with a world-class academic institution who has COE world-class capabilities provides a lower risk, a capital-efficient alternative to the ‘make' decision. The ‘buy' decision of NCE discovery could allow Unilever to have and build its NCE discovery capabilities while limited its financial, operating risks and time-to-commercial-market on converting commercially viable NCEs to useful new products. This ‘buy' decision was most readily available from the CMD and the CMD UIP structure.

Unilever accesses the latest capabilities and utilises the partnership to advance the University as well as the science and technology capabilities of the UK.

The CMD was notable for the attainment of extraordinary outputs regarding NCE discovery. The rate of successful NCE output allowed both UoL and Unilever to generate commercially-viable compounds. This created both a financial as well as an intellectual property set of rewards. The definition of high-performance provides a metric or benchmark in which to assess extraordinary performance. Extraordinary performance would be achieving well above the normative ranges for any pursuit that can be defined. In the case of materials science, the *'hit rate'* of NCE discovery is very low. The causes of low *hit rates* are not well understood by industry or academia (DiMasi, 1995; Keserù and Makara, 2006).

When the sciences of computational chemistry started to emerge in the early 2000s, many people thought this would address the problems of NCE discovery (DiMasi and Grabowsk, 2007). It was argued that individual organisations would achieve increasing amounts of success, but the industry as a whole would still suffer the plight of low success rates of new compounds (Mestre-Ferrandiz, Sussex and Towse, 2012). This fact alone is very noteworthy as the level of NCE discovery in academia and industry is in the range of < 1 to 3 % for each chemical compound made (DiMasi, Bryant and Lasagna, 1991; DiMasi, 1995; Wratschko, 2009; Mestre-Ferrandiz, Sussex and Towse, 2012).

The factors of success for higher *hit rates* in NCE discovery from the empirical data suggest that the industrial and academic laboratories may not be optimally approaching NCE discovery. This study has identified some key factors for the NCE discovery success at the CMD UIP. The categorical themes of people, environment, and instrumentation seemed to have played a more dominant role in the influences on NCE discovery than did communications and the business and legal factors. The effectiveness of these three more dominant categorical themes may be explained by the operating principles (global cross-cutting themes) of *'separate, but equal'* and *'singularity of focus'*. The role of people was apparent from the research data as the more senior and chemically-experienced researchers were recruited to become scientific CMD researchers. This was true from both the UoL and Unilever.

The people were also described in the interviews as more creatively oriented scientists who operated best on the 'edge-of-science'. The people would be more design-oriented chemists that general chemists assigned to the CMD UIP. In chemistry, the more creative design chemists make up new chemical structures based upon prior history and literature. The more linear thinking and repetitive approach chemists would do characterisation work that would continue to refine the properties of the chemical compound the 'process chemists'. These process chemists and design chemists can be assigned different work within a chemistry laboratory. This is like mixing apples and oranges in a bowl. The CMD UIP was very careful to recruit, select and nurture chemists that were more creative and design-oriented.

Taking this type of chemist and putting them into an environment that would focus on doing nothing but design chemistry for NCEs (the 'singularity of focus' operating principle) would increase the amount of time spent on this activity. The average time spent on creative chemistry design at Port Sunlight R&D at Unilever was a couple of hours a week at best from the interviews and observations I made at Port Sunlight. The average time spent on creative chemistry activities (computer research, computer design or chemical synthesis) would be six to eight hours a day, four days a week on average for Unilever scientists. When the CMD scientists weren't on the laboratory bench doing lab work, they would be spending time talking to chemical researchers like themselves about nothing but chemical design approaches. When not interacting with other chemists, they would be conducting internet database research on chemical structures and properties.

The categorical theme of instrumentation provided a backdrop to perform all this creative chemistry. With the CMD UIP housing the most up-to-date and state-of-the-art instrumentation, any capable research design chemist could ply their trade with the most advanced laboratories around the world. As the CMD UIP gained in success performance, the UK government also worked with UoL and Unilever to turn the CMD into a COE for the Northwest of the UK in materials chemistry. What made the three key categorical themes more synergistic were the heavy influences of the two cross-cutting global themes. The *'singularity of focus'* was more pronounced on providing an increase in richness and quality of the scientific operations of the CMD and the NCE outputs.

> *There are lots of people to help you. Everyone in the CMD is focused on just their chemical science work. There can be quite a lot of scientific discussions when you in the CMD, not the type of office talk we have back at Port Sunlight – Unilever CMD Researcher.*

The individual focus on the creation of chemical structures was not diluted with other activities that most of the UoL and Unilever researchers would experience outside of the CMD UIP. The difference between six to eight hours a day three to four days per week versus one to 2 hours over the course of a week makes a larger difference in the quality of time spent and the frequency of interactions for only one purpose: NCE discovery. The lack of dilution of scientific efforts was also influenced by the second global theme of ‘separate, but equal' in the ‘separate, but equal' theme, UoL and Unilever would be separated in their workspace and access to the laboratories.

In the more common laboratory work schemes, each partner would schedule a time to work on the more common lab instrumentation. They had equal access but at different times. For the more proprietary and confidential work, both partners would have dedicated laboratories to conduct scientific work within. In both of these scenarios for laboratory work, the researcher, regardless of where they came from, would be allowed as much time as they wanted to conduct the science only works. These operating principles (global themes) created a situation whereby the CMD UIP researcher could spend six to eight hours a day performing some activity relating to chemical design and synthesis. This wasn’t feasible or even possible in the more general chemistry labs at the UoL or Unilever's R&D facility at Port Sunlight. The impact on NCE success for both UoL and Unilever were well above the industry averages for NCE discovery and potentially commercially viable.

> *The Unilever guys know that the CMD is a unique place. Typical [NCE useable compounds for new products] faster timeframes like taking it [NCE discovery into new products on the market] down from 7 years to 2 years. Also making it more patentable. A 4-fold increase in patentable assets in just a few years. - Unilever CMD Researcher.*

In fact, the quality and quantity of the NCE outputs are extraordinary on any level documented by the CMD. The NCE discovery made into commercially-viable compounds for new products has dramatically and positively impacted both the UoL and Unilever. "Unilever had seen*…after two years of operation in CMD, they had 3 or more at the time. That caught the attention of Unilever"* (CMD Unilever Senior Researcher).

Many of the new product information from Unilever R&D is company confidential, but some recently cited numbers publically were as of 2013, Unilever rolled out over 90 new innovative products in 10 new emerging countries which represent a tenfold increase from the 2009 levels. In 2015, the emerging markets now accounted for about 57% of total Unilever revenues and more than half of the new growth since 2009. The combined commercial value of the successful product introductions is estimated to be over USD 10 billion as of 2015 (Jopson, 2013, Gelles, 2015). Several of the new chemical entities that were discovered and developed through the CMD UIP are part of this new product offering and have contributed greatly to the mission of Unilever of capturing a large share of the emerging market (Jopson, 2013, Gelles, 2015).

In summation, the success of NCE discovery and the extraordinary output of discovery can be tied to categorical themes relating to the people, environment and instrumentation organised into a structured and self-contained unit of laboratories focusing on only one imperative: conducting new design-based computational chemistry for NCE discovery. The categorical themes are further enhanced by the two cross-cutting themes that allow only science in a high frequency, long durations and only with others conducting the same type and level of science. This dramatically enriched environment with most of the week devoted to NCE discovery would increase the odds of finding NCEs not contemplated by more traditional laboratory work approaches. The richness and intensity of science only conducted in separate, science-only environment increases the odds of new thinking for discovery. Combine very senior researchers with other creative chemical researchers utilising world-class instrumentation the chances of increase NCE discover outputs are also increased. I believe the themes alone don't account for the high-performance of NCE discovery, well above industry standards. I put forth the notion that combing the categorical themes and organised and operated in a manner that utilises the two global themes creates a dynamic that contributes to the quality of laboratory efforts, increases in the richness of creative chemical thoughts. Lastly, adding the same type of chemical researcher to the group conducting the activities above and I believe you have a process formula for creating higher chances for discovering NCEs. This emergent finding in the study should be further explored. The financial and knowledge creation impact would be massive with new ways to consistently increase NCE discovery.

