

What policy initiatives are required to develop a knowledge-based economy in Ireland?

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Declaration

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Summary of Methods and Major Findings

A qualitative case study research design was implemented to investigate the necessary policy initiatives and requirements to develop a knowledge-based economy within the unique system represented by Ireland's small-scale economy. The case study approach was chosen with the case being Irish policy makers and the managers and CEOs of manufacturing companies in Ireland. The case study approach is best when one wishes to examine in detail a group, setting, place, organisation, etc. wherein a situation has occurred, is occurring, or will occur (Yin, 2014). The epistemological approach used in this research was empirical/interpretivist. The very nature of the interview-based approach means that the researcher will be interpreting the data, not just reporting it.

The participants in this study were all managers or chief executive officers of companies or policy related entities in Ireland. The goal of the study was to elicit their perspectives regarding changes to a knowledge-based economy in Ireland, with its advanced manufacturing base as a springboard. The nature of the interview questions asked allowed them to share a broad range of perspectives. Seventeen face to face interviews were conducted resulting in a large, complex data set. In the course of the interviews, a free-flowing, semi-structured, open-ended approach was employed to ensure that no pertinent information would be missed, which could call into question the validity of the study.

The research questions for this study are essentially subjective in nature, as they ask for recommendations, predictions for the future, assessment of possible outcomes, and so forth—all complex and subjective concepts. The data collected were, as a consequence, “messy”—the researcher needed to conduct several stages of thematic coding and analysis to organise and present it.

This study produced excellent and usable data to answer the research questions. The approach of interviewing high-level stakeholders in advanced manufacturing firms proved to be fruitful. Analysis of the data obtained from the transcribed interviews revealed the following three overarching themes: Development of advanced manufacturing, policy environment, and the building of a knowledge-based economy. The first theme was that advanced manufacturing was still being developed but had reached a mature phase in the Irish economy. The second theme was that Irish policy should be dedicated to easing the transition to a knowledge-based economy but for a variety of reasons, that policy was not yet consistent toward that goal. The third theme was that the building of a knowledge-based economy was a necessity and would probably occur with or without government policy intervention, however, it could be done more smoothly with the active collaboration of government and other stakeholders. Upon further analysis, subthemes subsequently emerged that correlated with the three overarching themes. As such, the development of advanced manufacturing theme included the subthemes of definitions and critical skills, whereas the policy environment theme included the subthemes of education and government policy. The final theme of building a knowledge-based environment incorporated the subthemes of human capital, culture, colocation, and innovation. Overall, the findings revealed that advanced manufacturing played an important role in building a knowledge-based economy. This finding was not inconsistent with the premise that advanced manufacturing may become less important in the Irish economy if the transition to a knowledge-based economy is accomplished.

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List of Abbreviations

AMT	- Advanced Manufacturing Technologies
CEO	- Chief Executive Officer
CES	- Centre for Economic Studies
DICE	- Database for Institutional Comparisons in Europe
DJEI	- Department of Jobs, Enterprises, and Innovation
EI	- Enterprise Ireland
EPTR	- Export Profits Tax Relief
EU	- European Union
FDI	- Foreign Direct Investment
GDP	- Gross Domestic Product
HR	- Human Resources
I2E2	- Innovation for Ireland's Energy Efficiency Centre
ICMR	- Irish Centre for Manufacturing Research
ICT	- Information Communication Technology
ID	- Identification
IDA	- Industrial Development Authority
IPRG	- Industrial Policy Review Group
IP	- Intellectual Property
IT	- Information Technology
KBE	- Knowledge Based Economy
MNC	- Multi-National Companies
NESC	- National Economic and Social Council
NSE	- Neo-Schumpeterian Economics
NUI-G	- National University of Ireland - Galway

OECD	- Organisation for Economic Co-operation and Development
PLM	- Product Lifecycle Management
R&D	- Research and Development
SBIR	- Small Business Innovation Research
SME	- Small to Medium Enterprises
UAE	- United Arab Emirates
UCD	- University College Dublin
UK	- United Kingdom
US	- United States of America

Summary

The word manufacture first appeared in English literature around 1567 and is derived from two Latin words, *manus* (hand) and *factus* (make) and the combination of these means literally made by hand (Groover, 2007). A large body of work exists examining the evolution of manufacturing, from agrarian society, through the Industrial Revolution (circa 1780-1840), innovation in product processes such as the assembly line from 1913 by Henry Ford, increases in productivity and quality driven by the World Wars and in the latter part of the 20th century by Japanese manufacturers. From the late 20th century onwards the literature begins to reflect the changes that advanced manufacturing technologies were having on the traditional manufacturing processes (du-Feu, 1988; Karwowski & Salvendy, 1994) and the argument intensified as to whether or not a services based, post-industrial economy, relying on the economics of information is the natural successor to the prevailing industry based economy, which relied on the economics of goods (Bell, 1973); (Cohen & Zysman, 1987). There is a significant contribution to be made by research into the nature of advanced manufacturing, its continuing evolution, and its relationship and integration with service-based industry.

The literature suggests that in both developed and developing economies worldwide, building a knowledge-based economy is a high policy priority for governments. Most developed economies now operate with a much-reduced traditional manufacturing sector and an increased service sector. Even traditional manufacturing has taken on many service-based attributes. Decades ago, manufacturing output relied on an employee doing “whatever they were told to do, day after day, adding very little individual value within the highly standardised labour processes of the production line” (Neef, 1999). As technology enabled the digital and knowledge-based economies to grow rapidly, so too technology had a large impact on the evolution of manufacturing theory and the manufacturing function within companies, rendering the original definition of manufacturing all but redundant. Soon, “the indicator for progress in manufacturing matters was the degree of exclusion of human beings in all stages of manufacturing” (Wobbe & Charles, 1994). However, as manufacturing continues to evolve, the integration of technologies has been placed in the correct context so that “discussions about advanced manufacturing today centre around the integration of three factors: people, organisation and technology and the dynamics between them” (Wobbe & Charles, 1994).

In the most recent decade, rather than using traditional inputs such as raw resources, real estate, or capital investment, knowledge is the primary input of knowledge-based economies (Jacob, 2014). In altering the economic inputs and goals, the emergence of knowledge-based economies (KBEs) as a primary economic model necessitated change to social, political, scientific and technological processes (Melnikas, 2012). This dissertation discusses studies relevant to the emergence of KBEs, including topic such as factors key to KBE success, political and social challenges, managing KBEs regionally, the manufacturing and service sectors in KBE, and the specifics of Ireland's KBE.

The Irish economy was largely supported by agriculture and low-tech manufacturing industries until the late 1990s and early 2000s when the economy became increasingly supported by high-tech manufacturing and service sectors (Hazelkorn & Massar, 2011). Ireland's national policy of supporting higher education led to a highly-educated workforce which subscribes to the national narrative encouraging innovation (Lolich & Lynch, 2016). The purpose of this study is to investigate the necessary policy initiatives and requirements to develop a knowledge-based economy within the unique system represented by Ireland's small-scale economy. Ireland is one of the most FDI-intensive economies in the OECD and beyond. Foreign affiliates account for almost 50 percent of manufacturing employment and 80 percent of manufacturing value added, around twice the equivalent EU countries (Barry, 2012). The changing economic landscape was identified as increasingly supported by a knowledge-based economy that required new strategies from the government. The nature of this study was then identified as qualitative and informed by a case study research design. The results of this study provided confirmation that advanced manufacturing played an important role in building a knowledge-based economy.

The data analysis confirmed that advanced manufacturing played an important role in building a knowledge-based economy. Ireland offered a unique context for studying this phenomenon, because of its history in building up advanced manufacturing and position as a hub for multinational companies. This study produced excellent and usable data to answer the research questions. The approach of interviewing high-level stakeholders in advanced manufacturing firms proved to be fruitful.

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Chapter 1: Introduction

In the early 2000s, Ireland's economy experienced a paradigm shift in response to technological advancements that laid the groundwork for an economy increasingly supported by knowledge-based services (Hazelkorn & Massar, 2011). The knowledge-based sector of a national economy includes information technology, information processing, data storage, and the technical and academic training and educational facilities necessary to create a workforce competent to work within that new sector. Ireland's changing economic landscape specifically impacted the competitiveness of manufacturing industries, whose growth started to decline in the early 2000s and continued to decline as a result of the global financial crisis (Forfás, 2013). The emphasis gradually moved away from heavy manufacturing, as Ireland was not particularly well placed to compete in the global marketplace for those products. According to research conducted by Forfás (2013), Ireland's former national policy advisory board for enterprise, trade, science, technology, and innovation, changing consumer demands, technological advancements, and increased competition related to globalisation were ushering in three new types of manufacturing factory models: smart, virtual, and digital. All three of these technologies involve a significant amount of information processing. Smart factories allow for flexible customisation of process automation, involve simulation technologies, offer greater options for sustainable manufacturing, and are underpinned with information communication technology (ICT). Virtual factories are frequently cloud-based, built on ICT systems, and involve complex global operation networks functioning as one. As an example of a leading virtual factory environment, the Intel 'copy exactly' process means that each fabrication facility within the Intel manufacturing and test network must operate with the exact same installed equipment base, configured in exactly the same way and with products manufactured using exactly the same process to facilitate total consistency of product irrespective of the manufacturing source site. Digital networks incorporate more simulation

than virtual factories and facilitate enhanced product lifecycle management (PLM). As the global recession of the first decade of the 21st century came to a close, Ireland was faced with the necessity to transition its somewhat obsolete manufacturing sector into an advanced manufacturing sector—one that employed the above mentioned digital technologies.

Although Forfás was dissolved in 2014, its policy functions and research capabilities were incorporated into the Department of Jobs, Enterprises, and Innovation (DJEI). To that end, the DJEI Enterprise 2025 (2015) provided a strategic framework for consistency across government agencies focused on facilitating sustainable enterprise growth and jobs between 2015-2025. The DJEI recognised the need for a transition to an advanced manufacturing base and that the government would need to create policy that specifically fostered innovation and intellectual growth. As shown in Table 1, part of the strategic framework included enhancing innovation in enterprises, which involved the government adopting new strategies for science, technology, and innovation that fostered the development of highly skilled researchers.

Table 1.1: DJEI Enterprise Strategic Framework for Innovation Policy 2015-2025

Key elements of innovation policy between 2015-2025	
Enhancing innovation in enterprise	Building on existing research capacity and infrastructure, ensuring that a broad base of support is in place across the full continuum of research and including at the higher (closer to market) Technology Readiness Levels; Exploring the options for a cross government ‘grand challenges’ approach that ‘creates’ a market for innovative products and services and addresses specific national priorities; Using the State’s circa €8.5 billion procurement budget to stimulate innovation in SMEs to develop solutions to meet the needs of the public sector including through rolling-out further Small Business Innovation Research (SBIR) initiatives; Ensuring that Ireland’s Intellectual Property (IP) framework remains fit for purpose and stimulating an increase in activity by enterprises across all forms of IP;

	Promoting innovation in services and business processing with measures tailored to the unique characteristics of this activity; Ensuring supply of researchers and human capital to underpin an innovative enterprise sector; Promoting greater collaboration between enterprise and HEIs including increased mobility between industry and academia. Establish appropriate governance and institutional arrangements to facilitate a cross government approach to implementation of the SSTI so as to create a dynamic, cohesive and well-functioning national innovation ecosystem that delivers economic and societal impact and outcomes. Achieve a 30 percent increase in the number of Irish and foreign owned enterprises with innovation activities of scale, and broaden the base of RD&I activity in Irish based enterprises generally. Monitor our R&D Tax credit offering to ensure it has an appropriate impact on R&D activity in enterprise, is internationally competitive, is attuned to evolving enterprise sectors and activities is not overly complex or administratively burdensome on business and to ensure clarity and consistency for enterprise. Drive participation in EU and international research programmes in areas of relevance and impact to the economy and enterprise base so that we achieve the ambitious target of €1.25bn for Horizon 2020, led by the national support network based in Enterprise Ireland. Deliver the ex-post evaluation of the FP7 programme and ex-ante evaluation of Horizon2020 so that we take the necessary and appropriate actions to maximise potential and impact towards the target of €1.25bn drawdown by 2020.
Facilitating a culture of innovativeness across all of enterprise	The introduction of Lean principles and approaches to problem solving and including manufacturing and services activities; Broadening the reach of programmes catering to management development for the innovative enterprise; Stimulating cross industry-research community mobility through for example, secondments and placements. Ensure our regulatory environment remains sufficiently agile in an increasingly disruptive innovative environment to accommodate sectoral development and emerging areas of potential.

Strengthen the role of NSAI as a crucial element of Ireland's sectoral and innovation ecosystem, by promoting the benefits of standards to the widest cross section of industry and ensuring that its focus is aligned with Enterprise Policy 2025 and informed by the future needs of enterprise.

Raise awareness of the importance of standards in the context of RD&I and encourage more companies to participate in the standards setting process.

Source: Adapted from DJEI Enterprise 2025: Ireland's national enterprise policy 2015-2025.

Since the DJEI outlined specific strategies for addressing issues related to a knowledge-based economy, it is important to explain exactly what a knowledge-based economy is. According to Cook and Leydesdorff (2006), although economists such as Schumpeter and Marshall identified knowledge as one of the most powerful means through which economies flourish, the concept of a knowledge economy initially emerged within the context of economic productivity analysis. Then, in the 1950s, policy makers and economists came to the realisation that the traditional economic factors of labour, land, and capital no longer offered sufficient explanations for the continued growth of Western economies (Cook & Leydesdorff, 2006). While the importance of knowledge as it related to economic growth started garnering more attention in the 1950s, it was not until 1962 when the concept of a knowledge economy was operationalised by Fritz Machlup, a pre-eminent Austrian-American economist. Accordingly, "Machlup classified knowledge production into six major sectors: education, R&D, artistic creation, communications media, information services, and information technologies" (Cook & Leydesdorff, 2006). Ultimately, studies into knowledge-based economies are directed at both human capital as well as knowledge factors characteristic of economic sectors.

The concept of a knowledge-based economy takes into account that human capital, as in the sum of the knowledge of workers in that economy, is the primary driving force behind

productivity and output. This is not dissimilar to the classic Marxist view of the means of production, such as factories, being the mechanism via which products were made. The only real difference in a knowledge-based economy is that knowledge itself is both capital and product; for example, a firm's primary output may be software (Cook & Leydesdorff, 2006). The need for a transition to a knowledge-based economy is based on the fact that knowledge is the single most valuable product that can be produced in a modern economy, though certainly, it could be plausibly argued that this has always been the case and that only recently has that been acknowledged. Moreover, a knowledge-based economy is based on human capital rather than raw materials and other such resources, making the transition feasible for Ireland, a nation whose primary resource is the skill, knowledge, and diligence of its people.

This chapter provides an overview of the study. The remaining sections in this chapter will begin with an overview of the study. The next section includes the research questions, which is then followed by a section that outlines the theoretical framework informing the study. Then, the nature of the study and the research design will be discussed. The final section will outline the research findings.