6.4. Research Question #3: What Factors Contributed to the Sustained High-performance Success of the CMD UIP?

There were two geographical precursors that set a potential foundation to build from the CMD UIP from. If the CMD UIP were successful, these two precursors would help to enable the CMD UIP to leverage other resources in its evolutionary development. During the research phase of the study, there were two very important currents running in parallel, and outside of the CMD UIP directly that impacted the CMD UIP. I refer to these two important precursors as setting a potential foundation for sustaining CMD UIP success. This would have been true for other UIPs and strategic alliances at the time. The two driving precursors existed before the CMD UIP and later co-existed during the maturation of the CMD UIP. These two precursors were regional economic redevelopment and the centre of excellence economic and science schemes of the UK and EU governments. The first driving precursor was the larger redevelopment of the city region of Liverpool. This redevelopment effort helped to put the city and the universities on a larger plan through financial support. History has shown that UIPs can have a dramatic impact on society (Etzkowitz, 2002; Wesser, 2003a; McClellan and Dorn, 2006; Etzkowitz, 2008).

Any strategic plan involving economic development and supported by the government involves a tripartite enterprise. The Triple Helix model discussed in this thesis aims to bring together universities, industry and government in synergistic programmes that leverage and support each partner directly. The Triple Helix can serve as its innovation framework for the three parties (university, industry and government) to proactively impact the larger role of economic development of society (Etzkowitz, Mello and Almeida, 2005). The second precursor was the UK government's focus in the early 2000s on creating regional economic and science development through regional centre's of excellence. This COE would add a synergistic element for leveraging the first driving precursor to create a more attractive justification for supporting the CMD and any UIP that could be created from the CMD. Think of the two precursors as foundation blocks of continued funding support if the CMD UIP achieved measurable success.

In the book, *Sustainable Partnerships*, the Authors, Steger, *et al.* (2008), discuss the importance of objectives and goals defined, articulated and measured by each party to the partnership. The clear vision of what the partnership is about and the rationale for the partnership helps to sort through the various elements and prioritises the weighting and importance of each party. In the CMD UIP, the vision for the partnership was computational chemistry capabilities performed in a dedicated centre that focused solely on NCE discovery. Anything that would keep this focused outcome from occurring was a point of discussion and made part of the structuring of the UIP framework. The importance of the CMD UIP achieving these outcomes was critical to the University of Liverpool and Unilever.

The University wanted to become one of the top global research universities (in the top 1%) and a leader in the emerging fields of materials science, nanotechnology and computational chemistry. Unilever's sole focus was to discover commercially-viable NCEs that could be used in new product development. These new products were part of a massive change of corporate strategy focusing on the developing world and the emerging markets within those areas of the world. The CMD was notable for operating success as a UIP. The CMD was also recognised as a unique place for NCE discovery with the extraordinary NCE discovery outputs. What would allow the CMD UIP to achieve this high-performance success over a long period?

The durational element of continued success has to do with both the CMD UIPs operational excellence as much as the scientific excellence of the NCE discovery. Lateral support was developed during the operations of the CMD UIP. This lateral support was the combination of operational and scientific factors that created a successful CMD UIP, but also led to a stronger emerging set of benefits from the CMD UIP. These would be sustainability success factors and are discussed in the innovation framework in Section 6.5. For this sectional discussion, the sustainability success factors stemmed from the factors that contributed to both the CMD UIP success (operational success) and the extraordinary NCE output (scientific success). The strong and exhaustively discussed mutual vision and purpose of the CMD UIP in the pre-formation stage led to a growing level of trust and commitment to risk/rewards. This growing bond established at the pre-formation and formation stages were reinforced by the operational and scientific successes of the CMD UIP during the engagement/operational stages. The five categorical themes provided building blocks for establishing the framework and operating model of the CMD UIP. The five categorical themes were also key resources that allowed the CMD UIP to operate. The two global cross-cutting themes provided a different demarcation through a singularity of efforts (NCE discovery) and with a richness and higher frequency through equal sharing of world-class resources. Together, the CMD researcher from either partner had a focused and well-organised framework for both operations and science.

In summation, the sustained success of the CMD UIP can be attributed to the clear and mutually shared vision from the beginning of the CMD UIP. This shared vision provided clarity of purpose and set up a business and scientific relationship that was seamless, well-organised, and flexible in operational design and highly committed to by all levels in UoL and Unilever. With the simplicity of science-only mandate and the high quality of time spent on nothing but NCE discovery, both partners achieved extraordinary results in an industry (materials science) and innovation model (UIPs) that normally would achieve much less (Fagerberg and Mowery, 2015). As the CMD UIP garnered more scientific success, both UoL and Unilever invested more time and money into the CMD. In turn, as the CMD UIP became an example of collaborative open innovation success, the government invested more resources in the CMD UIP as a COE. The CMD UIP as a COE also reinforced the importance of economic development programmes that centred on universities, industry and local government/societies. As the redevelopment of the city region of Liverpool began its larger trajectory, the importance of sustaining programmes of innovation excellence became the focus of future planning.

The CMD UIP sustainability of high-performance can be tied to the importance of regional influences providing enduring support coupled with operational successes that promote backing a winning model. If that operational model and success provide extraordinary output societal stakeholders will take notice. If that success is over a long period, stakeholders will want to understand how it operates and provide financial and policy support. If a framework could be developed from research on a sustainable, high-performance UIP, then replication of such a UIP would greatly benefit society.

6.5. An Actionable Framework for Innovation with UIPs

In this section, I will present an actionable framework for innovation professionals interested in designing and operating a sustainable, high-performance UIP. The framework is based on the empirical research of the CMD UIP. The innovation framework is focused on the sustainability of successful output. The innovation framework draws upon the pre-cursors that drive success in each phase of a UIP. My starting point for the framework was based upon published work on the stages that a UIP will go through in the life cycle of the partnership. The authors (Plewa *et al.*, 2013) highlight key phases in the evolution of a UIP. The phases contain a pre-phase, three operating phases and a latent phase that allows for future consideration of another partnership between the parties. The key phases of are processual and must be satisfied before moving onto another phase. These interconnected phases are referred to as 'linkages'.

Once any pre-condition is met, the potential partners can complete one step and enter another step in the UIP. If there are no key linkages, then the partnership process ends. I thought this a starting point for constructing my framework. The Plewa model lacks depth as to thematic elements that contribute to the successful outcomes from a UIP. The Plewa model doesn't take into account any pre-cursors that are required for each phase. The model doesn't outline or discuss needed elements that increase the likelihood of success before, during or after each stage of a UIP. of pre-stage success nor success factors that would achieve sustainability of the UIP's successful operational life cycle.

I have adapted the Plewa model to show a larger set of categorical as well as global themes that are present in a UIP through the life of the partnership. My model based on the empirical data of the CMD UIP is separated into my framework also provides pre-phase and post-phase success factors needed for UIP operational success. The innovation framework I present in Figure 20 provides actionable insights for an innovation professional working with UIPs in all evolutionary phases of design, operations and closure. This framework is my contribution towards designing and sustaining successful UIPs. The innovation framework is presented as a longitudinal multi-component conceptual framework comprising multiple phase blocks and corresponding success factor linkages that mutually exist throughout the life of the UIP.

The framework is laid out as four columns of importance in the creation of a UIP. The four columns are 1) *'pre-phase success factors'* 2) '*Phase Block'*, 3) '*Phase Block Success Factors'* and 4) *'sustainability success factors'.* The four columns represent building blocks for the creation of a UIP for sustainable success. The pre-phase success factors are those elements that represent key thematic considerations before the start of the key phase blocks. These precursors of success were needed to successfully enter into and execute each of the phase blocks in the CMD UIP. I have broken out the life cycle of the CMD UIP into five phase blocks that represent the life cycle of the CMD UIP. The five-phase blocks were 1) *'pre-formation'*, 2) '*formation'*, 3) ‘*operating*’, 4) ‘*high-performance’* and 5) ‘*sustainability*’. The pre-formation phase block was the activities that the UoL and Unilever conducted in the early discussion and negotiations stage. The formation phase block was the setting up, funding and organising of the CMD UIP before physical operations of NCE discovery being performed. The operating phase block contains the daily suite of events and activities to operate the CMD UIP. In the fourth phase block, high-performance, the elements of extraordinary performance was factored into the operations. The last phase block of sustainability is related to those necessary activities necessary for the CMD UIP to continue the extraordinary NCE performance.