Overview

The purpose of this study was to investigate the necessary policy initiatives and requirements to develop a knowledge-based economy within the unique system represented by Ireland's small-scale economy. This examination was done within the context of Ireland's ongoing transition to a knowledge-based economy, a fundamental premise being that such a transition was in progress and inevitable and that therefore, the only real question was how policy would be created and enacted to accelerate or inhibit the process. The research objective was to discover the relationship between knowledge-based economies' installed base of advanced manufacturing and industrial policy within the context of multinational

companies, both foreign direct investment and indigenous. The data was gathered by interviewing CEOs and senior managers of advanced manufacturing companies in Ireland and senior executives responsible for the development and execution of industrial policy. Interviewees provided information about policies and practices necessary to create and sustain this type of economy through the building of an advanced manufacturing foundation.

Research Questions

1. What policy initiatives are required to develop a knowledge-based economy?
2. What is the contribution that a base of advanced manufacturing can make in the development and sustaining of a knowledge-based economy?
3. In the context of Ireland, what policy initiatives are best positioned to assist in the development of a knowledge-based economy?

It is important to realise that there are two transitions being considered here. The first is the already accomplished transition from traditional heavy manufacturing to advanced manufacturing—that is referred to in Research Question 2. Within that framework, advanced manufacturing is defined as manufacturing using partially or wholly computerised facilities, including the use of robotics. The second transition is away from manufacturing altogether and toward the production of knowledge as Ireland's primary product. It is important to realise that not all of Ireland's policymakers and stakeholders agree that this second transition is necessary, inevitable, or even desirable. One salient aspect of this research was to find out how these practitioners felt about that potential transition and its impact on their business or on the status quo of their policy organisations.

Theoretical Framework

The theoretical framework informing this study was grounded in Neo-Schumpeterian economics (NSE). NSE provides an appropriate lens through which to study changing

economies (Hanusch & Pyka, 2007), which is especially useful for analysing the impacts that technological advancements have had on the rise of knowledge-based economies (Sledik, 2013). Moreover, an NSE perspective enables researchers to focus on the economic changes that result from the introduction of innovations and novelties, such as those associated with technology (Hanusch & Pyka, 2007).

The NSE perspective also allows for the consideration that knowledge is as much a product of a modern economy as goods from the primary or secondary sectors. In other words, it's somewhat intangible nature and the difficulty of measuring it in terms of output do not preclude its value (Sledik, 2013). This theoretical framework is particularly useful when discussing policy, because one of the obstacles that countries face when transitioning to a knowledge-based economy is that stakeholders and policymakers may not consider knowledge to be a "real" or tangible product (Sledik, 2007). Moreover, innovation, though a vital part of a knowledge-based economy, may not be seen by all as such but rather it might be seen as a by-product rather than as essential component of such an economy (Hanusch & Pyka, 2007).

Therefore, the NSE framework provides an excellent lens through which to view the situation. Economies evolve, but not everyone is comfortable with such evolutions, particularly since there are always winners and losers in such transitions. The Irish advanced manufacturing sector may eventually be a victim of such a transition, as much as its traditional manufacturing sector was previously negatively affected by changes in the countries cost base, by the global recession and the need to transition to advanced manufacturing. The essential premise of NSE is that the very nature of capital, output, and economic value may change when an economy is in transition. This is certainly happening in Ireland, and the interviewees in the study have first-hand knowledge of the situation.

Nature of the Study

This study was qualitative in nature and was guided by a case study research design. The rationale for this choice was that the case study approach provided the opportunity for detailed study of the modern phenomenon of a knowledge-based economy using real contextual evidence from those working directly in the field of interest (Yin, 2009). Case studies provide a means to examine a situation in depth by gathering data from a site or group where the situation is occurring (Yin, 2009). The original methodology proposed was a holistic single-case design with the unit of study as a multi-national company operating in Ireland. The research proposal was to explore how these companies would use the existing advanced manufacturing system to build a knowledge economy within the country; however, the availability of the actual collected data demonstrated the need to shift from an analysis based upon a single-case study design to a thematic analysis. This was a practical consideration and did not necessitate a fundamental shift in the study's inquiry; the purpose was still to understand the issues involved in Ireland's transition to a knowledge-based economy. This change occurred because while the detailed interviews provided a rich history of information for analysis, the supporting materials necessary to complete a full case study analysis were not available. As explained by Yin (2009), an effective qualitative case study will incorporate multiple data points that facilitate triangulation. Such triangulation was impossible due to the unavailability of supporting data. Baxter and Jack (2008) echoed Yin's sentiments by asserting that a qualitative case study enables the exploration of a phenomenon through the use of a variety of sources, such as observations and documents. Therefore, the researcher in this study chose to use thematic analysis of data from multiple cases, as in the individuals interviewed.

Results

Analysis of the data obtained from the transcribed interviews revealed the following three overarching themes: Development of advanced manufacturing, policy environment, and the building of a knowledge-based economy. The first theme was that advanced manufacturing was still being developed but had reached a mature phase in the Irish economy. The second theme was that Irish policy should be dedicated to easing the transition to a knowledge-based economy but for a variety of reasons, that policy was not yet consistent toward that goal. The third theme was that the building of a knowledge-based economy was a necessity and would probably occur with or without government policy intervention, however, it could be done more smoothly with the active collaboration of government and other stakeholders. Upon further analysis, subthemes subsequently emerged that correlated with the three overarching themes. As such, the development of advanced manufacturing theme included the subthemes of definitions and critical skills, whereas the policy environment theme included the subthemes of education and government policy. The final theme of building a knowledge-based environment incorporated the subthemes of human capital, culture, colocation, and innovation. Overall, the findings revealed that advanced manufacturing played an important role in building a knowledge-based economy. This finding was not inconsistent with the premise that advanced manufacturing may become less important in the Irish economy if the transition to a knowledge-based economy is accomplished.

Rationale for the Methodology

As explained above, practical considerations prevented the employment of a single case study. However, it is appropriate to explain why a qualitative approach was chosen at all. The primary reason is that the phenomenon of the two transitions in Ireland's economy mentioned above, firstly from traditional to advanced manufacturing and from advanced

manufacturing to knowledge-based production, is difficult to precisely measure at any stage. The Irish government has taken surveys of business concerns throughout the country, which have provided quantitative data. It is the presence of this data that is driving a different approach. These transitions are ongoing and are not occurring systematically. Therefore, it is more useful to understand these transitions and why they are taking place than to measure them.

Also, the research questions refer to policy. Policy initiatives, whether by the government or by private stakeholders, necessarily talk about the future and make predictions. This necessary speculation means that the concepts are necessarily qualitative in nature; the who, what, why, where and when. A qualitative interview-based approach can elicit the perspectives of stakeholders by asking them to consider these critical questions in a subjective, predictive manner. It is this researcher's contention that such subjective data could be as valuable as or even more valuable than simple statistics and survey data.

Summary

To summarise, the purpose of this study was to investigate the necessary policy initiatives and requirements to develop a knowledge-based economy within the unique system represented by Ireland's small-scale economy. This chapter began with information regarding how technological advancements have changed Ireland's manufacturing economy. The changing economic landscape was identified as increasingly supported by a knowledge-based economy that required new strategies from the government. As such, policy strategies for improving innovation in Ireland were provided by the DJEI Enterprise 2025 strategic framework, as shown in Table 1. The nature of this study was then identified as qualitative and informed by a case study research design. The results of this study provided confirmation that advanced manufacturing played an important role in building a knowledge-based economy.

Chapter 2: Literature Review: The Nature of Knowledge Based Economies

Introduction

While knowledge-based economies (KBEs) have been part of discourse since the 1960's, the concept of knowledge-based industries gained widespread traction in the 1990's. With the development and growth of the internet came a wider distribution of knowledge, and new knowledge-based industries changed the economic landscape in Ireland and abroad (Karwowski & Salvendy, 1994). Industries which were not technologically based are adapting, and the economy in Ireland is still in the early stages of understanding the needs, behaviours, and policy responses of a KBE.

Current literature examines the evolution of the manufacturing industry as it underwent significant change during the industrial revolution and again in the late 20th century as advanced manufacturing landscapes replaced traditional manufacturing processes (Macbeth, 1989). However, there are relatively few contemporary articles which discuss the impact of a knowledge economy on the continued evolution of advanced manufacturing.

Unlike many economies which are primarily focused on either manufacturing or knowledge-based industry, the Irish economy retained its advanced manufacturing base while incorporating the modernity of a knowledge-based economy. In general, the manufacturing industry is sensitive to changes in global demand due to recessions and other economic events, so there is an opportunity for Ireland to strengthen its knowledge-based economy without abandoning manufacturing as a core contributor to the Irish economy, and particularly as a source of employment to large sections of the population. The purpose of this study is to investigate the necessary policy initiatives and requirements to develop this type of economy within the unique system represented by Ireland's small-scale economy.

The following research databases were used to write the literature review: EbscoHost, ProQuest, JSTOR, TARA, Web of Science and Google Scholar. The search terms used

singularly and jointly were knowledge economy, knowledge-based economy, high-tech industry, manufacturing, advanced manufacturing, service sector, Ireland, Irish, economy, European Union, small-scale economy, human capital, research and development, education, and industry. All of the key search terms yielded literature relevant to the research questions.

The literature included in the review was published primarily between 2008 and 2017. Some older research studies were consulted and included to give context to the evolution of knowledge-based economies and the evolution of the Irish economy generally. Additionally, older foundation books and articles about KBEs, innovation and Irish industrial and political development were used to inform the current discussion and were therefore included.

In this literature review, the researcher will provide an expanded background information on KBEs through an analysis of related literature. The first section will discuss KBEs in general, focusing on their origins, structure, implementation, challenges, and key factors. The second section will discuss KBEs in small-scale economies in terms of their unique structure and management. Other small countries in the European Union and internationally will be used as case studies. The third section discusses the manufacturing industry in KBEs. The fourth section will discuss Ireland's KBE in terms of its structure, performance following key-factors, relationship with the government, and the service sector.

Theoretical Framework

The economic framework utilised in this study is Neo-Schumpeterian Economics (NSE). NSE studies the changes which occur in economies based on the introduction of novelties or variations (Hanusch & Pyka, 2007). According to a study performed by Hanusch and Pyka in 2007, innovation is the most visible and impactful form of novelty when viewed through a NSE lens. Technological innovation, in particular, has immense power to transform economies and reshape whole industries and countries (Hanusch & Pyka, 2007). While technological innovation is often the focus of NSE studies, Hanusch & Pyka stress that

novelty and change at all levels have the power to transform economies. Therefore, it is important to consider not only technological changes but also alterations to a country's monetary, organisational, structural, environmental, and human landscape.

According to Sledik (2013), Schumpeter's growth theory, which is the core theory of NSE, is the most appropriate lens through which to consider knowledge economies. As technological advances continue to change our world, economies are increasingly based on and driven by knowledge and information (Sledik, 2013). Over the course of recent history, modern economies developed through a number of "long waves", each of which were characterised and driven by a particular innovation. The first wave was the industrial revolution (1780-1840) characterised by textile factories. The second wave occurred between 1840 and 1890 and was driven by steam railways. The third wave, the age of electricity and steel, occurred between 1890 and 1940 and was characterised by the introduction of electricity and steel production. The fourth wave occurred between 1940 and 1990 and is best known for mass production and Fordism (Sledik, 2013).

The fifth wave, which is currently occurring, will almost certainly be characterised by modern computers, sensors and the internet. As the innovation of our age, these technological drivers continue to impact and reform modern economies. As economies driven by knowledge, KBEs are particularly sensitive to innovations which reshape how companies and people operate. Sledik divides innovation into five categories: new product launches, applications of new methods, opening new markets, acquiring new supplies of raw materials, and new industry structures (Sledik, 2013). Each of these innovation types are relevant to KBEs and drive economic growth.

The Evolution of Irish Industrial Policy from 1922 to 1992

As any nation's economic situation is a function of its past, it is important to realise what factors led to Ireland's present situation. Ireland, before its independence from Britain, was almost exclusively a rural nation, with its economic output composed largely of agricultural products and textiles. The rudimentary installed manufacturing base in the early years of the Irish Free State largely existed in Dublin, as the largest population centre. England had ruled Ireland for centuries as a resource colony and did not allow its industrial development beyond that which was needed to serve England's needs.

The Irish Free State was created with the passing of the Irish Free State Constitution Act 1922. "Prior to independence Ireland was part of an integrated single market within the United Kingdom, and the United Kingdom was committed to the free trade world that had benefited it for so long. After independence, the first government in Ireland maintained the status quo" (Durkan, 2010) and Ireland pursued a policy of free trade. In fact, the Durkan paper goes on to point out the unique situation Ireland found itself in when, in response to the Great Depression, governments worldwide including the UK turned towards protectionist policies. "For a few months at the turn of 1931 into 1932, between the introduction of the British tariff and the change of government in Dublin, it (Ireland) was the last surviving example of a predominantly free-trading state left in the world" (Meenan, 1970)

During the first period of Irish self-government, when the government was called the Executive Council of the Irish Free State, one policy decision stands out as exceptional. This was the decision by the W.T.Cosgrave cabinet to invest fully 20% of its 1925 budget of £25m into the £5.2m hydro-electrical infrastructure project at Ardnacrusha. Patrick McGilligan, who served as Minister for Industry and Commerce, between 1924 and 1932 is recognised as the force responsible for pushing through the Shannon scheme at Ardnacrusha in the face of considerable political controversy. When it opened in 1929 the Ardnacrusha plant was the

largest hydroelectricity project in the world. Such was the social, industrial and economic impact of the project on the newly formed state that an artist Sean Keating was commissioned to record the building of the power plant and in honouring his work in 2012 the Minister for Communications Pat Rabbitte commented that the construction of Ardnacrusha was “one of the greatest industrial and social developments this country had ever seen” and “changed the course of history in this country and has improved the quality of life of many generations.”

In 1932, a Fianna Fail government lead by Eamonn DeValera came to power and quickly instituted a change in policy away from free trade to protectionism (Durkan, 2010). The most notable legislative instruments of that time came in 1932 and 1934 with the Control of Manufacturers Act which mandated that the majority ownership of Irish companies was to be limited to Irish citizens. This “industrial protectionism, introduced in the 1930s, initially raised the rate of employment growth in manufacturing, from 1.6 per cent in the free-trade years after 1926, to an annual rate of 4.3 per cent over the protectionist 1930s and 1940s” (Barry, 2000). However, that growth eventually stalled and due to its protectionist policies Ireland missed out entirely on the worldwide post-war boom. Perhaps because of this, in 1949 the first Inter-Party coalition government led by Fine Gael’s Sean T. Costello, took a number of outward looking actions including the setting up of the Irish Development Authority. “The IDA’s brief was to ‘investigate the effects of protective measures’, to initiate proposals and schemes for the creation and development of Irish industry’, and ‘to advise on steps necessary for the expansion and modernisation of existing industries’. (Lee, 1990).

One the most significant first moves towards the development of an open economy were taken by Sean T. Costello, in his second term as the leader of an Inter-Party government, with the introduction of the Export Profits Tax Relief in 1956. This allowed for 50% tax remission on profits earned from increased export sales. Barry (2011) points out that Costello announced in October 1956 that EPTR would be introduced in a major policy speech

prepared only with his personal advisors, and that he did not agree on the policy with other members of the government prior to delivery. The policy was subsequently enacted by the Department of Industry and Commerce. The IDA also produced a report in 1956 supporting this tax initiative commenting that if “further industrial development is to make a substantial contribution to our employment problem, some bolder measures of tax concession must be introduced, so as to enable this country to compete with other countries which are also trying to attract foreign industrialists.” (Lee, 1990). This act of leadership by Costello seems to have had a catalytic effect on the horizon of Irish Industrial Policy. In the highly competitive world of Irish politics in the 1950’s it offered the electorate an alternative vision to protectionism, and it established the pattern of Ireland basing its international competitive offering on lower corporation taxes. Lee (1990) makes the point that it may have prompted the Department of Finance to act decisively to “re-establish supremacy in economic policymaking”. In any case it set the scene for the publication in 1958 of the ‘Economic Development’ report by Secretary of the Department of Finance, T.K. Whitaker. This watershed “report began with an introduction that ‘the greatest fault lies in pursuing a policy after it has proved to be unsuitable or ineffective’” (Lee, 1990). The Economic Development report became the basis for the White Paper published on 12 November 1958, called the Programme for Economic Expansion. It reflected an outward looking modern approach to economic development and introduced the concept to Irish industrial policy of stimulating economic activity first rather than approaching “the question of development from the aspect of employment, that is by setting out the numbers of jobs required and then attempting to plan how these might be created” (Whitaker, 1958). The basic Whitaker proposal was to shift public expenditure from ‘social’ to ‘productive’ investment, initially by reducing expenditure on housing. It established the importance of productivity as part of the toolkit of Irish Industrial policy. Mechanisms for offering tax breaks and grants were created to attract foreign firms wishing

to establish their business in Ireland. The Economic Development report and the subsequent government approved white paper “are important because they signal a shift from protection towards free trade and from discouragement to encouragement of foreign investment in Ireland, involved a dramatic reversal of the rhetoric, and to a large extent of the practice, of all policy, but especially Fianna Fail policy, since 1932” (Lee, 1990).

The next significant shift towards the precursors of a knowledge-based economy occurred in 1967 with the introduction of the ‘free education scheme’ (Walsh, 2009). Initially proposed in the Investment in Education Report, the Department of Education argued that greater access to education was linked with Irish economic and social development. Prior to the report, many who finished primary school did not continue their education, which resulted in a shortage of workers able to perform increasingly technical work. Even for those who did receive further schooling, many attended vocational schools, which focused on practical job skills rather than the education traditionally offered in secondary schools (Walsh, 2009). The result was that the working class lacked technical proficiency, hampering modernisation and innovation. The Irish economy had been stagnating as a result (Walsh, 2009). The Investment in Education report was implemented and the “introduction of free secondary education in 1967, by linking greater access to further education with future economic and social development, demonstrated a commitment to change Ireland’s education system” (Ferriter, 2004) and the economic and employment prospects of future generations.

As if to further underline the significance of the developments in the 1960’s of a solid base for future Irish industrial development, in 1969 George Colley as the Minister of Industry and Commerce reinvigorated the Industrial Development Authority and gave it a powerful suite of tools in one body that were almost unparalleled in one organisation anywhere in the world (MacSharry, White, O’Malley, 2000). The aspirations of the country for the newly strengthened IDA is notable in the Spring 1972 Journal of the Institute of

Public Administration of Ireland which devoted a full special issue to the reinvigoration of the Industrial Development Authority and leads off with the unambiguous declaration of intent by the IDA's R.J. McLoughlin that "The IDA's job is to create JOBS" (McLoughlin, 1972). The capitalisation is the author's not mine. To bookend the more than half century that had passed since the formation of the Irish Free State in 1923, after more than a decade of trying, Ireland finally joined the European Economic Community, together with the UK. At this time Ireland's economic ambitions were still very much linked with the UK to the extent that in 1975 UK firms still accounted for 13% of Ireland total manufacturing.

It quickly became clear that from a policy perspective in joining the EEC "Ireland had a clear view of its role which was economic development for Ireland first and foremost" (Keatinge, 1998). In total in the first three decades after joining, Ireland received over €17 billion in Structural and Cohesion funds from the EEC. With this increased level of funding and an increased level of integration with Europe the task was now to move Ireland's agricultural based economy characterised by its heavy dependence on the UK market, low levels of income, mass unemployment and emigration into the realms of modern outwards looking international economies. To do this a new approach to the formation of Government policy would be required. The first significant post-EEC report occurred with the publication in 1982 of the Telesis report – A Review of Industrial Policy. The National Economic and Social Council sponsored a multi-part study of policies for industrial development. This study was undertaken by a team from the Telesis Consulting Group and hence the report became known as the Telesis report. 'The objective which the Council gave to Telesis for the study was: To evaluate existing industrial policies, and to make recommendations designed to ensure that the Irish Government's industrial policy is appropriate to the creation of an internationally competitive industrial base in Ireland which will support increased employment and higher living standards' (NESC 1982). It is important to note given the

emphasis on ‘employment’ and ‘living standards’ that the Council membership was made up of representative bodies of the ‘principle economic and social interest groups’ and of its 46 members, 10 were nominated by agricultural organisations, 10 were nominated by the Irish Congress of Trade Unions and 16 represented Government departments directly or were appointed by Government. Only 10 were nominated by the Confederation of Irish Industry and the Irish Employers’ Confederation. T.K. Whitaker, by now a Senator was nominated by the Government. The Telesis Report states that its "recommendations are offered as amendments to current Irish industrial policy rather than as a fundamental reshaping of that policy" (Lee, 1990). The report claimed that "no country has succeeded in developing high levels of industrial income without developing a strong indigenous sector" (Kennedy, 1982). Telesis also pointed out “a further possible constraint, often spoken of but difficult to pinpoint, namely the question whether there may be a deficiency of native entrepreneurial ability in manufacturing activity.” (Kennedy, 1982). This potential entrepreneurial deficiency is a theme that continues to the present day.

Firstly, the Telesis report recommended ‘a reallocation of public expenditure on industrial promotion in favour of internationally traded indigenous industry and skilled sub-supply firms.’ (NESC 1982). They recommended a more structured approach than that of the IDA and existing industrial policy ‘which would focus on building competences within companies’. ‘They refer to their recommendation as a “hands on” approach which could only be undertaken in a selected number of cases’. (NESC 1982). This is the first reference in Irish industrial policy to the theme of “picking winners” and culling certain less successful projects to divert resources to projects with a greater chance of success. ‘This approach is expected to make job creation initially more expensive, but to result in more successful companies and a reduction in the present rate of job losses in indigenous firms’. (NESC 1982). Once again the report states that the IDA ‘says that the main constraint on the development of indigenous

industry has been the shortage of entrepreneurs and companies willing to start up new companies or expand existing enterprises (NESC 1982).

‘A second major recommendation by Telesis is that there should be a substantial reduction in the level of grants offered to new foreign firms’ (NESC 1982). Telesis estimated that ‘Ireland offers considerably higher incentives than other comparable locations for the average project which is of interest to Ireland’ and ‘that the funds could be better used in the development of indigenous industry’ (NESC 1982). This recommendation does not seem to have been given much credence given the ramp up in incentives offered to multinational firms to locate in Ireland and also in light of the decision in 1982 to introduce a 10% Corporate Tax rate for certain types of enterprises. Kieran Kennedy commented at the time that “the low rate of profits tax on manufacturing enhances the incentive to invest and the resources available for investment, provided the firm is profitable. Thus, while it is a good incentive for attracting foreign enterprise and encouraging expansion in well-established indigenous enterprise, it is of limited value to new indigenous enterprise where there are major barriers to entry and expansion” (Kennedy, 1982). However, the NESC comment on this recommendation is interesting and quite perceptive in the longer term reputational context given the preference that MNCs have for stable policies and also in recognising the growing capability of the IDA to understand the fundamentals of internationally mobile capital and their ability to establish a national competence at attracting foreign direct investment. The report states that ‘in defence of the present levels of incentives it is argued firstly that they are based on a detailed knowledge and experience of attracting foreign industry which has involved extensive negotiations with foreign firms by state agencies and the monitoring of incentives offered by countries, and secondly, it is said that experimentation with reduced grant levels could have the effect of destroying Ireland’s reputation for consistency in its policies for attracting foreign investment’ (NESC 1982). A

third major recommendation by Telesis relates to improving control of the process of industrial development. NESC 1982. ‘They say that Ministers and Government Departments should play a more active role in the setting of overall strategy and policy direction, monitoring results and reviewing on-going policy’. (NESC 1982). Telesis felt that the IDA was primarily and by inference overly responsible for the formulation of current industrial development strategy. In addition, though Telesis concedes that the staff and information that are ‘necessary for an effective primary role in steering the direction of industrial policy’ (NESC 1982) was not available to the relevant Government departments. So, the recognition at that time was that there was a lack of entrepreneurial talent and also a lack of talent in the Government sector. The question that arises is whether this apparent lack of appropriate personnel was due to the continuing haemorrhaging of talent through emigration or was it due to the failings of the Irish education system.

As recounted to the researcher in the interviews that will follow later in the dissertation, the Telesis Report was not well received in the IDA and therefore was not implemented in any significant way. The official policy response was the 1984 White Paper on Industrial Policy. In terms of implementing the Telesis report the White Paper outwardly took some of the recommendations of Telesis but generally it seems that these were window dressing and the White Paper was very much shaped by the existing economic philosophy of the IDA at the time. The White Paper states that “the object of this White Paper is to maximise the benefits from the existing industrial incentives and thus ensure that the benefits from them significantly exceed their costs” and that to this end “arrangements must be made to quantify more effectively both the costs and the benefits” and that “this will meet the criticism in the Telesis Report that data and information systems in Irish industrial policy need to be improved” (White Paper on Industrial Policy, Government Publication, 1984).

Through this period Ireland remained weak on formulation of policy and very weak on implementation, as demonstrated by its ‘worst-in-the-OECD’ record on fiscal mismanagement in the 1980s. By 1985, Ireland became the first country to see public debt exceed 100% of GDP and the mismanagement of the economy reached crisis point with the rapid snap elections of the late 1980’s. Something had to change and in 1987 due to some brave political leadership the leader of the Fine Gael party Alan Dukes expressed what came to be known as the Tallaght Strategy and undertook to support the actions of the minority Fianna Fail government so long as they pursued fiscally sound policies. One of the first signs that joined up thinking was now inspiring government policy came in late 1987 with the establishment of the Irish Financial Services Centre through legislation approved by the EU. The IFSC seems to have been another example of major Irish policy successes being possible only through the direct intervention of a strong leader – in this case Charles Haughey, the Taoiseach of the day. It is also an example of the frequent occurrence in Irish policy making of the concept of obliquity as defined by John Kay in his book ‘Obliquity’ which says that in a world of uncertainty and complexity, the problems we encounter aren’t always clear and often our goals are also unclear and, in these circumstances, an indirect approach, or just ‘muddling through’ can sometimes be the best answer and provide unique solutions. The obliquity of the conditions that allowed for the creation of the IFSC seem to have been brought about by a neat marriage between a set of urban regeneration incentives that had been put in place by the Gareth Fitzgerald government for the Dublin Docklands area, overlaid with the concept of the financial services brought to Charles Haughey by financier Dermot Desmond and the political desire to be seen to do something positive for the economy in the midst of a chaotic political and economic situation. Charlie Haughey and Padraig O’Higgin set up the IFSC committee and quickly agreed the conditions that the IFSC had to have substance, had to be licensed, and had to qualify for the 10% tax rate. The

personal power of Charles Haughey aligned the whole system around this endeavour and made sure that all aspects public and private were pulling in the same direction to ensure that the implementation of the IFSC happened in a timely and coordinated manner.

While the Tallaght Strategy and the subsequent correction of the Irish public finances was having a positive effect, by 1992 the economic was still not operating to its potential and so another major report on Irish industrial policy was commissioned. The report was called “A Time for Change: Industrial Policy for the 1990s. Report of the Industrial Policy Review Group” and it became known as the Culliton report after the Jim Culliton who chaired the group. The report begins with the opening quote “We need a spirit of self-reliance – a determination to take charge of our future – to build an economy of real strength and permanence which will give jobs and wealth sufficient to our needs” (IPRG, 1992). The sense was that there was a ‘series of obstacles to economic growth in Ireland’ and if removed that ‘should be sufficient to ensure a shift to a more rapid growth path’ for the economy (McDowell, 1992). The report states that “Ireland’s economic problems are deep-rooted and persistent” and that “the principle economic goal of our nation is to produce a high and rising standard of living for our citizens and this depends on the productivity of our resources” (IPRG, 1992). In general terms the report calls for urgent reforms in of the formulation and evaluation of policy for industry, the personal and industrial taxation system, infrastructure, education and training systems, spending on R&D and the role of the industrial agencies. Once again, the taxation system and in particular the corporate tax rate was a target of those that comment on Irish industrial policy with the report stating that “no indication should be given of any continuation of the 10 per cent Corporation tax rate beyond 2010; the range of activities to which it applies should not be extended”. The report also calls for improvements in the transport and communications infrastructure. The implementation of this

recommendation received a huge boost with the receipt of EU Structural funds in 1992 in particular. ‘During both the 1989 to 1993 and 1994 to 1999 periods, Ireland was treated as an Objective 1 region’ and between 1989 to 1999 received a total of €10 billion or ‘equivalent to about 1.7 per cent of average GDP over the entire period’ (Hegarty, 2003). The Culliton report also called on the government to “push for greater competition in air services, telecoms and energy supply”. This mention of deregulation as a policy came more than a decade after Margaret Thatcher’s push towards deregulation transformed the industrial structures in the UK. Culliton’s report was also vocal on the need for reform in the Education and Training system particularly in the areas of technical, vocational education and management training. One interesting note in this section is the call for the role of FAS to be clarified. The report states that ‘with the exception of its apprenticeship programmes, much of what it does is seen as of little relevance by industry’ (IPRG, 1992). This seems ironic given the revelations in recent times of the scale of mismanagement of the budget of FAS while it was built into a billion-euro entity. Culliton also addressed the issue of spending on research and development. In terms of implementation, actors close to the topic such as Frank Gannon, later to be appointed DG of SFI, observed (in his personal blog) that this mention of the need for greater R&D spending in the Culliton report planted a seed that lead to the discussions that eventually lead to the creation of Science Foundation Ireland over a decade later. Culliton’s observations on future R&D spending were that they should be helped by EC structural funds, they shouldn’t remain too remote from industrial application and should contain a stronger emphasis on technology acquisition. All of these points could be seen to start the debate on R&D spending that lead to positive changes to Ireland’s R&D tax policy that resulted in that aspect of our taxation system becoming one of the cornerstones of the IDA’s promotion of Ireland as a destination of choice for foreign investment. Culliton also addressed the role of industrial promotion agencies. In alignment with previous policy

reports, Culliton recommended that “grant aid to be squeezed even at the risk of losing some of the costlier projects” (IPRG, 1992). The report also recommended “fostering clusters of related industries building on leverage points of national advantage” which would represent “a shift from the existing over-emphasis on ‘high-tech’ sectors per se in areas such as pharmaceuticals” (IPRG, 1992). Surprisingly Culliton recommended “a decisive shift away from grants for indigenous industry, in favour of an expansion of equity and venture capital activities by the State agencies” (IPRG, 1992).