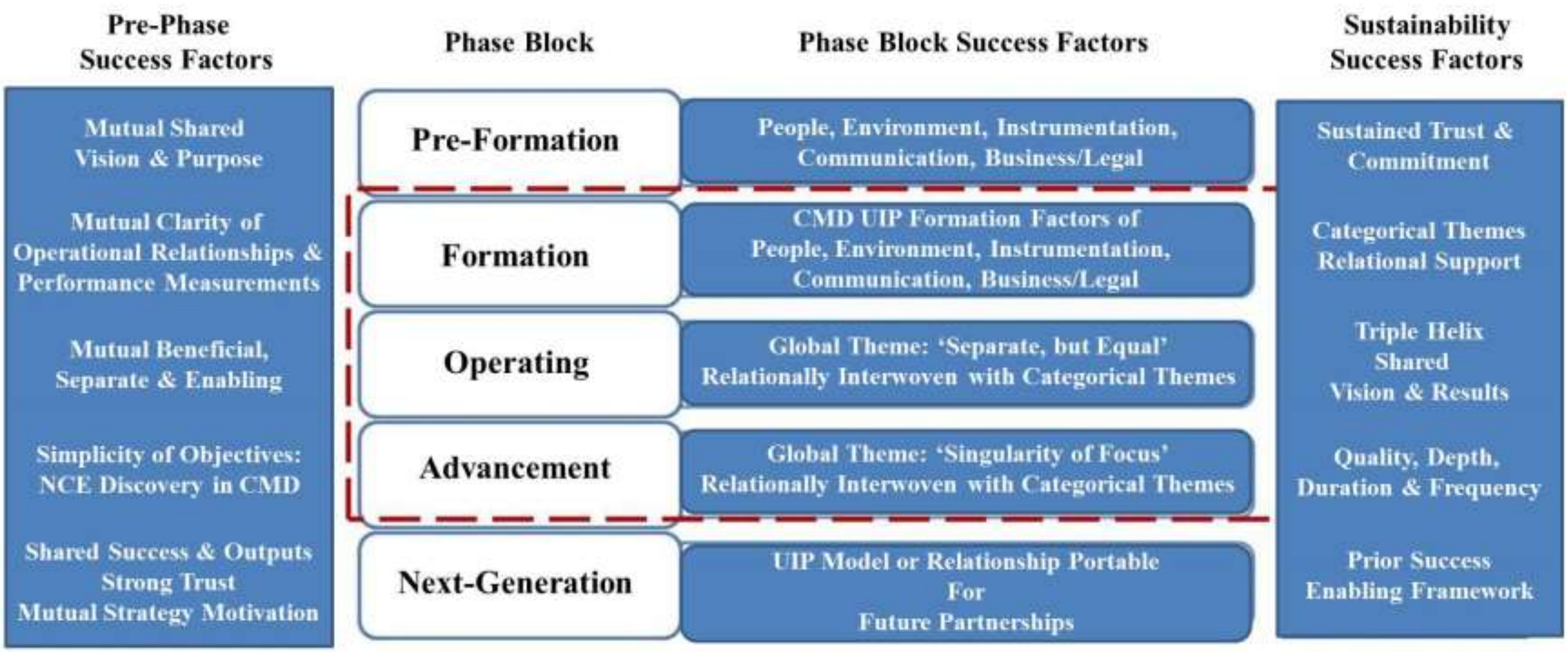
For each of the phase blocks just described, there were key thematic factors that contributed to the success of the CMD UIP during each of the phase blocks of the partnership. The phase block success factors were the five categorical themes of 1) ‘*people’*, 2) ‘*environment*’, 3) ‘*instrumentation*’, 4) ‘*communications*’ and 5) ‘*business and legal’*. The two global themes that were cross-cutting amongst the five categorical were ‘separate, but equal’ and ‘singularity of focus’. The last remaining column focused on those key partnership themes that contributed to the sustainability dimension of the CMD UIP. The sustainability success factors are critical as they contributed to each key phase block and allowed the CMD UIP to build sustainability into the partnership over time by addressing the key phase blocks of the CMD UIP.

The CMD UIP success can be discussed through the innovation framework. In the framework, the pre-phase success factors provided a solid foundation in the pre-formation phase of the CMD UIP where a mutually shared vision and clarity of purpose between UoL and Unilever. This was achieved in the pre-formation phase block by the five categorical themes. The importance of each of the five categorical themes together provided the early impetuous for building trust and commitment to the goals of the CMD UIP. As the discussions were held over a two year period, both partners understood the importance of the pre-planning and deeper definitions of what the UIP had to achieve. In the formation phase block, the continued importance of mutual clarity allowed each partner to define in great detail the operational relationships and performance measurement needed for success. The five categorical themes again provided a relational clarity of the objectives and goals of the CMD UIP for each partner. This continued sharing of mutual vision, purpose and required outcomes led to growing deeper relationship support by each partner. By the time the actual partnership agreements were finalised, the CMD UIP was a very well defined and organised partnership model. The global themes of ‘separate, but equal' and ‘singularity of focus' influenced the five categorical themes and together provided several benefits. The CMD facilities were set up with the state-of-art instrumentation, but the access was controlled, and each laboratory work area would give each partner an advantage to use the best equipment, but not share with each other at the same time. This allowed for intellectual property to be protected by each partner. The pre-phase success factors that led to the operating phase block performing well centred around the ‘separate, but equal' and in allowing the researchers in the CMD UIP to devote upwards of six to eight hours a day to just science. The global themes were interwoven relationally with the categorical themes to create a very well defined and physically demarcated UIP. The sustainability success factors that came from this operational designed lead to a greater quality of the CMD UIP.

The high-performance of the NCE discovery resulted from the intense working environment of the CMD UIP. No other activities were conducted other than science design, research and NCE experimentation. The reinforcement of the operating phase block resulted from the funding and operational approach for the CMD UIP as a COE. The COE strategy provided greater governmental support through policy and funding. The clear articulation of the CMD UIP objectives and goals allowed for greater clarity, vision and purpose. This depth of mutually sharing everything between partners offered a strong growth component to trust and building common bonds. My belief was the CMD UIP is an actionable framework that can be replicated for other UIPs by innovation professionals. The actionable insights that come from each phase of the framework can develop a systematic way to understand sustainable high-performance in UIPs. The framework presented provided insights for each phase of a UIP's maturation. Each component of the framework can serve as a building block towards the processual design of an open innovation model for UIPs. Each component of the framework also serves as a starting point for each evolutionary phase of the partnership by looking at necessary requisites in the design, formation, and operation of a UIP. The factors necessary for success can be longitudinally defined for building sustainability into each phase block of a UIP.

Figure 20. **An Innovation Framework for Professionals Working with UIPs**

Based Upon the Empirical Research Findings of the CMD UIP



Adapted from: Plewa, C., *et al.* (2013) 'The evolution of university-industry linkages: A framework', *Journal of Engineering and Technology Management*, 30(1), pp. 21-44.

Chapter 7: Conclusions and Implications for Professional Practice

7.1 Main Conclusions for Professional Practice

Innovation is important in the knowledge economies globally. Open innovation programmes are important to add to an organisation's capabilities for new product and service development. Universities have long been an active partner in providing new knowledge for innovation. Historically, UIPs have been one main driver of new knowledge creation for innovation. Innovation professionals in industry and government want new models that can leverage knowledge creation for wealth and economic development. Creating partnerships that deliver extraordinary performance is important and sustaining that high-performance is the goal of innovation professionals. In this chapter, I will highlight some key points for innovation professionals in pre-formation, formation, operating and sustaining UIPs.

In partnerships involving UIPs, there are key pre-formation success factors that each partner should consider before engaging in discussions or negotiations. The benefits of a clear vision and purpose of the partnership allow for higher quality planning and discussions. The vision, purpose and deliverables should be mutually shared and defined by each partner. The importance of establishing a common bond and building trust will make the discussions and pre-formation activities easier to gain agreement. The implications for professional practice from the findings of the CMD UIP appear to be quite portable in their use in other UIPs that may be formed by innovation professionals. The factors for the CMD UIP that innovation professionals should consider will both address the quality of the UIP itself, but also the factors of creating possible success through defined and organised approaches. Each partnership should be planned out with key building blocks put into place that act as an organising process. In the framework I present, I suggest looking at the life cycle of the partnership as pre-formation and formation events that define and articulate the overall structure of the UIP. The operational processes and relationships should be outlined and demarcated so that each partner can maximise their time spent in the partnership. Define the reason for the UIP. You define the reasons for the UIP in your terms. The UIP from your definition should have major milestones to outline positive progress. At the end of the milestones, what is/are the ultimate objective(s)? What are the short-term and medium-term success definitions? What is the timeframe that you contemplate for the UIP to deliver on your required output(s)? The last element that became a very important factor in the pre-formation stage of the CMD UIP was putting key material issues on the table before negotiations started.

The factor of thorough and well-defined planning allowed the business and legal setup of the CMD UIP to be extraordinary compared to most UIP structuring and negotiations. The critical element in this factor was the business issues, and definitions take place first before engaging the legal side of the UIP agreements. Notable was the fact that the CMD UIP held discussions for more than 7months on business issues before engaging the lawyers to finish the CMD UIP agreement. The level of commitment is sincere, genuine and multi-level. These strong bonds create both engagement and durability in the relationship. This is important because as the UIP matures, there may be issues that arise. These partnership issues can threaten the UIP organisation. With clear and constant multi-level communications between UoL and Unilever, there wasn't any issue, problem or new knowledge discovery that couldn't be addressed.

Operate the UIP as if it were a business. The selection of people process was very long and specific for both UoL and Unilever. The other element that made the CMD UIP a business was the organisation, operations and methods of communications made it a 'quasi' industrial company. This was done in the CMD UIP agreement to ensure that both parties were serious in their commitment and support to the CMD UIP. This was also structured to make the process of NCE discovery more business-like because of the complexities of the emerging science.

There were two general global themes that emanated from the study: a) 'separate, but equal' and b) 'singularity of focus'. The 'separate, but equal' theme can be used to provide intellectual property protection for each partner. Establishing parallel operating facilities with world-class instrumentation is not redundant. The separate allows each partner to spend a lot of high-quality time in the laboratory. The corresponding element provides partners with abilities to stay current with the equipment, software and other technologies needed to keep on top of the science. Each partner had access to common laboratory and common areas, but each partner had to schedule their time in the natural laboratories. The common areas were for leisure, coffee discussions, etc. The common labs had the most leading-edge instrumentation for computational chemistry, and both partners could use this with equal access, but separate their timing of use. This scheduled separation was important learning from the CMD UIP as it protected confidentially for both partners. It also made the extension of confidentially to ensure that any intellectual property that could be created was properly protected, and b) the 'singularity of focus' drove the main reason for the CMD UIP of NCE discovery.

The singularity of focus was predicated on having a place (CMD) where chemistry researchers could work on chemistry problems without the distractions that both academic and corporate life brings daily. The agreed upon goal in the CMD UIP was to ‘protect' researchers from UoL and Unilever when they were researching the CMD. It was agreed that their only focus was science. The researchers would not be penalised for not participating in the daily grind when in the CMD. This was awkward at first, but over time the researchers in the CMD became part of CMD project teams that would more effectively communicate with other project teams at the conclusions of periods of CMD work. This was notable as the data suggests that more time spent on the problem in close working relationships with one focus have a higher tendency to be successful than a situation where the time spent is highly fragmented with other activities not related to the task at hand.

For the UIP professional practice some factors for industry to consider would be the following factors: 1) set up the industrial side of the UIP as a business operation, 2) use ‘separate, but equal' to structure the physical, operational and communication element of the daily corporate work environment, 3) treat your UIPs like a business operation within your company. When forming a UIP, the partnership should be viewed as an extension of your company's R&D departments. The research, operational and communication systems should be devised by all parties to integrate smoothly into each partner's organisational structure. The treatment of UIPs as part of an organisation's overall department helps to build lasting commitment to the UIP. Important learning from this study was to have a whole emphasis on the only goal. In the case of the CMD UIP, it was NCE discovery. Structure the operations, environment and working requirements of your researchers in such a way that the researchers are 100% free to do science with no repercussions from the organisation. The separate, but equal provided long periods of access to the laboratories, and the singularity of focus provided the quality of time. This devotion and physical set up on one element can't be more emphasised in the importance of efficiency of creative work. The constant distractions one would experience at corporate work or academic schools would seem to provide a very fragmented flow of work time and a lack of critical reflexive thinking that would be needed for such a complex subject.

In industry, buying capital equipment, CAPEX, is treated as a separate designation in accounting terms and has to be amortised over a certain number of years. This amortisation is usually 5-7 years and depends upon on the local and national government revenue laws. This depreciating of the instrumentation can lengthen the time that companies use the equipment. This is important as it would affect any company with limited budgets. If spending is tight, companies may reduce the CAPEX component of the budget or may delay upgrading much-needed capabilities of the instrumentation. Unilever stated during the research that it was too risky to buy the equipment itself without the laboratory scientists already in Unilever. As the COE model includes continued funding to keep the venue state-of-the-art, the benefits are great to an industry that may be hampered by financial or accounting issues relating to CAPEX. The CMD accessed important regional funding from the U.K and eventually E.U governments. The innovation funding schemes were an important contribution from the government to Unilever. Unilever was going through major reorganisation with its R&D programmes and funding for new programmes was low.

7.2 Implications for Governments and Innovation Policy

There were two very distinct governmental support strategies at play during the time of pre-formation and formation activities regarding the CMD UIP. The first governmental programme of support was a series of programmes and projects over a 20 year period that made the city region of Liverpool a more favourable target of inward investment schemes. That programme was the regeneration of Liverpool through Liverpool Vision, E.U. funding, The Grosvenor Liverpool One projects. The combined effort by the U.K. government to regenerate Liverpool to leading-edge technology and cultural city for the 21st century (Skyscraper.com, 2014; Liverpool Vision Master Plan, 2017). This was outside of the direct operations of the CMD UIP but had a strong influence in scoring possible new tenders relating to Liverpool and the universities (Pringle, 2005; Boardman, 2009; Barr *et al.*, 2013).

Building a city region also can create an ecosystem in which you can design innovation schemes into such as the Liverpool Vision Master Plan did. With multiple universities contained in the same regional plan, the university can contribute to the ecosystem being developed or the one that exists. This was true for the UoL CMD and CMD UIP. The timing of both the CMD pre-formation activities dovetailing with the early phases of redevelopment couldn't have been better timed by all parties.

The tenders submitted for the formation of the CMD UIP supported all three parties' goals for the UoL, Unilever and the city of Liverpool. UoL gained the start of world-class materials chemistry set of laboratories that would eventually become a COE for the Northwest of England. Unilever gained as it provided for expansion of its R&D capabilities for NCE discovery, create new jobs relating to the innovation work and establish a continued footing in the local economy. The city of Liverpool benefits as its universities move towards global top research universities, gain new job creation, raise wages and improve the quality of life as new people come to live and visit Liverpool. The governmental policies still today are continuing the original Liverpool Vision plans and have further spawned new UIPs based upon the CMD and CMD UIP model.

The evolution of the CMD UIP partnership framework has become to be known as the 'Liverpool Model'.

The second major implication from the CMD UIP regarding governmental innovation policies is the role that COEs can play. The U.K. has struggled in their abilities to stimulate successful science innovation programmes (Henry and Walker, 1992; Beise and Stahl, 1999; Lambert, 2003; NESTA, 2008; Harris and Albury, 2009; Meadway and Mateos-Garcia, 2009; von Tunzelmann, 2010). Interesting, since the mid-20th century, U.K. innovation funding and policy strategies have focused on supporting individual companies within key industrial sectors instead of the sectors themselves (von Tunzelmann, 2010; Owen and Hopkins, 2016).