Background on Knowledge-Based Economies

The previous section has provided the context on the evolution of the Irish economy from a mainly agricultural and low-tech manufacturing economy to the creation of the policy platform which enabled the beginning of ‘The Celtic Tiger’ era in Ireland in the early 1990’s. The following section will provide context on the background to, and emergence of the knowledge-based economy. According to Melnikas (2012), intellectual economics is the one of the most important faucets of contemporary economic science because it studies the modernisation and growth of knowledge-based economies. Melnikas argues that creating such an economy is the priority of modern societies, particularly the European Union (Melnikas, 2012). The development of such a society results in changes not only to business sectors, but also to a country’s social, political, scientific and technological process. According to Melnikas, the widespread creation of such societies inherently results in globalisation and knowledge sharing, which further impacts economies and societies. As KBEs are constantly transforming based on the introduction of new methods and innovations, Melnikas argues that more scientific studies must be done on the drivers and influencers of KBEs.

The primary product of a knowledge-based economy is information. The primary productive mechanism of a KBE is intellectual capital (Jacob, 2014). Thus, an older, physical capital-based manufacturing economy may not be well positioned to compete with other KBEs. This was, in fact, the case in the latter decades of the 20th century for Ireland, a situation that has persisted through the recent global recession. However, the transition to a KBE is smoother when the population already has stores of intellectual capital, through being well educated and skilled (Jacob, 2014).

Though discussion of KBEs is relevantly new to literature, Jacob (2014) argues that world economies have been driven by intellectual capital for decades. As previously mentioned, Schumpeter's growth theory states that economies expand based on the introduction of novelty (Sledik, 2013). The industrial revolution, which lasted from the 1760s through the 1850s, represents the "first wave" of change, and the expansion of technological influence over global economies (Jacob, 2014). During this period, Jacob argues, technological innovation became continuous in that new techniques and technologies constantly shaped and reshaped the world economy. During each new wave of economic transformation economies expanded rapidly but doing so required significant change to traditional understanding of business best practices (Jacob, 2014). Subsequent economic transformations have occurred as the concept of capital has been refined and re-defined. One major shift in economic thinking was caused by the success of economies such as Singapore, which has virtually no natural resources and very limited physical capital, but a significant storehouse of intellectual capital.

True discourse of KBEs began in 1970s when economists began to notice that traditional drivers of wealth in the industrial sector such as land, facilities, and financial capital were no longer the focus of business decision (Bedford & Wiley, 2016). Instead, knowledge replaced them as the key factor of production, in the form of intellectual capital. Much as

physical capital produces physical goods, so intellectual capital produces intellectual goods, such as data systems, software, information technology and others. According to Bedford & Wiley (2016), this fundamental shift resulted in both businesses and governments reconsidering how human capital must be managed. To support a knowledge economy, the workforce must have new skills and competencies which evolve as technology changes; these include the ability to innovate in the information technology field. The new economic format stresses the importance of relationships, cultural competencies, and innovative management (Bedford & Wiley, 2016). Despite the widespread acknowledgment of a changing landscape, there is still a gap among researchers and governments about how best to support and manage a rapidly changing economy. This could be because of the relative newness of KBEs as the primary economic drivers of a country's economy. It also could be due to stakeholders and government policymakers not having fully absorbed the transition even as it was happening all around them.

Though individual countries have unique economic drivers, literature suggests that components crucial to successful KBE management include: strong educational systems, large financial sectors characterised by growth, and competent management of information technology (IT) and human capital (Salem, 2014; Zarevski, 2016; Low, Tee, Kew & Ghazali, 2015). Increasingly, societies which have a KBE or are looking to develop one are aware of the crucial role universities and other academic institutions play in supporting economic growth (Salem, 2014). Unlike older economic structures, successful business is not propelled primarily by capital and natural resources, and therefore the human capital must be prepared to take on a larger role in profit generation (Salem, 2014). Salem noted the critical connection between the presence of institutions of higher learning and the growth of intellectual capital. In fact, KBEs are unlikely to flourish when the population is underserved by colleges and

universities. The enterprises that make up KBEs will likewise be starved for competent employees and managers who have the skills that KBE enterprises need.

While arguing that universities play a crucial role in generating the knowledge which drives economic profit, Christinidis and Ellis (2013) noted that universities and societies cannot lose sight of knowledge generation for the purpose of public benefit. Equally important, they claim, is the role of universities in preparing students to be engaged with the communities which such innovation serves (Christinidis & Ellis, 2013). Without community engagement and involvement in the political process, students will be ill-equipped to lead companies which seek to fill societal gaps with products or services. Of course, many would argue that what is good for business is also good for society. Hunjet, Kozina and Mulovic (2014) discussed the close connection between higher education, cultural values, and economic development in a study of 125 university students. In the study, researchers found that students were most satisfied with an education which combined academic rigour, real world applicability, and cultural competency (Hunjet, Kozina & Mulovic, 2014). In a KBE, a student would be most likely to succeed if he/she acquires intellectual capital; universities can emphasize that the skills necessary to function in a KBE will have immediate applicability and that graduating students can expect to find lucrative and productive employment (Hunjet et al., 2014).

For KBEs to be successful, countries must also have a sufficiency base of information technology available. In a study of KBEs in Argentina, Costa Rica, and Mexico, Mungaray-Moctezuma and Perez-Nunez (2015) found that the highest indicators of success in KBEs were education and human resources, innovation, and information communication technology. The results suggest that even highly educated workforces will struggle to meet the demand of KBEs without access to modern technology and innovative techniques (Mungaray-Moctezuma & Perez-Nunez, 2015). In other words, students have to be educated

in technology, particularly information technology, to integrate into a KBE. Moreover, the innovation that a KBE needs will not be present if the workforce is not so educated (Mungaray-Moctezuma & Perez-Nunez, 2015).

Several factors can impede a country's transition to a knowledge economy, as demonstrated by the struggle of some countries in the Arab region (i.e. Gulf Coast). From a political perspective, countries with a lack of freedom, good governance, and political commitment will not be able to transfer to a KBE (Osman, 2014). Furthermore, countries with unstable political climates often had leaders who did not prioritize the development of knowledge economies, which resulted in less progress (Osman, 2014). Additionally, the study found that rent-seeking economies such as those which dominated the oil-rich Arab region, struggled to transform into knowledge economies despite significant wealth and economic growth. Though profitable in the short run, economies which rely heavily on one non-renewable resource may fail to develop knowledge economies unless guided by the public sector (Osman, 2014). This problem is reflected in the belief by traditionalists that knowledge is not a tangible product of an economy and only the physical goods it produces matter. It would be in particular quite difficult for the petroleum-products-based economies of the Gulf States to transition to KBEs, especially since they have become rich and powerful due to their oil reserves. However, as those reserves are depleted, the transition to KBEs will become a necessity, as when the oil is gone, the Gulf States will be almost completely without natural resources (Osman, 2014). The United Arab Emirates recognised this some years ago and in 2010 set out its strategic vision to transform its economy to a KBE over the next 11 years. The UAE Vision 2021 states that "Innovation, research, science and technology will form the pillars of a knowledge-based, highly productive and competitive economy, driven by entrepreneurs in a business-friendly environment where public and private sectors form effective partnerships."

Outside factors can affect a country's transition to a knowledge economy, such as a lack of international business and knowledge sharing (Tiit & Anne, 2013). Using Estonia as a case study, researchers found that knowledge-based businesses were more successful when they could share knowledge with similar firms located in more robust knowledge economies. This, of course, assumes that borders are open, and that knowledge can be exchanged freely; that is the case in Estonia, which belongs to the European Union. The transfer of information resulted in benefits on both sides (Tiit & Anne, 2013). A second study performed by Ortega, Maria, Cabera, Mercedes and Alan in 2016 found that the ability of businesses to compete and share knowledge on an international stage was important for the development of KBEs. However, for businesses operating outside of KBEs to do well, managers needed to be culturally competent within the host country (Ortega et al., 2016). This finding suggests that a closed economy and society will have difficulty in operating as a KBE, due to the fact that it will be forced to rely on its own resources exclusively (Ortega et al., 2016). The converse is also suggested, that a country that shares knowledge across its borders and with its neighbours will be more successful in developing a KBE.

In a 2014 related study on sustainable development and knowledge economies, Al-Roubaie and Alvi found that developing economies could benefit from knowledge sharing relationships with strong KBE countries. The result of knowledge sharing was that developing countries were able to speed along the process of developing sustainable KBEs (Al-Roubaie & Alvi, 2014). Knowledge sharing was particularly beneficial to small developing economies because it enabled them to sustain development in a more reliable way. Additionally, small developing economies with knowledge sharing relationships showed increased productivity and greater economic diversity (Al-Roubaie & Alvi, 2014). The conclusion was that the best that small developing countries could do in terms of forming relationships was to form them with larger nations that already had developed KBEs. The

cross-fertilisation of ideas occurs not just within a country but also without, as the effects of clustering apply across national borders as well as within physical business sector clusters.

In 2015, Khan and Shenkar studied the effect of socialisation mechanisms on international knowledge transfers. In the study, researchers sought to determine the extent to which formal and informal interactions between managers in KBE countries and managers in non-KBEs increased the productivity of knowledge transfers (Khan & Shenkar, 2015). The researchers found that formal socialisation exercises such as workshops and meetings increased both the speed of knowledge transfers and comprehension, while informal socialisation mechanisms such as collegial relationships and side communities enhanced the depth of comprehension but not the speed of the knowledge transfer (Khan & Shenkar, 2015). The presence of social interaction mechanisms, while perhaps not the most salient feature of a social/technical alliance between countries, may be its most important, as cross-fertilisation of ideas often occurs informally (Khan & Shenkar, 2015). The transition to a KBE by a presently non-KBE country may be best facilitated by its friendship with a neighbouring KBE country.

In 2015, Sindakis, Depeige & Anovrkati argued that communication channels and networks between countries, cities, and regions create a network of stakeholders interested in promoting the development of knowledge economies. They found that official and unofficial networks supported innovation and accelerated progress for the entire “cluster” of companies (Sindakis, Depeige & Anovrkati, 2015). The researchers found that clusters were particularly beneficial when the member groups shared common customer classes or supply chains. As the products of a KBE are likely to be disseminated well beyond a country’s borders, such relationships form naturally in the course of doing business (Sindakis et al., 2015). The concentration of customer knowledge allowed all involved to share information and gain a

more sophisticated understanding of their buyers. This resulted in a faster discernment of buyer trends and increased technological development (Sindakis et al., 2015).

As previously mentioned, strong academic structures are crucial to healthy KBEs, and universities are historically the backbone of that framework (Contantin & Florina, 2015). However, in a 2015 study, Contantin and Florina discussed how other types of educational systems are crucial for the support of KBEs, and universities must adapt to the changing demands of modern economies. The study identified three challenges which impact the ability of universities to meet the needs of KBEs. The challenges include: separating university decision making from government funding streams, resist the urge to commoditize education, and to integrate intellectual capital and strategic thinking of students. In a capitalist supply-and-demand economy, from which universities are not insulated, students will demand a focus on the skills that they need to find jobs in a KBE. Universities will respond to this demand in order to remain relevant and, when needed, profitable (Contantin & Florina, 2015). The university can in turn promote itself as a source of intellectual capital that prepares students for positions and roles in the developing KBE.

Though the previously discussed studies present challenges which KBEs and developing KBEs are likely to face, a body of literature exists on supporting KBEs and furthering economic growth in a manner consistent with the principles. According to recent literature, strategies for supporting KBEs include the following four pillars of knowledge occurring simultaneously: high quality information technology, the presence of knowledge intensive business services, competent business leadership and thoughtful government regulation (Madrak-Gorchowska, 2013; Al-Busaidi, 2014; Kanagatova, Nuketayeya & Suleimenova, 2014). In 2013, Madrak-Gorchowska described four pillars of knowledge which support and grow KBEs. The pillars were: economic incentives for knowledge-based businesses, a well-educated and entrepreneurial society, high quality IT services, and a

culture of innovation (Madrak-Gorchowska, 2013). Other studies reflect similar support systems, as did Al-Busaidi in the 2014 study which included a discussion of the importance of modern IT to KBEs. In the study, Al-Busaidi stated that information and communication technology (ICT) was a pillar of any KBE and considered a prerequisite for economic growth by the World Bank, alongside the other three pillars: the economic and institutional regime, education and skills, and the innovation systems. In the study, researchers found that IT played a crucial role in developing and supporting KBEs from 1995 to 2012. Additionally, it was determined that the role of IT was steadily increasing and was likely to continue to do so as KBEs make further progress (Al-Busaidi, 2014). In fact, ICT could be considered the essential conduit of a KBE just as a transportation infrastructure is critical to a traditional manufacturing-based economy. If one accepts the premise that the KBE is the economy of the future, then ICT is the figurative highway upon which a KBE will travel (Al-Busaidi, 2014).

In a similar vein, Zieba found in a 2013 study that knowledge-intensive business services were crucial to the support of KBEs and lessened the challenge of growing new knowledge-centric businesses. In the study, Zieba defines knowledge-intensive business services as companies which provide services to other companies and are largely based on professional knowledge associated with a particular field or discipline. This includes dedicated R&D firms that are either standalone or offshoots of an existing enterprise. Knowledge-intensive business services are defined many ways, but they often offer intangible services with a high degree of adaptation to needs of individual business customers (Zieba, 2013). In the study, Zieba states that knowledge-intensive business services are important to KBEs because they create the appropriate infrastructure in which industries can operate. Such services include R&D, data storage, data security, IT contractors, and other associated benefits. KBEs can make up for shortfalls in growth by hiring knowledge-

intensive service businesses to perform tasks that cannot as yet be done in-house (Zieba, 2013).

In addition to appropriate infrastructure and ICT services, KBEs require strong leadership to flourish (Yigicanlar & Sarimin, 2015; Tahima & Jaegal, 2013). Using Malaysia and Bangladesh as case studies, the researchers determined that federal governments had significant influence over the development of KBEs. Studying Malaysia, Yigicanlar and Sarimin discussed the role of innovative government leadership in creating an ICT structure and urban development plan which was conducive to the development of a KBE (Yigicanlar & Sarimin, 2015). In the study, researchers found that Malaysia was successful in laying groundwork for a KBE by employing a “top-down” approach that encouraged the development of a KBE where interest from local leadership was limited. This is a positive feature of a planned economy in developing a KBE, in that the government may be the only entity with the resources, power, and inclination to do so. If on the local level, businesses are reluctant or indifferent regarding the benefits of a KBE, government incentives, mandates, or dictates (depending on the nature of the government involved) can help to bridge the gap. Contrary to the findings in Malaysia, Tahima and Jaegal (2013) found that the government of Bangladesh had a suppressing effect on the budding KBE. Rather than directing growth and providing a stable support structure, government entities grab power at the expense of democratic processes and show little interest in supporting the development of knowledge-based businesses (Tahima & Jaegal, 2013). The difference here may be that while both nations are Muslim, Malaysia may be less traditionalist in its views and attitudes. Plus, Malaysia is in the midst of a number of growing KBEs and may want to match its neighbours in productivity and prosperity.

Small-scale Knowledge-Based Economies

Though there is significant research on developing and supporting KBEs in large countries and economies, there is less research on supporting KBEs at the level of smaller countries, regions, and cities. This section discusses the structure of small KBEs and how KBEs are managed at the regional level. Due to the limited number of studies focused on supporting Ireland's KBE specifically, studies from economies with comparable features are examined. The comparable included countries are: Persian Gulf countries, Iran, and Romania.

In a 2015 study, Bedford, Carlson, and Wagner discussed the importance of tracking knowledge economies at the city level. According to the researchers, knowledge economies are driven by the production and consumption at knowledge, which is best observed at a transactional level (Bedford, Carlson, & Wagner, 2015). The city-level KBE is also known as a knowledge cluster, which is discussed in further detail in a later section. In order to measure the quality of KBEs at city levels, the researchers developed six factors that incentivise knowledge transactions. The factors include: business environments, societal regime, civic engagement, environment, human ecology and cultural context (Bedford et al., 2015). According to data gathered at the city level, the researchers concluded that per capita engagement of citizens in knowledge transactions was the most meaningful indicator of a mature knowledge economy (Bedford, Carlson & Wagner, 2015). Similarly, Mandanipour, in a 2011 study, found cities with high levels of knowledge-based transactions were more likely to develop strong KBEs. A knowledge-based transaction in this sense refers to the exchange of intellectual property rather than goods. It could also refer to the provision of services, such as data processing, consulting, etc. (Mandanipour, 2011)

As at the city level, there are challenges and strategies associated with developing KBEs at the regional level. In 2016, Tkachenko, Rogova and Bodrunov studied the models of

knowledge economies at the regional level and examined the evolution of such economies over time. Ultimately, the researchers determined that evaluating the impact knowledge-based businesses had on a mixed economy was challenging. However, indicators of healthy regional KBEs included: gross regional product, labour productivity, average wages, and unemployment rate. In this manner, assessing regional economies mirrored the process of assessing health of national economies (Tkachenko, Rogova & Bodrunov, 2016). Many nations, such as China, have developed “special economic zones” wherein government rules and regulations are business-friendly (such as employment regulations and taxation). It is therefore appropriate to examine performance within these zones rather than that of the country within which they are found. Tkachenko et al. (2016) found that KBEs within such zones tended to be more successful than others, sometimes very much so.

In terms of frameworks for regional KBEs, Tkachenko, Rogova and Bodrunov developed four separate models: the top down model, the program-based model, the strategic management model, and the ecosystem model (Tkachenko, Rogova & Bodrunov, 2016). Under the top down model, governments are directly involved with directing economic development. The program-based model is the most common according the researchers’ data. In the program-based model, programs are developed to address regional concerns, and each program includes objectives, validity tests, and a set of actions and financial sources. The strategic model employs a “scorecard” technique which rates regional management based on activities and strategies employed to control economies. Finally, under the ecosystem model, services are created organically based on need in order to grow and develop the KBE (Tkachenko, Rogova & Bodrunov, 2016). These are best implemented in a command economy, or at least one wherein the government has significant say in business development. In a Western-style capitalist democracy, it may be difficult to foster the needed

buy-in on the part of private stakeholder, even if the government is fully committed to the project.

Like KBE development at the city and regional level, KBE development in small countries can vary from development in larger countries. Though each economy is unique, case studies from Poland, small countries in Eastern Europe, Persian Gulf countries, Iran, and Romania will be examined for relevancy to KBE development in Ireland. As with larger economies, innovation and research are crucial factors to small KBEs (Woodward, Yörük, Koc & Pander, 2010). According to researchers in a 2010 study, Poland struggled to promote innovation despite implementing a nationwide “innovation system” which connected businesses, public research institutions, and academic institutions in KBEs (Woodward, Yörük, Koc & Pander, 2010). Additionally, researchers attributed Poland’s struggle to implement a KBE partially due to a lack of research and development funding. Poland spent less on research than almost any other country in the European Union, partially because the business sector financed only 33 per cent of research while the government funded 63 per cent (Woodward, Yörük, Koc & Pander, 2010). This would likely have worked had the government had greater resources. Also, Poland, while a member of the European Union, is somewhat culturally isolated from the richer democracies of Western Europe, meaning that diffusion of innovation across borders is slower than it otherwise might be.

Upon examining developing countries in Eastern Europe and Central Asia which were once under the Soviet Union’s control, Veugelers determined in a 2011 study that most struggled to implement the frameworks for KBEs. Additionally, Veugelers developed indicators which suggested the potential for KBE development in the relatively near future and determine that most countries lacked many of the pre-requisites (Veugelers, 2011). The indicators included: quality institutions, macro-economic stability, well-functioning markets, and innovation capacity. The small countries in Eastern Europe and Central Asia were

particularly disadvantaged in terms of quality institutions and well-functioning markets. The countries performed better in terms of macro-economic stability, which suggests the possibility of KBE development if other indicators were to stabilise (Veugelers, 2011). One possible reason for the lag in developing KBEs might be due to the overall difficulty of establishing a capitalist economy in a pluralistic, democratic society when the country has spent decades under autocratic communist rule. The Soviet Union itself has failed to install a modern capitalist economy since the 1989 fall of communism (Veugelers, 2011).

In 2014, Ceptureanu studied familiarity with the concept of a KBE among the population of Romania. Ceptureanu found that most managers and entrepreneurs were familiar with the concept of a KBE, and awareness was on the rise (Ceptureanu, 2014). Managers in the Western and North Central Region were particularly familiar with the concept of a KBE, suggesting that Romania may be taking a regional approach to KBE development. In terms of actual KBE progress, the service industry showed the most developed indicators of KBE stability (Ceptureanu, 2014). This finding suggests that a government's receptiveness to the idea of a KBE may be the single most important factor in its creation and implementation, at least at the nationwide level. For many smaller economies, private entities, even in concert, simply do not have the wherewithal to bring about a KBE all by themselves.

Cluster Economies

In any discussion of Ireland's recent economic development, an examination of cluster economies is appropriate. A cluster economy is one wherein interconnected elements of an economic base are located in close proximity to one another. This can be in manufacturing, as Detroit in the U.S., or in information technology, such as Taipei in Taiwan. The value of a cluster economy is in economies of scale, lower transportation and

communication costs, ease of collaboration between related businesses, and single-jurisdiction government oversight.

Ireland is, whether by accident or design, a cluster economy simply because so much of its manufacturing base, as well as the elements of its knowledge-based economy, and most of the country's high-tech and largely foreign-owned sectors –including computer hardware and components, computer software, and international financial services – are clustered in the Southern and Eastern region, which is centred around the capital city of Dublin (Barry, 2013). There is room for expansion into other areas of the country, however. The issue is encouraging new enterprises to locate in other cities in the country when the lack of a cluster there means that such enterprises will be at a competitive and operational disadvantage.

The following section provides an overview of current thinking on cluster economies. Research has focused on the transitions and changes that such economies have reflected in developing countries. In some form, cluster economies have existed for thousands of years, reflecting one of the primary reasons why large urban centers have developed throughout history. The early- to mid-20th century saw the development of some of the world's first massive cluster economies, as both capitalist and communist governments saw the value of locating related industries in close proximity to one another.

Research has suggested that cluster economies accelerate innovation, as close communication and economies of scale promote cross-fertilisation of ideas (Ilinskaya, 2016). Ilinskaya also posited that cluster economies provide for the more frequent generation of new ideas. This author also noted that what she called “innovation kernels,” or conditions that generate new ideas, were more likely to be generated in cluster economies. Ilinskaya (2016) also noted that economies of scale had an even greater effect when a large enterprise was located in a cluster economy.

Those sentiments were echoed by Moshkov, Zherebov, and Zdol'nikova (2016), who mentioned the need for a “scientifically planned” clustering of the manufacturing economy. These researchers, as well as Ilinskaya, were located in the Russian Republic, which in its former incarnation as the Soviet Union, was perhaps the world’s most prolific creator of cluster economies. Its command economy structure and ideological mindset caused entire cities devoted to a single manufacturing sector (such as tractors and vehicles) to be created from scratch. While the Soviet economy cannot be held up as a model of efficiency, the cluster model did work for the Soviet Union, which is why there is still so much research on the subject in ostensibly capitalist modern-day Russia.

Of course, for a cluster economy to function, the region cannot consist of manufacturing only but also, must have the needed support structure. That includes schools that can train those who will work in the cluster (Sezonova, Galchenko, & Khodirevskaya, (2016). These authors noted that a cluster economy must include institutes of higher education that train future workers if that economy is to grow and thrive. Sezonova et al. (2016) observed that in *de facto* cluster economies (rather than ones that were planned), the local educational institutions did not always fulfill the need for competent, skilled personnel, particularly in technical fields. Moreover, Klimova, Kozyrev, and Babkin (2016) stressed the need for specially trained high-level managers in a cluster economy. Specifically, that training should be in how to function best within a cluster economy, implying that to do so, one needs specific skills (Klimova et al., 2016).

China, like Russia, is a now ostensibly capitalist economy that was once a communist planned economy. The mindset favouring cluster economies still exists, however. Lianhe and Qian (2014) observed that clustered businesses and manufacturing sectors allowed for more efficient taxation and allocation of government revenue. This situation did not exist in China when the economy was entirely state owned and operated. Lianhe and Qian (2014) theorised

that the financial efficiencies inherent in clustering were often more present in theory than in practice, as China's economy had not made the transition to state-sponsored capitalism smoothly and the previous command economy had not allowed financial decisions to be made locally.

The concept of an information technology-oriented cluster economy may seem contradictory, as information can be shared worldwide, and co-location is not necessary. However, Zhao and Zheng (2013) found that co-location of information networks fostered innovation and cooperation. They mentioned such phenomena as knowledge spillovers, wherein one actor acquires the knowledge of another by working together on an unrelated project, and communication of ideas, wherein physical proximity led to informal conversations and interactions whereby knowledge was shared—thereby suggesting that face-to-face communication is valuable even in a digital world (Zhao & Zheng, 2013).

Supporting the idea of clustering imparting unique qualities to different areas, Li (2013) compared the performance of two electronics manufacturing clusters, one on the west bank and one on the east bank of the Pearl River delta in China. Li found that despite the fact that both clusters were about the same size and that each had had the same access to investment capital and government resources, the cluster had performed differently. Li observed that the eastern sector had significantly outperformed the western sector in innovation, despite the above similarities and the fact that the western sector had possessed greater branding capacity, giving it better access to markets. Li's finding suggests that cluster economies function in independent and unpredictable ways, taking on characters of their own.

That finding supports those of Stough (2015), who in conjunction with testing a model of cluster economies, conducted a single case study of the Korean shipbuilding industry, which has been purposely built in a cluster. Stough posited that cluster economies

have a life cycle, noting that Korea's shipbuilding cluster was in a mature state. The end of such a cycle, per Stough, could be either the reversal of clustering, wherein an industry disperses geographically, or the obsolescence of the industry itself (wherein the primary sector of the cluster dies, taking with it the rest of the cluster).

Government policy within clusters. Clusters have often been created as special zones wherein the rules are different. This has often been the case in planned economies, or in post-communist autocratic capitalist countries. The Special Economic Region of Shanghai is an example (Qi & Wei, 2014). These authors sought to evaluate the performance of the Shanghai cluster as compared to the rest of China. They found that the Special Economic Region had outperformed the rest of China in that regard, particularly in fostering innovation. They remarked that Shanghai was becoming a global technological and financial center (Qi & Wei, 2014). These authors did not speculate, however, on whether the government-sponsored shift to laissez-faire capitalism (as opposed to the previous planned/capitalist hybrid economy) had been responsible for that growth in Shanghai (Qi & Wei, 2014).

Local authorities might also set special rules and regulations for cluster economies. Yu, Ma, Hu, and Wang (2014) found that in China's pharmaceutical industry, local governments had taken major steps to accommodate the growth and operation of clusters oriented on that sector. This was noteworthy, particularly because in China's former planned economy, local governments would have had no say in the matter whatsoever (Yu et al., 2014). Of course, local governments in many other countries do formulate policies specifically meant to accommodate cluster industries, such as favorable tax treatments.

One of the leaders in not just creating economic clusters but also in formulating government policy specifically for those sectors is Japan. Japan, though a democracy, also tightly regulates its business sector (Vorobeve, Island, & Region, 2014). Vorobeve et al. (2014) made some interesting observations about clusters in Japan. One observation was that

clusters are often sited in areas that have a comparative advantage, such as access to transportation and shipping infrastructure, co-location with universities, access to raw materials, access to a skilled labor force, etc. This, they noted, was the case in Japan, where a lack of natural resources made the optimal location of clusters imperative. They also observed that that lack of natural resources had been a driver of Japanese innovation, as they had historically been forced to invent novel solutions to problems arising from those resource deficits (Vorobeva et al., 2014).

Implications for Ireland. The implications of the above research suggests that Ireland, in its transition to a knowledge-based economy, would benefit from clustering to as large an extent as possible. First, there would be cross-fertilisation of ideas from the advanced manufacturing sector to the information technology sector. The above research suggests that such knowledge transfer occurs naturally when related enterprises are located in close proximity to one another. The presence of institutes of higher education in such clusters would certainly help with that process. This cross-fertilisation occurs informally, without government support or intervention, simply as a result of highly trained and skilled persons being in close contact with one another, even (and especially) informally.

Summary

In the most recent decade, intellectual economies played a large role in economic theory and discussion due to global emergence of KBEs (Melnikas, 2012). Rather than using traditional inputs such as raw resources, real estate, or capital investment, knowledge is the primary input of KBEs (Jacob, 2014). In altering the economic inputs and goals, the emergence of KBEs as a primary economic model necessitated change to social, political, scientific and technological processes (Melnikas, 2012). This literature review discussed studies relevant to the emergence of KBEs, including topics such as factors key to KBE

success, political and social challenges, managing KBEs regionally, the manufacturing and service sectors in KBE, and the specifics of Ireland's KBE.

Relevant literature revealed common components between strong KBEs. In international examples of KBEs, human capital was found to be crucial to economic success, with the provision of high quality education a particular national priority (Christinidis & Ellis, 2013; Hunjet, Kozina & Mulovic, 2014; Mungaray-Moctezuma & Perez-Nunez, 2015). Other factors which were found to be universally important to KBEs included political stability and free expression (Osman, 2014). Democratic societies were found to have stronger KBEs, and the commitment of country governance to promoting innovation and education were found to be equally important (Osman, 2014). Finally, countries which focused on research and development had stronger KBEs than those which did not and widespread access to ICT influenced KBE strength in international markets (Madrak-Gorchowska, 2013).