HTS chemistry methods and computational chemistry science fields are an example of an individual area of several sectors such as pharmaceuticals, materials science, nanotechnology, consumer package good products (Unilever's CPG business groups). One important implication for government innovation policy should be to focus on how to advance the sector elements itself. The sector approach with regional COE strategies could be put into place for building and funding COEs and specialised institutes co-located with universities and not so much a company-by-company approach. For universities, establishing COEs is a model to establish new beachheads of knowledge or grow existing capabilities around a particular discipline. Universities create and diffuse knowledge and can help to address adsorptive capacity knowledge gaps with outside organisations through more formal COEs. Taking a broad stance on having multiple companies partner with universities can lessen the risks of failure and also increase the chances of successful outputs as you have more than one commercial partner (Fazackerley, Smith and Massey, 2009).

Chapter 8: Reflections of a Scholar-Practitioner

8.1 Reflections on My D.B.A Programme

I have found the DBA programme's processes and research thesis to be quite instructive in the way I approach life. I get up every morning and think a more holistically. The thinking has positively impacted my personal life through scholar-practitioner thinking, sensing and acting to address situations in my life. Understanding a scholarly and theoretical process has helped to frame inquiry, insights and analytical probing into everyday activities. This new approach to daily life has created a new range of perspectives that enlighten, redefine and forge new paths. In situations that are familiar to me, I have found that there are many new elements that present themselves and I can create new forms of information for knowledge creation. The most significant gift to my personal life has been a processual framework in which to think critically about my problems. As quoted by Cunliffe*…"The critically reflexive practitioner embraces subjective understandings of reality presented as a basis for thinking more critically about the impact of our assumptions"* (Cunliffe, 2004, p. 407).

In particular, this thesis study topic and the findings of the research have opened my eyes to a much broader set of perspectives about UIPs. The successful impact UIPs have on economic development and advancement of society. This has had a personal influence on my professional life. The daily work routine is not as challenged as it used to be as I appreciate the difficulties as a process of problematizing and solution seeking. This was one of the surprises for me concerning the overall programme. One approach was the process of the conceptualisation of the problem or *'problematising'* Problematising the situation and sorting through the various elements of the situation at hand is a critically reflexive approach to addressing a situation.

Problematising helps in defining the questions to ask so that answers can inform and enlighten. This process was a basic, but important learning from the D.B.A. programme. I used the problematising approach for professional practice with my innovation development teams, but it became apparent that the same process for work should be used for personal situations and choices. The first and foremost element that I regard highly from the D.B.A. programme has been the more scholarly and rigorous approach to my personal life. When confronted with a situation, like in professional practice, I will outline the situation and define the elements and questions I seek answers to. I'll research the situation and construct approaches for consideration. This approach now has become commonplace and used daily to address the varied conditions I face each day.

In conclusion, the D.B.A. programme has had a significant impact on my personal and professional life. This effect has been both the scholarly journey through the programme and research in my area of professional interests. The impact of the experiences of the D.B.A. programme has, in my mind, set the stage for continued life-long learning and application as a scholar-practitioner in personal and professional pursuits.

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Appendix A

Informed Consent, Recruitment and Researcher Bio

UNIVERSITY OF LIVERPOOL

INFORMED CONSENT FORM

Title of Research Project: The Sustainability Dimension of High-Performance Teams (HPTs) in University-Industry Partnerships/Collaborations of Science & Technology: What Drives Extraordinary Performance over Time?
Researcher: Neil Campbell

Please initial box

1. I confirm that I have read and have understood the information sheet dated 15 July 2013 for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my rights being affected. ☐

3. I understand that, under the Data Protection Act, I can at any time ask for access to the information I provide and I can also request the destruction of that information if I wish. ☐

4. I agree to take part in the above study. ☐

Participant Name	Date	Signature
Name of Person taking consent	Date	Signature
Researcher	Date	Signature

The contact details of lead Researcher are:

Researcher:
Neil j. Campbell c/o University of Liverpool Management School, Chatham Street, Liverpool, UK L69 7ZH.
Email: neil.campbell@liverpool.ac.uk UK PHONE: +44 (0) 7904699094

Version 1.0
15 July 2013
[NJC]

1 for subject; 1 for researcher

1

INFORMED CONSENT FORM
OVERVIEW OF THE PROPOSED STUDY

1. You are being invited to participate in a research study that is part of a doctoral thesis requirement for the Doctor of Business Administration (DBA) for Neil J. Campbell. There is additional interest in the study report on the findings of this proposed research to generate knowledge and frameworks for future University-Industry partnerships. The findings will be presented to the University of Liverpool and the Unilever Corporation to improve their university-industrial collaborative partnerships.

   The title of the research study is' **The Sustainability Dimension of High-Performance Teams (HPTs) in University-Industry Partnerships/Collaborations of Science & Technology: What Drives Extraordinary Performance over Time?**

   The purpose of the research study is to gain a deeper understanding of the extraordinary environment that makes up the University of Liverpool School of Physical Sciences, Chemistry and the Centre for Material Discovery (CMD) and its collaborative partnership with the Unilever Corporation that started in 2000 and has culminated with the new initiative Materials Innovation Factory (MIF) starting 2014. Most Uni-Industry partnerships have a much shorter duration and do not yield as many outcomes as this collaboration: so the question is why has this continued for so long and so successful for 13 years?

   The methodology of this research study will be participatory between the researcher and the participants whereby the researcher and participants will interact during the course of research study and the participants will have an evolving sense and participation of the findings/discoveries of the work being conducted. The research study approach will be a qualitative study using an interviewing approach of 2-3 in-depth, open-ended and semi-structured interviews conducted one-on-one with the researcher and conducted over a 3-6 month period of time. As the study findings emerge, the emerging information and themes will be shared and discussed with each participant through a variety of communication tools (face-to-face, email, blog, skype, etc.) The study is planned to commence in July/August, 2013 and is estimated to conclude in the January/February 2014 timeframe. The interviews will both be conducted in person or via audio/video link and will be digitally recorded for later transcription and use by the researcher.

2. **RISKS.** The estimated risks by your participation in this study are minimal and all information will be anonymised and masked and your identity in interview transcripts will also be masked. All materials will be secured digitally and any comments, quotations supplied by you during the interviews can be reviewed by you at any time.

3. **RIGHTS.** Your participation in this study is voluntary and you may withdraw at any time during the course of the study. If you refuse to participate or drop from the course of study, the actions by you would not carry any penalty to you. The study involves in-depth interviewing and digital audio recording of your comments to questions involving the collaborative CMD partnership between the University and Unilever.

4. **POSSIBLE BENEFITS.** As the extraordinary high-performance of the members of the collaborative partnership, known as the CMD or forerunner to the formation of the CMD, have been observed for almost 13 years between

University of Liverpool and Unilever are unprecedented compared to most collaborations. The knowledge generated and any frameworks or models resulting from such research findings may be massively beneficial to all universities and industry organisations. The focus of the study is to understand deeply the 'how', 'what' and 'why' the members of the CMD work so well together. The commercial outputs in the discovery of a large number of commercially-viable compounds have been noted and this output provides direct benefits to society and the partners. It is very important to understand the underpinnings of why this phenomenom has and is occurring for future programmes. From this study, it is anticipated that new knowledge and applications of this knowledge will be able to replicate future success in other collaborative partnerships such as the Material Innovation Factory (MIF). Your participation in this study can provide you and your research work new potential insights and applications for future collaborative endeavours.

5. **CONFIDENTIALITY.** Your individual identity will be kept confidential and assigned a neutral code name for all materials. You participation in this study through multiple interviews will also be kept confidential and any comments, quotations that may use to form thematic clusters of insights will be protected through this approach. You will have access to your recorded and transcribed comments/materials during the study and the researcher will share with you the on-going collection of data and progress during the study as you will have the chance to interact with the researcher as major new findings are occurring.

6. **DISSEMINATION OF RESULTS.** This study is in partial fulfilment of the requirements for the degree of Doctor of Business Administration by the researcher and as such, the findings of this research study will be compiled into a published thesis when completed. As the findings of this study could have broad and beneficial implications for all university-industry collaborative partnerships, the researcher will plan on publishing books, articles and may make presentations utilising the findings of the study. The researcher would ask that you provide support and the agreed release for the use of the participant's interview materials. Your identity and identifying marks will be kept confidential as mentioned in Section 5.

7. **COMPREHENSION AND LANGUAGE.** You, as the participant in this study, acknowledge that you have read and comprehend the purpose, scope of this study and that the language written in this Informed Consent Form is understood by you.

8. **CONTACT INFORMATION.**

Researcher:
Neil j. Campbell c/o University of Liverpool Management School, Chatham Street, Liverpool, UK L69 7ZH.
Email: neil.campbell@liverpool.ac.uk UK PHONE: +44 (0) 7904699094

Personal/Home: United States. 25242 Conrad Court, Damascus, Maryland, 20872, U.S.A., Email: neil@campbell-clan.com US PHONE: +1-301-792-4345

Research Thesis Advisor:
Dr. Murray Dalziel, Director of the Management School, University of Liverpool, Chatham Street, Liverpool, U.K. L69 7ZH.
Email: murray.dalziel@liverpool.ac.uk UK PHONE: +44 (0)151 795 3002

NEIL J. CAMPBELL

DBA STUDY PARTICIPANT RECRUITEMENT EMAIL

[DATE]

Dear [PARTICIPANT'S NAME],

My name is Neil Campbell and I am a scholar-practitioner who works in the research, development and Commercialisation of science & technology. As a practitioner, I am interested in learning about High-Performance teams (HPT) in the sciences and to witness extraordinary performance and discovery of seminal outcomes in quite amazing. As a scholar, I am continuing my academic interests and pursuing a doctoral degree in business administration (DBA) at the University of Liverpool. I am also an Executive in-Residence at the Management School and visit regularly to conduct my research and corresponding interests in the field of scientific discovery and commercialization.

The DBA Thesis I am working on is studying the long and extraordinarily successful collaborative partnership between the University of Liverpool and the Unilever Corporation and specifically the eventual formation of The Centre for Materials Discovery (CMD). The title of my thesis is: The Sustainability Dimension of High-Performance Teams (HPTs) in University-Industry Partnerships/Collaborations of Science & Technology: What Drives Extraordinary Performance Over Time? As part of this research study, I will recruit past and current members of the partnership from both the University and Unilever and conduct a research study of the partnership. This research format will be a series of 2 to 3, in-depth interviews.

You have been identified as a [PAST or CURRENT] member of the CMD and the partnership and I would like to invite you to participate in this very exciting and hopefully, knowledge generating, study of the unique and extraordinary sustained performance over 13 years of the University of Liverpool's CMD and Unilever partnership. Attached you will find my Bio for further reference on my background and experience as well as the Research Study Overview, Informed Consent Form and additional contact information for myself or my thesis advisor, Dr. Murray Dalziel, Director of the Management School, University of Liverpool.

I hope you decide to participate and I look forward to speaking with about the study and any questions you may have.

Sincerely yours,

Neil J. Campbell

Neil J. Campbell

President & CEO, SuperNova Diagnostics®, Inc.
Chairman & Managing Director, Mosaigen® Corporation

Neil J. Campbell is President and CEO, Co-Founder of **SuperNova** Diagnostics®, Inc., a privately held global diagnostics company with a proprietary bionanochemistry platform for conducting in-vitro diagnostics at the site of interest. SuperNova Diagnostics has offices in Washington, D.C., London and Hong Kong. Additionally, Mr. Campbell also serves as Executive Chairman for **Mosaigen**® Corporation, a global technology development corporation with offices in America, Europe and Asia, and Chairman for **Child Health Research Institute**, a global children's charity.

Mr. Campbell has more than 25 years of life science/healthcare/investment industry experience. Formerly, Mr. Campbell was a Partner for **Endeavour Capital**, an Asia/Pacific organization in the life sciences, cleantech and information communication technologies (ICT). He was previously President & COO/CEO for **EntreMed Pharmaceuticals** (Nasdaq: ENMD), a clinical-stage pharmaceutical company committed to developing a selective angiogenic kinase inhibitor, for the treatment of cancer. Prior to EntreMed, Mr. Campbell served as Senior Director of Commercial Development for **Celera Genomics** (NASDAQ:CRA), where he built global genomic & proteomic businesses around the human genome project. Mr. Campbell has held General & Executive Management positions at **Life Technologies**, Inc. (NASDAQ: LIFE), **IGEN**, Inc., acquired by **Roche** (NASDAQ:IGEN), and **Abbott Laboratories** (NYSE: ABT) the global diversified healthcare company. Mr. Campbell was also a member of the Faculty for many years of the Carey Graduate School of Business at the **Johns Hopkins University** and lectured in the **JHU Medical Institutes** as part of a joint business/medicine program. Mr. Campbell is now a visiting professor/research fellow at universities in the USA, Europe and Asia.

During his career, Mr. Campbell has successfully developed and/or introduced more than 275 products and services in the areas of high-performance computing, medical software, ecommerce, pharmaceuticals, medical devices, clinical & industrial diagnostics, consumer healthcare products, research products, bioinformatics and nanotechnology. Mr. Campbell serves on several industry, government, non-profit and company boards and is a well-published author on a wide variety of subjects relating to the research, development and commercialization of science and technology.

Mr. Campbell currently is pursuing his Doctorate from the University of Liverpool in the United Kingdom and earned his M.B.A. and M.A. from Webster University and his B.S. from Norwich University.

LinkedIn Profile URL: *www.linkedin.com/in/**neilcampbell**biotechit*

Appendix B

Interview Guide – Research Questionnaire

Interview Guide - Research Questionnaire.

The aims of the study questions were to gather information about the CMD to understand the major areas of any UIP, but in a context of this UIP and in particular the long duration (sustainability) of the CMD UIP. Each question had multiple directional points it could go and the qualitative interviewing was meant to develop fully the comments being made by each interviewee. For each question posed, the responses were facilitated without leading questions or cues to continue those thoughts and recreate where every possible some greater vivid recollection of the CMD.

- Q1: What is your positon within the CMD, how long have you been with the CMD?
- Q2: Describe for me the CMD in which you work? Tell me what comes to mind?
- Q3: How would you describe the structure of the CMD?

  Q4: How would you describe the working relationships amongst colleagues?
- Q5: Recreate a day in the CMD, how is this same and different from when you are working outside the CMD at UoL or Unilever?
- Q6: Tell me about your research projects, not the confidential technical information, but what you do relating to activities during the day whilst at the CMD?
- Q7: What is it that makes the CMD work the way it does? Tell me about those things you think make a difference?
- Q8: Do you believe what you do in the CMD is similar or different from work you do when outside the CMD?

- Q9: CMD has lasted a long time, would you say it is successful or not successful?

  - Do you believe the CMD has been successful? Explain what you mean by giving me examples of the successes.

  - If not successful, explain what you mean by giving me examples of the reasons for not successful.

- Q10: if you were to provide me with one word descriptors about anything relating to the CMD what would they be?

- Q11: Is there anything else you would like me to know that wasn't said previously or was said, but you wanted me to know more about it as it relates to the CMD?

Appendix C

Indicative Field Research Notes

[redacted]

and the direct impact of risk mitigation of R&D this together, provides for a synergistic system of management of the budgets and milestone and provides directly for gains in Capital Efficiency (CE)

R, D, C, Post Commercial

IPM

Shaded grey white areas

the highly counter-intuitive nature of MIPM is offered as one antecedent of why these

types of Structures/models don't exist within the realm of partnerships ⇒

Find God (REF) humans seek what is the path of least resistance and most obvious choices

- highly autonomous and dynamic systems (Chaos theory of Systems) tend to self-regulate and self-assemble into manageable systems over time but these self-regulating stability is constantly evolving over time
- MIPM provides a chaotic theory inside dynamism through structure environments that setup a perimeter around the scientific work and allows the cognitive and intellectual freedom to explore with boundaries, the researchers tend to self regulate their activities (WHY?)