In 2015, Bedford, Carlson, and Wagner determined that tracking economies at the regional and city level was important for overall economic health. For regional and city level economies, knowledge sharing prompted economic stability and growth (Tkachenko, Rogova & Bodrunov, 2016). In 2016, researchers developed four models for promoting economic growth at the local and regional level which included the top down model, the program-based model, the strategic management model, and the ecosystem model (Tkachenko, Rogova & Bodrunov, 2016). In small economies, the following indicators were associated with preparedness for a KBE: quality institutions, macro-economic stability, well-functioning markets, and innovation capacity (Veugelers, 2011).

Chapter 3: Literature Review: The Nature of Advanced Manufacturing in Knowledge Based Economies

Introduction

Unlike many economies which are primarily focused on either manufacturing or knowledge-based industry, the Irish economy retained its advanced manufacturing base while incorporating the modernity of a knowledge-based economy. In general, the manufacturing industry is sensitive to bank rescission and other downturns, so there is an opportunity for Ireland to strengthen its knowledge-based economy without abandoning manufacturing as a core contributor to the Irish economy. The purpose of this study is to investigate the necessary policy initiatives and requirements to develop this type of economy within the unique system represented by Ireland's small-scale economy.

The literature included in the review was published primarily between 2008 and 2017. Some older research studies were consulted and included to give context to the evolution of knowledge-based economies and the Irish economy generally. Additionally, older foundational articles about KBEs were used to inform the current discussion and were therefore included.

In this literature review, the researcher will provide expanded background information on KBEs through an analysis of related literature. The first section will discuss manufacturing in KBEs and how the manufacturing sector in a KBE evolves from traditional low-tech manufacturing to high-tech manufacturing. The second section discusses the particular elements of the KBE in Ireland. Topics covered include an overview of the development of Ireland's KBE, followed by a discussion about the role of research and development. Next, the review of literature will include studies discussing the role of human capital and education in fostering KBEs and how government intervention influences the economy. The

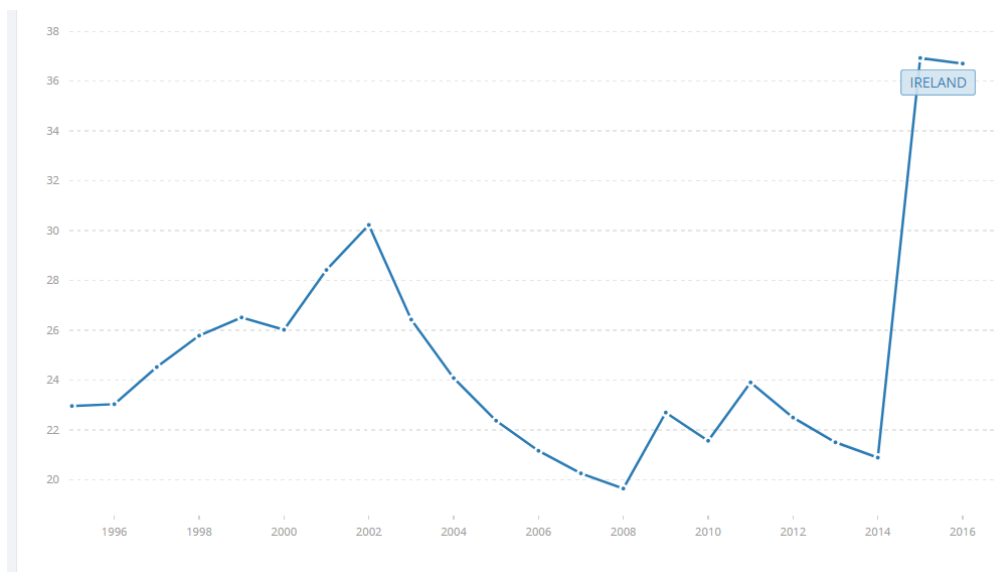
third section will focus specifically on the service sector in Ireland's KBE. The covered literature includes a discussion of the role of information communication technology (ICT) and how innovation influences the service sector. Next, the literature will discuss the role of the service sector in influencing the economy as a whole, as well as the similarities between service and knowledge offerings. Finally, the literature will include a discussion on managerial structures in service sectors based in KBEs.

The Knowledge-Based Economy in Ireland: 1990s and onwards

By the 1990s, Ireland had acquired a reputation as the "Celtic Tiger" for its rapid economic growth and increasing influence in the European economy, increased by its joining the European Union.

The first decade of the 21st century saw a downturn in Ireland's fortunes, however. The global recession affected Ireland by weakening its export market and causing financial turmoil. That recession, coupled with the obsolescence of much of Ireland's manufacturing base, as typified by the decision by textile manufacturing company Fruit of the Loom's decision to wind down its Irish operations in the early 2000's, spurred Ireland's transition to advanced manufacturing (Roper, Love, & Higon, 2006). Ireland now has a strong presence in several manufacturing sectors, especially pharmaceuticals, micro-electronics and medical device technology. In recent years Ireland has in fact grown the proportion of its GDP that is derived from manufacturing operations from 22.96% in 1995 to 36.7% in 2016.

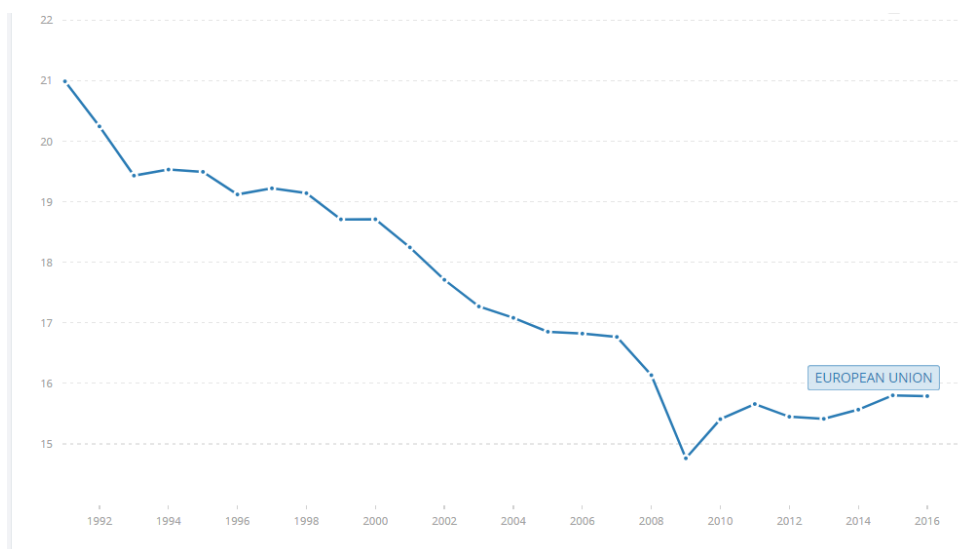
Figure 3.1: Manufacturing, value added (% of Ireland GDP)



Source: World Bank national accounts data, and OECD National Accounts data files

Over approximately the same time period as measured by the World Bank and the OECD, the EU countries experienced a reduction in GDP derived from manufacturing operations from 21% in 1991 to 15.79% in 2016.

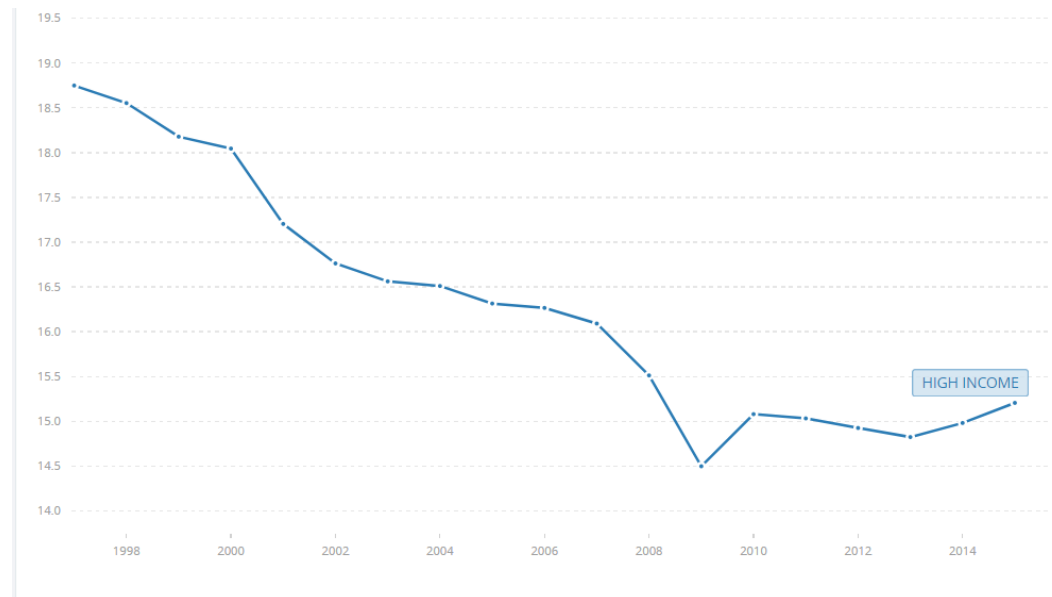
Figure 3.2: Manufacturing, value added (% of EU GDP)



Source: World Bank national accounts data, and OECD National Accounts data files

Similarly, what the World Bank and the OECD classify as high-income countries globally had in aggregate over approximately the same time period experienced a reduction in GDP derived from manufacturing operations from 21.68% in 1995 to 15.27% in 2015.

Figure 3.3: Manufacturing, value added (% of High Income Countries GDP)



Source: World Bank national accounts data, and OECD National Accounts data files

After recovering from the 2007 recession, the role of high tech foreign exports grew in Ireland (Brady, Doyle, & Noonan, 2013). In 2001, IT foreign exports accounted for 40 percent of total Irish exports. By 2013, nine of the top ten international ICT firms had operations with bases in Ireland (Brady, Doyle, & Noonan, 2013). In a 2013 study of Ireland's ICT sector, Brady, Doyle and Noonan determined that Ireland had diversified into a broad range of ICT products, which resulted in high export revenue streams. However, the researchers also determined that most of Irish exports came from well-established products, with relatively little innovation occurring. The researchers found instances of "disappearing products" or products with declining sales, not being replaced by new offerings (Brady, Doyle, & Noonan, 2013). This could be because Ireland had encouraged outside investment from established global firms that produced tried-and-true products, such as semiconductors,

and were trying to expand operations into markets where land and labour costs were lower, such as Ireland and other developing countries such as Mexico and China. These companies were not interested so much in innovation as in expanding what had been profitable in the recent past. The downside of all those subsidiaries being located in Ireland was that the parent companies could shut them down on short notice if their products became unprofitable. This, in fact, happened in 2011-2013, resulting in a decline in Ireland's export revenues (Brady et al., 2013).

Despite concerns about disappearing exports in 2013, Ireland ranked highly among European Union countries on several important economic indicators in 2015 (Lyons & Alshibani, 2015). According to the 2014 Innovation Union Scoreboard, Ireland ranked 9th in innovation performance (Lyons & Alshibani, 2015). Though ICT exports remained important to the Irish economy, exporting of engineering products, clean tech, electronics, and consumer goods supported the KBE. Researchers in the 2015 study attributed Ireland's success as a KBE largely to its very strong educational sector. The government and stakeholder groups encouraged the inclusion of entrepreneurial education in almost every academic institution, and the population as a whole is familiar with concepts related to entrepreneurial undertakings and innovation (Lyons & Alshibani, 2015). This is crucial if a nation is to maintain a strong position as a KBE—as discussed in Chapter 2, a KBE's primary productive mechanism is human capital, with information networks serving as the infrastructure along which that capital moves.

In a similar 2016 study, Lolic and Lynch represented Ireland's higher education system as an “assurance against economic risk”. The researchers determined that Ireland's higher education policy resulted in a population of young people who firmly believed the national narrative about the importance of higher education (Lolic & Lynch, 2016). These authors expressed the sentiment that a highly educated populace would be better able to adapt

to global shocks and recessions. The large-scale study determined that, when discussing their decision to attend universities, students echoed the messaging that university attendance would improve their economic condition and protect them from risks associated with economic downturns (Lolich & Lynch, 2016). In this study, researchers demonstrated the connection between the government, education, and KBE narrative. The students and researchers seemed to agree that higher education was an insurance policy against hard economic times, both for individuals and for the national economy.

The European Union as a whole followed a similar trend to Ireland's "intellectualisation of society" (Melnikas, 2013). According to researchers, the achievement of a KBE is one of the core goals central to the creation of an intellectual society. Though intellectualisation of its students was historically the goal of a higher education institution, researchers in a 2013 study argued that the emergence of a KBE in Ireland changed the purpose and goals of higher education (Miller, Moffett & McAdam, 2013). According to the researchers, the core function of educational institutions through the 20th century was the teaching, researching, and dissemination of knowledge. Following the emergence of a KBE in Ireland, educational goals shifted to include teaching creativity in research, technology, and innovation (Miller, Moffett & McAdam, 2013). While certainly, knowledge itself is and will always remain important, innovation is key to the maintenance of a robust KBE. The premise was that Ireland's recent success had been due in large part to its educational institutions' shift from simply teaching knowledge to teaching innovation and entrepreneurship (Miller et al., 2013). However, it should be noted that there is a broad counter argument that suggests that the issue is not a problem with the supply of entrepreneurs but a misalignment of incentives, such that entrepreneurial activity has been directed into unproductive, and what recently might be considered, destructive rent-seeking behaviours (O'Gorman, 2015).

The Irish government updated its education policy in 2011 with the creation of the “National Strategy for Higher Education” (Walsh & Loxley, 2015). While continuing a national policy of encouraging higher education, the Irish government sought to correct the issues which arose during the “Celtic Tiger” era (Walsh & Loxley, 2015). These issues had included over-specialisation, both at the educational and business institutional levels. The Celtic Tiger had lost its momentum largely due to Ireland relative inability to adapt to changing global economic circumstances and the educational system’s failure to inculcate innovation (Walsh & Luxley, 2015). Echoing educational visions shared throughout the European Union, some of the policy goals were: increasing and widening participation, reform university governance structures to conform to national polices, and to reduce bureaucratic waste. Many elements of the program were designed to continue a commitment to higher education while reducing the cost of delivering widespread, high quality, education (Walsh & Loxley, 2015).

Despite the convergence of literature around the importance of higher education policy, research also stressed the continued relevancy of a “low-skilled” workforce (Turner & D’Art, 2008). In the study, researchers asserted that though the rapid expansion of Ireland’s economy pre-2007 economic crisis was largely attributed to the high-tech sectors, the low and medium skilled job market expanded at a similar rate (Turner & D’Art, 2008). The findings suggest that the Irish government must take a balanced approach to training and educational policy so that students have an opportunity to be trained in a broad range of skills, rather than funnelled exclusively into highly skilled positions (Turner & D’Art, 2008). Certainly, not all workers will be capable of filling high-tech jobs. It is inevitable, however, that some lower-tech jobs will obsolesce, meaning that retraining must be provided when that happens (Turner & D’Art, 2008).

Similar to Ireland's focus on higher education, policies supportive to research and development played a large role in shaping the Irish KBE (Love, 2011). In 2011, Thomson Reuters Essential Science Indicators ranked Ireland's research performance as being amongst the top 20 countries internationally. According to researcher's, Ireland's success in the field of research and development could largely be attributed to a governmental commitment to research and a rigorous funding process for proposed projects (Love, 2011). Love argued that the government committed 75 percent of funding directly to scientists, which resulted in varied and innovated projects (Love, 2011).

Recognised as one of the most advanced KBE in the world (among the United States, Switzerland, Sweden, the Netherlands, Denmark, and Finland), Ireland has an advanced information infrastructure which is supported by both education institutions and research initiatives (Madrak-Grochowska, 2016). In a 2013 study, Nauwelaers, Maguire and Marsan argued that Ireland's international partnerships contributed to the creation of an advanced information infrastructure based on research. Collaborations such as InterTradeIreland, created between Ireland and Northern Ireland, led to increased budgets and greater funding stabilisation (Madrak-Grochowska, 2016). Other successful international partnerships include the US-Ireland R&D Partnership program and the HALO Angel Network. The programs facilitated peer review systems, co-funded research, stimulated investments in innovation policy, and streamlined funding processes (Madrak-Grochowska, 2016).

Researchers Enright and Dalton (2014) asserted that Ireland's specialisation in pharma-chem production is well established, and that many of the top multinational corporations are based out of Ireland. According to researchers in the 2014 study, pharma-chem production accounted for 11 percent of the Irish GDP in 2014, though its job share was much lower due to the highly knowledge intensive nature of pharmaceutical production (Enright & Dalton, 2014). Though the industry accounts for a significant portion of the Irish

economy, it is threatened by patent losses, and the potential impact was demonstrated in 2011 when one of the top producers lost its patent protections. The researchers estimated that patent losses could account for a reduction of between two to four GDP percentage points over a four-year period if new research does not rise to replace them.

The decrease in pharma innovations produced by research is an argument for increased research and development spending in Ireland, despite the country's relatively solid placement on the world stage. In a 2016 study of research and development spending across world economies, Born and Guo asserted that developed countries typically spend at least one percent of their Gross Domestic Product (GDP) on research (Born & Guo, 2016). Countries which were ranked among the strongest KBEs in the world, such as Sweden, Finland, and Denmark spent more than 3 percent of GDP on research and development (Born & Guo, 2016). While Madrak-Grochowska's 2016 study ranked Ireland as one of the top KBEs, it typically spent 1.5 percent on R&D, which put Ireland in line with the United Kingdom. Born and Guo argued that, while Ireland's research and development sector is strong, it is lagging behind other top KBE countries of similar sizes. In the long term, the smaller research and development budget could have a cooling effect on innovation, similar to what was experienced in the pharma-chem industry.

Despite the benefit of robust research and development budgets, Naghavi and Walsh (2011) argued that funding must be well planned out and carefully placed. According to the researchers and previously discussed literature, Ireland's large research and development budgets led to a rapid increase in scientific exploration (Naghavi & Walsh, 2011). Time revealed flaws which Naghavi and Walsh argued resulted in inefficiencies and wasted funding. One such example included the funding of projects in the short term only, without providing researchers an opportunity to obtain additional funding if their projects appeared to be promising. Short term funding opportunities and research positions led researchers to

leave the country after a number of years, resulting in a lack of return on investment (Naghavi & Walsh, 2011).

Though imperfect, Irish governmental policies played a large role in shaping and supporting Ireland's KBE (Grimes & Collins, 2003). According to Parker (2007) the Irish government's management of the KBE represents a fundamental shift in ideology. Studying the governance of KBEs at a regional level, Parker identified characteristics which differentiate governments which simply regulate from those which play an active role in steering the economy (Parker, 2007). Such characteristics include interconnectedness with other governments, breadth of governance and idea sharing (Parker, 2007). Similarly, Wiele and Iwaarden's 2010 study demonstrated economic benefits associated with similar characteristics in corporation's upper management, such as idea-sharing and mutuality.

In 2015, Shi, Li, and Wang demonstrated the positive impact government intervention could have on KBEs on a national level. In the study, Shi, Li and Wang determined factors which facilitate knowledge generation and transfer in economies and found that government participation increased the overall success. The study referred to the spread of knowledge within an economy as belonging to either a vertical or horizontal model. Under the horizontal model, knowledge is shared between two groups, while in the vertical model knowledge is passed from one group to another. Results of the study indicate that governments can support knowledge sharing with encouragement, but knowledge transfers are best facilitated through governmental policies (Shi, LI & Wang, 2015).

According to a 2015 MENA report, governmental policies played a large role in generating high-value job creation. By supporting research and development, funding educational systems, and promoting industry growth, the EU created more than 5 million jobs between 2008 and 2010, 800,000 of which came from high value research sectors. Policies which encouraged idea sharing and free movement of citizens promoted notions of a

“European Single Market” which had widespread benefits for the economies of member countries (MENA, 2015).

In 2016, O’Shaughnessy studied how social enterprises, directed by Irish public policy, encouraged economic stability and growth throughout the country (O’Shaughnessy, 2016). First emerging as a topic of conversation in the 1990s, social enterprises are an effective mechanism for job creation and economic stability in regions where the Irish KBE is slow to reach. O’Shaughnessy argued that they were especially effective after the recession in creating new jobs and spurring economic recovery in disadvantaged communities (O’Shaughnessy, 2016). Though not all social enterprises fit into the high-tech business model the “economic and entrepreneurial” model focuses on producing goods or selling services which benefit the community, and high-tech products and services could meet the features exhibited by other KBE enterprises (O’Shaughnessy, 2016).

Though the research previously discussed found that governments could play a significant role in growing and influencing a KBE, other researchers argue that too much government oversight and intervention could have a chilling effect on businesses (Khadir-Poggi & Keating, 2014). In a 2014 study, Khadir-Poggi and Keating argued that Ireland experienced a surge in government regulatory oversight after the 2007 recession. The researchers found that such intense oversight from Irish financial authorities resulted in constraints which were hard for businesses to manage without hiring additional staff (Khadir-Poggi & Keating, 2014). Hiring a large number of employees who did not contribute to product creation or other value-adding activities affected profitability and competitiveness internationally (Khadir-Poggi & Keating, 2014).

In a 2013 study, Haugh echoed the argument that excessive government interference was counterproductive to the creation of a strong KBE (Haugh, 2013). While evaluating the Irish regulatory strategy, Haugh agreed that some government policies and interventions were

useful to the creation of a KBE, such as the promotion of entrepreneurship, education, and science (Haugh, 2013). Policies which supported and encouraged business development were beneficial, but other policies were overly burdensome and did not further the directives they were designed to achieve. For example, Haugh recommended simplifying the national strategy to focus on innovation. Furthermore, Haugh recommended reducing the number of government agencies involved with KBE development so the link between academia and business would be more direct (Haugh, 2013). Other recommendations for simplification included focusing on applied research centres, streamlining intellectual property law, allowing more direct access to non-bank funding and upgrading the broadband network (Haugh, 2013).

Introducing Knowledge-Based Economies in Other Parts of the World

No matter where the location might be, introducing KBEs into existing economies can be difficult. On a fundamental level, doing so is change, and change can be disruptive and unsettling for many. If such change occurs gradually, as in impelled by choices that the private sector makes, it can happen almost without anyone realising it. However, if it occurs as the result of government intervention, it can be sudden and sometimes, traumatic. This section will explore the introduction of KBEs in parts of the world other than Ireland.

One feature of the KBE is that not only is its primary product information, but dissemination and diffusion of that information is an integral part of the economy (Ceptureanu, 2014). This author observed that in Romania, much attention was being paid to the function of a KBE as an information conduit in addition to its role as an information creator. Ceptureanu suggested that the success of a national economy had become more and more dependent on how and how well it handled information. Any nation without a robust

information network will not be able to process information optimally, nor will it be able to share knowledge with other nations (Ceptureanu, 2014).

A KBE can be either centralised or regional. In Sweden, there are several local KBE regions that are relatively autonomous (Leydesdorff & Strand, 2013). These authors sought to determine the extent to which synergy had occurred among Sweden's three major KBE clusters. They found a high level of such synergy, even though these clusters are not very close to one another geographically. The premise behind clustering is that physical proximity of related industries can be more efficient and lead to cross-fertilisation of ideas; however, the findings of Leydesdorff and Strand (2013) seem to indicate that synergy can occur even when the actors are not in close proximity.

In other parts of this review, the close relationship between a KBE and higher education has been noted. Sum and Jessup (2013) used the Harvard Business School as a model for KBEs and clusters in terms of competitiveness. They found that the most effective clusters were ones that contained knowledge-based enterprises in close proximity to and cooperation with institutions of higher learning. In fact, these authors went so far as to suggest that a KBE without higher education facilities would not succeed. The area surrounding Harvard (eastern/central Massachusetts) is home to several world-class universities and a booming tech-oriented business sector (Sum & Jessup, 2013).

Of course, a KBE encompasses the totality of a nation's economy, not just the activities of its elite and most highly educated. Morel (2015) noted an increase in demand for domestic services in Europe where KBEs had been established. While not dwelling on the causes of that increase, he did note that high employment created a demand for such services. Morel was critical of government efforts to regulate the domestic services labor market and noted that such measures had led to inequality in many cases. This finding indicates that in societies wherein the government has a major role in fiscal policy, the creation of a KBE

must take into consideration the effect on all members of society, at all levels of the social strata, not just those who will be directly participating in the KBE. Also, it should be reiterated that the creation of a KBE may reduce jobs in associated sectors, and governments should anticipate and adjust for that.

Echoing this sentiment were Ejdys, Ustinovičius, and Stankevičienė, (2015). These authors stated that a KBE must use an interdisciplinary approach, employing the economic and social sciences in order to create the best outcomes for society. The government cannot think only in terms of the added prosperity that a KBE provides; it must also prepare for the adjustments that may be necessary (Ejdys et al., 2015). These authors also noted the need for innovative management in a KBE, implying that older methods were less effective.

Returning to the role of universities in a KBE, Leydesdorff (2013) referred to what he termed the “Triple Helix” as an integrated structure consisting of the government, industry, and universities. The intertwined nature of a physical helix suggests the metaphor, that the three parts of the helix support one another and are inseparable (Leydesdorff, 2013). While this is simply one way of looking at the situation and in fact, in locations such as Sweden, these three sectors are not always closely intertwined, the model provides food for thought. In the past, government, industry, and universities have been thought of as sometimes in close cooperation, sometimes not, but always as separate entities. Leydesdorff viewed them as parts of a synergy, that a KBE does not really exist unless all three elements are present and, per the Triple Helix model, intertwined and interdependent.

The transition to a KBE often involves moving away from a commodity-based economy. The United Arab Emirates (UAE) are an affiliation of petroleum-producing kingdoms clustered around the Persian Gulf. As their oil supplies are vast but nonetheless finite, they have been searching for ways to transition to a KBE (Ibnouf, Dou, & Knight, 2014). Their method has been to build university campuses and attract students from all over

the world. The UAE's population is small, and the economy therefore will have to depend on outside workers to grow its KBE. Ibnouf et al. (2014) observed that the UAE's education hub was the largest in the world and attracted more foreign students than any other nation, which is particularly impressive considering the size of the UAE. The UAE, like many other nations transitioning to a KBE, realises the fundamental necessity for expanded educational facilities so that the needed workforce will be trained and available (Ibnouf et al., 2014).

The need for the addition of educational facilities to a KBE was also noted by James, Guile, and Unwin (2013). These researchers focused on the United Kingdom (UK) and suggested that such facilities were necessary to foster learning and innovation. They went further to say that advanced nations should discard manufacturing altogether and let it be done by nations where costs are lower. James et al. (2013) were comfortable with the notion that the UK could solely trade knowledge and information for the products of other manufacturing nations. Also, Popescu, Comănescu, and Sabie (2016) agreed with other researchers that the fostering of the growth of human capital in Romania by increasing available educational resources was the best way to ensure the success of the nation's KBE.

It is interesting to consider that concept in the light of current political developments in the United States. The U.S. is and has been the world's leading KBE. However, Donald Trump was elected as President of the US in 2016, with a heavy emphasis in his promised programme for government to return the U.S. to the relative prosperity of the 1950s-style, heavy manufacturing and raw materials extraction driven economy. This scenario is highly unlikely given global trends but the recent events in America underscore the fact that the benefits of the transitions to KBEs must be appropriately quantified politically even if their advantages may seem obvious.

The synergy among education, business, and government mentioned above is present to a significant degree in China (Leydesdorff & Zhou, 2014). China is a unique nation in

terms of its governance and economy; it is an ostensibly capitalist nation, but one with no personal freedoms and tight governmental control over even the smallest aspects of life.

Leydesdorff and Zhou wished to examine how the concept of synergy in KBEs applied in such a situation. They noted that capitalist economies are usually an aspect of free societies and that China was still, in many ways, a command economy. China, they reported, has less synergy than comparable other nations, and mid-level and high-tech manufacturing are less embedded than in other nations. This suggests a level of inefficiency when firms are not free to make their own choices (Leydesdorff & Zhou, 2014).

It might seem that introducing policies to create a KBE would be a high priority for governments given the demonstrated benefits and the inescapable fact that nations and societies that fail to do so inevitably fall behind. But there are obstacles to overcome. Most such obstacles are political. Leaders could be conservative and not wish to profoundly alter the country's economy—in essence, its livelihood. They also could have shared societal memories of the dangers of over-specialisation. The political system could be aware that a large percentage of their electorate may not have the skills or capacity to fully participate in a KBE as it is currently defined. Furthermore, the premise of forming a KBE is that knowledge can be traded for commodities that the nation does not manufacture. That is only true when trade is free and fair and globalisation makes it easy to trade for products. At the time of writing there is a disturbing trend with the Brexit initiative, the ascension of right-wing politics in Europe, and the U.S.'s recent turn towards inward focused policies and the renegotiation of such trade agreements as the North American Free Trade Agreement (NAFTA) and the abandonment of plans for the Transatlantic Trade and Investment Partnership (TTIP). Finally, there is the problem of disruption. If advanced manufacturing is transformed to the production of knowledge, then some jobs will be lost and the lives of some people will be disrupted. If a person loses his job because of a societal change, it is difficult

to convince him that it is all for the greater good. A person fearful of such change may vote/advocate against it simply from perceived self-interest. This literature review has illustrated many instances wherein the imposition of a KBE was not as smooth or easy as might have been expected.