UCI inspired IPR

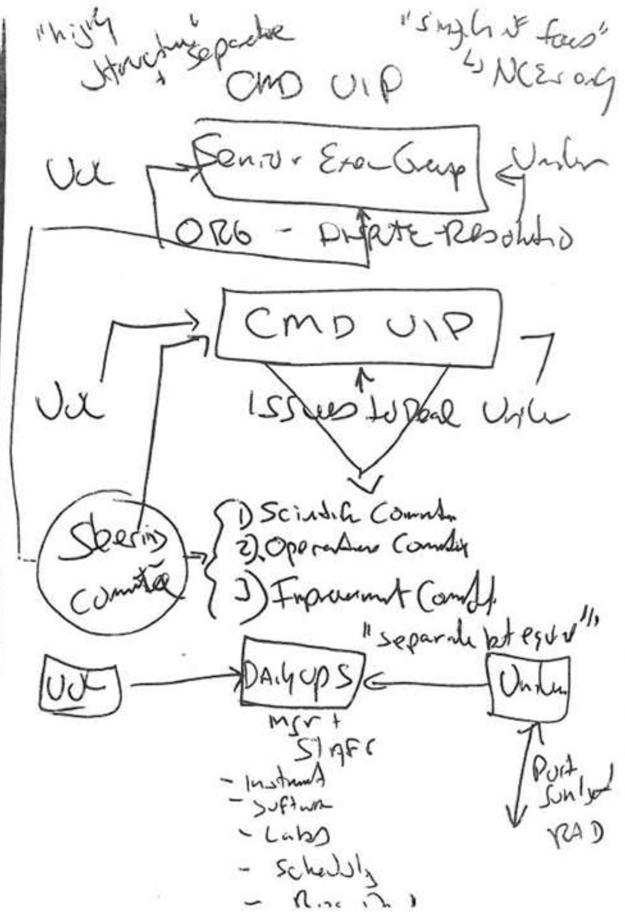
IPR Protection Approaches

- UIP: (1) Separate spaces
  (2) Controlled access
  (3) Space allocation
  (4) Space use record keeping

think?
(1) Clearbright
(2) Parkman
Bowler
(3) Bekkers - Bio

UIP Commentary: IPR

- separate servers / email
- Common areas for non-confidential discussion
  - coffee bar popular
- Locked, controlled access soundproofed meeting rooms
- CMD Lab next in, but separate from UCI School facilities



Appendix D

Non-Disclosure Agreement

THIS MUTUAL CONFIDENTIALITY AGREEMENT is made on **05/08/2013**

BETWEEN

(1) **THE UNIVERSITY OF LIVERPOOL** of [redacted]

(2) **Mr Neil Campbell** [redacted]

BACKGROUND

A Each party possesses valuable information, technical knowledge, experience and data of a secret and confidential nature which may be regarded as assets of scientific, clinical and/or commercial value and wishes to enter into discussions of mutual interest.

B In the case of these discussions each party ("the **Disclosing Party**") is willing to disclose such information to the other ("the **Recipient**") for the Provision of evidential documents and commercial contracts relating to the Centre for Materials Discovery, for the purposes of research entitled "the Sustainability Dimension of High- Performance Teams (HPTs) in University- Industry Partnerships/Collaborations of Science & Technology: What Drives Extraordinary Performance over Time? " (the **"Specified Purpose"**) on the terms and conditions of this Agreement.

IT IS HEREBY AGREED as follows:

1. CONFIDENTIAL INFORMATION

"Confidential Information" shall mean all information or data (including all oral and visual information or data and all information or data recorded in writing or in any other medium or by any other method) disclosed to or obtained by either party whether directly or indirectly from the other party and without prejudice to the generality of the foregoing definition the term "Confidential Information" shall include but not be limited to any data, technical information, know-how, formulae, ideas, processes, programs, information ascertainable by the inspection or analysis of samples, and any information relating to either party's operations, plans, processes, trade secrets, intentions, know-how, design rights, software or business affairs.

2. OBLIGATIONS OF THE PARTIES

2.1 In consideration of the disclosure of Confidential Information by either party to the other, each party shall treat as strictly confidential and not divulge to any third party any of the Confidential Information disclosed by the other and shall not make use of any such Confidential Information without the other's prior written consent other than for the Specified Purpose in accordance with this Agreement.

2.2 In the event of either party visiting the establishment of the other, the visiting party shall ensure that any further Confidential Information which may come to its knowledge as a result of any such visit, shall be kept strictly confidential and will not be divulged to any third party and will not be made use of in any way by the Recipient without the other's prior written consent other than for the Specified Purpose in accordance with this Agreement.

2.3 The Recipient shall take such precautions and make such arrangements as are reasonably necessary to protect the Confidential Information and, in any event, shall protect the Confidential Information with no less than the degree of care which the Recipient uses to safeguard its own confidential information.

3. OFFICER/EMPLOYEE OBLIGATIONS

Each Recipient shall only allow access to the Confidential Information to those of its directors and employees that need to have access for the Specified Purpose and then only on condition that such directors and employees as are bound by strict obligations of confidentiality or have first agreed to observe the provisions of this Agreement to be bound by the confidentiality and use terms within it.

4. LIMITATION

The obligations of confidentiality under clause 2 above shall not apply to the disclosure, treatment or use of any part of the Confidential Information which the Recipient can by evidence in writing show:

4.1 is in or comes into the public domain in any way without breach of this agreement by the Recipient;

4.2 was lawfully in the possession of the Recipient at the date of this Agreement;

4.3 was obtained lawfully and properly after today's date otherwise than directly or indirectly from the Disclosing Party; or

4.4 is disclosed by the Recipient in accordance with the prior written approval of the Disclosing Party; or

4.5 is required by law or by court or administrative order to be disclosed; provided however that the Recipient shall have first given prompt notice to the Disclosing Party of such required disclosure.

5. FREEDOM OF INFORMATION

The parties recognise that the University is subject to the Freedom of Information Act 2000 ("FOI") and the Codes of Practice issued under the FOI as may be amended, updated or replaced from time to time. In the event that the University receives a request under the FOI to disclose any Confidential Information provided by **Mr Neil Campbell** under this Agreement it shall notify **Mr Neil Campbell** of the same and **Mr Neil Campbell** shall respond within five working days of the University's request for assistance in order to determine whether or not an exemption to the FOI applies.

6. NO LICENCE

No licence to either party of the Confidential Information or under patents, trademarks, copyright or any other intellectual property rights is granted or implied by the disclosure of Confidential Information under this Agreement except as expressly stated.

7. TERM

The parties agree that after five years from the date hereof, they shall be relieved from all obligations under this Agreement.

8. GOVERNING LAW

This agreement is subject to the laws of England and both parties hereby submit to the exclusive jurisdiction of the English Courts.

Appendix E

Indicative Manual Transcription Raw Pages

Pre-Interviewing

DBA Pre-Interview **Preliminary Research Interviews** **Profile Name: Praxis 1**

Conducted with Dr. [redacted] **of University of Liverpool**

1 July 2013 [REDACTED]

Start of Interview

[redacted]: I'd be happy to discuss the partnership with you.

NC: we've had this discussion about what you and [redacted] have seen together and far into the future. You have been part of this project for 13 years now with the beginnings in 1999. Can you describe how the relationship started and the people involved from the beginning to the creation of the Centre for Material Discovery which I will refer to as "CMD" going forward?

[redacted]**:** I knew [redacted] before when he was at **Unilever**, but I did not know him that well. Mostly being done on chemistry work.

NC: what I am curious about is what scientists don't do; [redacted] were champions of a potential project in chemistry. At the time you started this project could you have envisioned that it would last the 13 years it has and maybe a lot longer.

[redacted]**:** when we started to have discussions about the **University** and **Unilever** working together in chemistry, I had known [redacted] for about 2-3 years, but I wouldn't say I knew him very well. We taught a class together and some interactions with post-docs. We got on very well and [redacted] is someone who seems to always have a strategy and sometimes he can plan ahead too well. The work was mostly in longer term element from the **Unilever** side and they had been doing things over and over again with not much luck. He [[redacted] felt that there had to be a better way to do chemistry research and this started our discussion about the CMD, this was around 2000. [redacted] We setup the CMD through the ESPRC funding proposal and wrote up what we thought would be a great proposal. The proposal was for £2.5M with Manchester to build up a high-throughput drug screening and chemistry. Combi-chem, when I was just appointed in late 1999, we outlined a center for material discovery around the high-throughput chemistry. There was a second proposal stage and we ended in 4th from the top two. One of the main feedback was you can't do it [the chemistry discovery] between two universities and it became a top priority in my career. I'm there was two main feedback points: 1) the request is not enough for this type of work across two sites. We needed to have more than £2.5M in our request and the 2) was the reviewers wanted it to be based at one site with all focus on that site's activities. The conclusion I came to was I needed to talk to [redacted] **Unilever** had provided a letter of support, but no commitment to money or true partnership at that point. So I started to talk to [redacted], something better, something bigger. What was interesting was we did not write a proposal for a new strategy, but we wrote a funding proposal to the Northwest Funding Agency and they were the regional fund, there is a long story (WDA), but I won't give you the whole story. The WDA was all over the place and doesn't exist today. They [WDA] provided funding support for projects all over the place from early to later stage work. We tried as we had no money,

Appendix E

DBA Pre-Interview **Preliminary Research Interviews** **Profile Name: Praxis 1**

Conducted with Dr. [redacted] of University of Liverpool

1 July 2013 [REDACTED]

Start of Interview

[redacted]: I'd be happy to discuss the partnership with you.

NC: we've had this discussion about what you and [redacted] have seen together and far into the future. You have been part of this project for 13 years now with the beginnings in 1999. Can you describe how the relationship started and the people involved from the beginning to the creation of the Centre for Material Discovery which I will refer to as "CMD" going forward?

[redacted]**:** I knew [redacted] before when he was at **Unilever**, but I did not know him that well. Mostly being done on chemistry work.

NC: what I am curious about is what scientists don't do; [redacted] were champions of a potential project in chemistry. At the time you started this project could you have envisioned that it would last the 13 years it has and maybe a lot longer.

[redacted]**:** when we started to have discussions about the **University** and **Unilever** working together in chemistry, I had known [redacted] for about 2-3 years, but I wouldn't say I knew him very well. We taught a class together and some interactions with post-docs. We got on very well and [redacted] is someone who seems to always have a strategy and sometimes he can plan ahead too well. The work was mostly in longer term element from the **Unilever** side and they had been doing things over and over again with not much luck. He [[redacted] felt that there had to be a better way to do chemistry research and this started our discussion about the CMD, this was around 2000. [redacted] We setup the CMD through the ESPRC funding proposal and wrote up what we thought would be a great proposal. The proposal was for £2.5M with Manchester to build up a high-throughput drug screening and chemistry. Combi-chem, when I was just appointed in late 1999, we outlined a center for material discovery around the high-throughput chemistry. There was a second proposal stage and we ended in 4th from the top two. One of the main feedback was you can't do it [the chemistry discovery] between two universities and it became a top priority in my career. I'm there was two main feedback points: 1) the request is not enough for this type of work across two sites. We needed to have more than £2.5M in our request and the 2) was the reviewers wanted it to be based at one site with all focus on that site's activities. The conclusion I came to was I needed to talk to [redacted] **Unilever** had provided a letter of support, but no commitment to money or true partnership at that point. So I started to talk to [redacted], something better, something bigger. What was interesting was we did not write a proposal for a new strategy, but we wrote a funding proposal to the Northwest Funding Agency and they were the regional fund, there is a long story (WDA), but I won't give you the whole story. The WDA was all over the place and doesn't exist today. They [WDA] provided funding support for projects all over the place from early to later stage work. We tried as we had no money, then there was money in the WDA and then it died again several times. And then they [WDA] came back and said we would like to support your plans. At the same time we also went to the ERDF (European Research & Development Fund) all of which was very complicated at the time. We wanted a chuck of the money, a 4-way proposal it became 1) **University**, 2) **Unilever**, 3) WDA and 4) the ERDF. It was three direct stakeholders and the ERDF I suppose was the 4th.

NC: Was this European money tied to a matching, right?

[redacted]**:** Yes, we sort of matched the overheads. The **University** put the money in and put staff time in. the whole fit was setup in an enormously complicated way and the CMD had one, maybe two, at least one person who worked on this. It was an incredibly inefficient way to do business; they wanted to see a room so they could inspect the carpet and another room. I asked 'don't you want to see the equipment we have as it was about £4M, but they said "No" we want to see the carpet. We went into the office, looked at the floor and ticked a box. The Bureaucracy for those things was nuts.

NC: what time frame was this process?

[redacted]**:** the timeframe was a very long time. The funding received in 2007, started building in 2005 and over the years from 2000 to 2005 we kept trying to find the funding; all the while, [redacted] kept it alive in **Unilever** and I kept it alive here, [redacted] were two strong supporters before [redacted].

NC: why was [redacted] supportive in this?

[redacted]**:** in general [redacted] was very supportive; in fact, [redacted] is a very supportive guy. [redacted] is on of those guys who have a tendency to back an idea if he thought it is a good. He saw the industry link a good thing and the CMD was a new idea in the field. He was very supportive. I don't remember discussing the strategy with him, ah; yes I did discuss the strategy with him. I doubt he didn't see it going as far as it did, I know I didn't. Back in 1997 we had a little equipment, not too good and we didn't really do materials chemistry, actually it was not very good at all[redacted] was a geneticist. The **University** did realize that possible benefits existed by linking with **Unilever** and there had been attempts as linking with **Unilever**. The reason they failed, this is where I have some insight. We would get together, share project data, talk about what both sides were doing. We would then go away and nothing would happen. This is typical. They did this for a couple of years and nothing took off. The matching of people is important. The importance of getting people together who want to do some is important. One important thing I learned about from this is you can't force people together to do this. People are either hit it off and a common view or they don't. What you need is 100 meetings of that type before you get one match. You need to do a lot of them, the hit rate is low.

NC: the frequency?

[redacted]**:** I go to conferences; at least one in four was a waste in time. One in four possibly good. You don't know which one is really good. I come back after a week and say, 'that wasn't a good time spent' other times, I come back and the meeting was good.

One thing I learned from this was the importance of management to encourage people to do big things. If I thought the VC was just spinning a line and after the second time failure of the WDA I would have packed it in. you can't have people going out on a limb if they think no one will care. That is actually the biggest learning point, senior people backing these big visions; you need two types of people, the people at the bottom wanting to do this and have a vision and the senior people supporting and encouraging the organization to keep doing it. These bigger visions take a while to produce and a lot can happen along the way to stop it. And very often, org get restructured, one thing that was unusually, if there had been a major change at either the **University** or **Unilever** this thing would have been dead.

NC: at one level you have the VC vision, your vision, **Unilever**'s vision but how do you keep it going and in the same direction and keeping alive the original vision that motivated all of you to do this?

NC: how did the motivation keep going, how did you coordinate this with the University and what did **Unilever** do?

[redacted] yeah, something I did quite well was articulate this to the senior management, we had a simple way of communicating the project: 'it was **about both sides getting to a solution quicker on their own requirements and needs**. If high throughput, it is not a difficult sell. Everybody get that, it's about accelerating research, and I spent a lot of time talking with [redacted]. We spent a lot of time talking about what the CMD would do and the benefits it would have over the present situation at both ends [**University** & **Unilever**].

NC: Was there a grant vision? Was there a plan for the **University**? Did the **University** have a grand plan for what they wanted to do and you just implemented it or was it something quite different?

[redacted]

NC: you said you had an idea as time went on, why did you stay after so many failures?

[redacted]**: Confidence,** to be honest, if you take the mad egotistical approach that everything will work is mad. There are so many reasons that the project could fail and to extrapolate these was mad. I thought about it and it seemed that it would work and I wanted it to work out. If it didn't work out, I would have to move. Thinking about CMD 1 and then CMD 2 where things have come; you know, hanging in the balance was hard to do. **Another lesson that I learned is it is hard to think about your next or future plans if you only have a 5% chance of success. It is very hard to envision or work towards continuing goals if the current ones are on shaky ground. It is very hard to work and plan for the future when nothing is certain. .** <u>**It is easier to aim high, if you don't feel that bottom fall out of the boat is not going to fall out. It is not easy if you are working hand-to-mouth. Top research places support bigger research visions and that is what makes them top.**</u>