Advanced Manufacturing in Knowledge-Based Economies

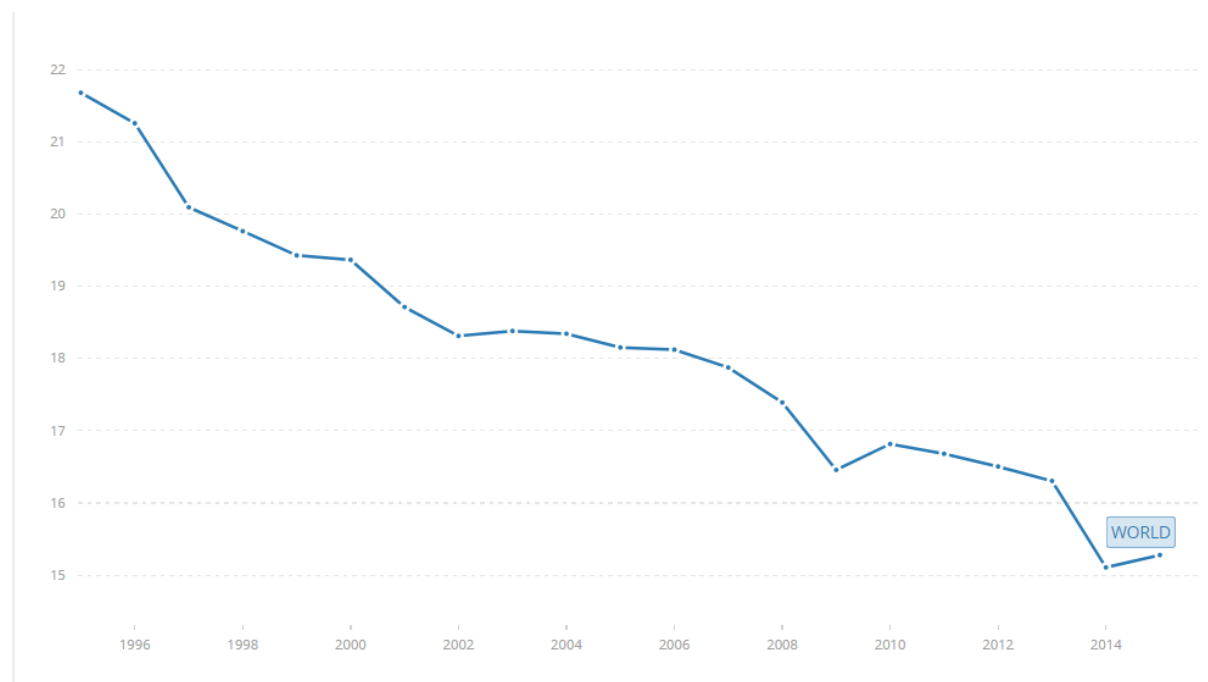
The literature provides insights into the characteristics of Advanced Manufacturing and they can be summarised as follows:

- It is characterised by a wide range of high-technologies involved in manufacturing, leading to improvements in terms of new product properties, production speed, cost, energy and materials consumption, operating precision, waste output reduction.
- It consists of capital intensive industries with complex assembly methods.
- It is focused on creating marketable knowledge-based goods and services.
- It requires significant investment in intellectual capital and continuous upskilling of human capital.
- The reliance on technology and automation means nearly the same amount of staff is needed whether the production throughput is busy or slow.
- Its outputs are generally export oriented in high volume.
- Advanced manufacturing facilities are often suited to produce more than one thing due to the large initial capital investment and the inbuilt flexibility of the complex toolset.
- The products are complicated, and the processes are unforgiving, demanding high levels of intellectual capital, and relentless pursuit of being best in class.

Examples of advanced manufacturing in KBEs include the production of pharmaceuticals, computers, electronics, and aerospace amongst others (Hatch, 2014). In the 2015 study,

Spirkova and Stehlikova determined that high-tech manufacturing sectors were more resilient to economic downturns than low-tech manufacturing and other industries, as demonstrated by strong performance during the 2007 recession. Across most of the EU, high-tech manufacturing sectors continued to grow during the recession and recovered better. In conclusion, the study found that an expansion of high-tech manufacturing could lead to improved economic stability in the EU (Spirkova & Stehlikova, 2015). In contrast to the growth of high-tech manufacturing, while manufacturing as a whole continues to be an important contributor to economies around the world, according to the World Bank national accounts data, and OECD National Accounts data files, manufacturing as a percentage of global GDP has dropped from 21.68% in 1995 to 15.27% in 2015.

Figure 3.4: Manufacturing, value added (% of Global GDP)



Source: World Bank national accounts data, and OECD National Accounts data files

In recognition of the growth potential of the high-tech manufacturing sector and the vital part that knowledge-based, and technology-driven industries will play in the continued

economic stability of the EU, in September 2009 a Communication from the European Commission introduced the concept of “Key Enabling Technologies”, the deployment of which “is not only of strategic importance, but indispensable for Europe’s competitiveness”. The KETs are a group of six technologies: advanced manufacturing technologies, micro and nanoelectronics, nanotechnology, industrial biotechnology, advanced materials and photonics. They have applications in multiple industries and help tackle societal challenges. According to the EC, “KETs are knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure and highly-skilled employment” (High Level Expert Group, 2011). The KET Expert Group predicted that countries and regions that fully exploit KETs will be at the forefront of creating advanced and sustainable economies. Those nations and regions mastering these technologies will be at the forefront of managing the shift to a low carbon, knowledge-based economy, which is a precondition for ensuring welfare, prosperity of its citizens. In particular the HLG recognised the importance of advanced manufacturing technologies (AMT) and the KET Sherpa Group provided the following definition of AMT in June 2010 “Advanced Manufacturing Technologies (AMT) comprises manufacturing systems and equipment , including automation and robotics, cognitive information processing, signal processing and production control by high-speed information and communication systems, advanced machinery, manufacturing engineering and industrial processing of new, waste, or recycled materials”.

For countries with large manufacturing sectors, creating a stable KBE may necessitate or encourage converting a portion of the low-tech manufacturing sector into higher tech operations (Ken, 2014). Historically, China was an example of a country with a largely low-tech manufacturing sector which resulted in China lagging behind similarly developed countries in terms of innovation and intellectual property development (Ken, 2014).

However, according to Ken in a 2014 study, China was able to transform its labour-intensive manufacturing model which resulted in less than ideal outcomes for a KBE into a culture of innovation. Ken attributed the country's success to KBE friendly policymaking which included more robust support for science and technology, re-establishing educational priorities, re-funding laboratories and correcting the Soviet Union style economic model. By working to redevelop the population's educational experience first, the negative externalities associated with industry conversion such as job loss could be minimised (Indergaard, 2015). In addition to the workforce and priority changes, China improved intellectual property protections which resulted in greater incentives to innovate (Ken, 2014).

Manufacturing sectors can be influenced and modernised by expanding the use of knowledge-based engineering (Tiuca, Rusu, Noveanu & Mandru, 2015). According to researchers in a 2015 study, knowledge-based engineering is particularly useful to manufacturing operations because it helps to identify and solve problems within the development process (Tiuca, Rusu, Noveanu & Mandru, 2015). Though such systems can be beneficial to individual operations and the economy as a whole, the workforce operating such systems requires specific knowledge and expertise which basic academic structures do not necessarily provide (Tiuca, Rusu, Noveanu, & Mandru, 2015).

By expanding the role of knowledge in manufacturing, the engineering profession transforms from a practical profession to a scientific one (Young & Muller, 2014). Engineers play a key role in identifying process problems, innovating solutions, and working the solutions back into the process mechanics. In order to develop a component workforce of engineers with the skills to develop a KBE, academic institutions must combine both theoretical knowledge and problem solving with the practical application of skills which mirror real world engineering requirements (Young & Muller, 2014).

Knowledge and the ability of a workforce to innovate technologically is a key pillar of a knowledge-based manufacturing sector (Castro, 2015). According to Castro in a 2015 study, competing in high-tech industrial markets require innovation which is best promoted by a high-quality workforce. In a 2016 study, Sinanovic and Becirovic argued that maintaining a high-quality workforce suitable for a KBE required human capital to undergo a process of lifelong learning. Factors like increasing automation, changing computer technologies, cheaper transportation and enhanced communication capacities incentivise firms to be lean, which puts pressure on the workforce to keep up with changing workplace environments (Sinanovic & Becirovic, 2016).

Though discourse on manufacturing in KBE tends to focus on high-tech manufacturing, lower tech manufacturing operations play a role in supporting KBEs as well (Hansen, Winther & Hansen, 2014). In 2014, Hansen, Winther and Hansen analysed workforce requirement in Denmark's high and low-tech manufacturing industries. The researchers determined that, though a highly skilled workforce is crucial to high-tech manufacturing, the share of highly skilled workers is rising steadily in low-tech manufacturing.

Like highly educated human capital, research and development plays a crucial role in supporting the manufacturing industry in KBEs (Ayaydin & Karaaslan, 2014). In a 2014 study, Ayaydin and Karaaslan (2013) argued that companies must continue to fund research and development, despite rising costs and pressure to limit spending which carries a higher risk of not being returned as additional profit. In tough economic conditions or expensive areas, firms are incentivised to obtain a competitive advantage by reducing cost. However, Ayaydin and Karaaslan (2013) found that robust research and development budgets were essential to the manufacturing industry in Turkey's KBE, as demonstrated by a correlation between research and development and financial success. According to the researchers,

robust research and development budgets helped manufacturing firms to specialise and gain competitive advantages (Ayaydin & Karaaslan, 2014).

Though the direct benefit of robust research and development budgets might be primarily felt by the individual firm, research suggests that research and innovation can have a “spillover” effect which creates positive benefits for the local economy (Turkcan, 2015). According to Turkcan (2015), research and development helps firms which did not participate in either the research or production, because knowledge disseminates quickly, even without violating intellectual property laws. Creating new products incentivises others to do likewise, and new manufacturing processes influence other firms to try similar techniques. In this manner, research and development has a broader effect than the financial gains of one firm (Turkcan, 2015).

In a second study performed in 2016, Samadi asserted that knowledge spillover can have broad reaching effects which stretch beyond the local economy or related firms. In the study, Samadi found that a significant amount of knowledge can eventually be appropriated by other firms and industries. In this manner, the original innovations and techniques are broadened for use in other applications (Samadi, 2016). The process by which knowledge created in one industry is applied to another is sometimes referred to as exogenous technological progress. An example of exogenous technological progress from the manufacturing sector is photovoltaics, created for the microprocessor industry being used to make solar panels (Samadi, 2016).

In a 2014 study, Chen argued that countries which do not innovate are often left to rely on the innovations of other countries to grow their economies. Referred to as dependency theory, Chen argued that the condition of relying on international innovations to support a manufacturing sector puts countries in a weaker and less stable economic condition (Chen, 2014). In some instances, patterns of dependency early in the development of a KBE resulted

in long term dependence which became harder to escape as time elapsed and more of the economy was reliant on outside technologies.

In 1970, Schumpeter argued that there are instances in which viable firms perish under a certain set of circumstances which would have been able to go on had not a particular event occurred. In 2005, Stewart asserted that the dotcom boom was an example of changing industry, or a moment in time which changed the face of economic theory and altered economist perspectives of capital and investment. Referencing Schumpeter's (1970) theory of "creative destruction", or the process of new innovations destroying established firms and enterprises to replace them with new ones, Stewart argued that capital goods should be considered separately from consumption goods in order to properly value knowledge-based firms which lack the capital-intensive structure of old style manufacturing operations. Echoing Schumpeter, Stewart states that measuring capital is challenging, especially in knowledge-based firms. According to Stewart, the challenging of quantifying value distracts from the more relevant economic goals of meeting the consumption impulses of modern consumers, who are increasingly interested in products and services which require intensive knowledge-based capital. In conclusion, Stewart suggests that KBEs represent the new markets and new forms of industrial organisation referred to in Schumpeter's theory of creative destruction.

The Role of the Service Sector in Transitioning to a Knowledge-Based Economy

In 2017, Svarc and Dabic discussed the evolution of KBE in Europe as they transformed from economies primarily based on high-tech production and manufacturing to economies with larger service sectors. In the study, the researchers found that economies with large service sectors had different structural and scientific requirements than those which were primarily focused on production and manufacturing (Svarc & Dabic, 2017). The

change, Svarc and Dabic argued, was due partially to the realities of globalisation and partially due to the evolution of an economy which was increasingly focused on knowledge as a core product and input (Svarc & Dabic, 2017). Knowledge in the service sector, though still produced through innovation, research, and academia, focused on business management, ICT services, and internet-based services (Svarc & Dabic, 2017).

Many countries underwent significant change in the late 1990s, and governments attempted to influence the direction of economies from resource intensive manufacturing to KBEs with knowledge as the primary input (Leydesdorff, Perevodchikov, and Uvarov, 2015). Russia was such a country, and after the fall of the Soviet Union, the new leadership sought to transform the economy from one driven largely by oil and gas revenues to a more modern KBE input (Leydesdorff, Perevodchikov, and Uvarov, 2015). Government intervention played a large role, and Russia focused on establishing research centres, such as the Skolkova Innovation Centre and high-tech business area on the outskirts of Moscow, growing the incentives to innovate, and increasing federal funding for academic institutions. The researchers found that, as of 2014, Russia's transformation was still underway. Their findings suggest that the presence of knowledge intensive services are important to the overall strength of the KBE, and though increasing, knowledge-intensive services are lagging at just 13 per cent of the market share and are concentrated primarily in Moscow (Leydesdorff, Perevodchikov, and Uvarov, 2015).

Though the manufacturing sector in Ireland remains prominent, services play an increasingly large role in the economy. In a study of Ireland's KBE before the 2007 recession, Haskel (2007) found that market services already made up 42 per cent of the GDP. Knowledge intensive business services play a large role in supporting KBEs, because they support other sectors and fulfil necessary functions. In a 2003 study, Kuusisto and Meyer stated that knowledge intensive services play a role as "carriers, shapers, and creators of

innovation” (Kuusisto & Meyer, 2003). In KBEs, the need for services is potentially even wider than in more traditional economies, and offerings include ICT, recruiting, and financial management. Due to the close yet separate link to many types of businesses, Kuusisto and Meyer argue that service firms in KBEs are uniquely positioned to provide valuable market and managerial insights. Furthermore, despite being inherently different in nature, service firms such as ICT providers can rely on research and development as heavily as high-tech manufacturing operations” (Kuusisto & Meyer, 2003).

Widespread and efficient ICT is crucial to the Irish high-tech service sector and the KBE as a whole (Barry, 2013). In a 2013 study, Barry asserted that the widespread use of ICT reduced transaction costs between customers, suppliers and businesses, which resulted in greater profit margins and room for increased innovation. Additionally, ICT allows for a greater ability to outsource non-core functions, which resulted in increased firm specialisation which found to be linked to increased profits (Barry, 2013). Furthermore, Barry argued that robust spending on ICT allowed Ireland’s significant high-tech service sector to hold an international presence. Barry stated that the ability to retain a global presence through ICT is particularly important to Ireland’s service sector due to the high concentration of high-tech firms in the west coast US Silicon Valley region (Barry, 2013).

In a 2013 study, Wegrzyn sought to determine how the service industry in European Union countries influenced the rapidity and character of KBE development (Wegrzyn, 2013). The researchers found that the presence of a strong high-tech service industry directly influenced the overall development of KBEs in member countries (Wegrzyn, 2013). Additionally, in economies where knowledge was a significant driver of competitive advantage, services related to acquisition, distribution, and creation of knowledge were particularly influential (Wegrzyn, 2013). In directly contribution to the competitive advantage

of a country, Wegrzyn found that knowledge-based service activities heavily influenced economic performance in terms of knowledge creation, distribution and use (Wegrzyn, 2013).

Value creation in service-based KBEs is different than value creation in the historical models of heavily industrial economies (Jurigova & Tukova, 2016). In a 2016 study, Jurigova and Tukova argued that the convergence between knowledge and services makes the service sector particularly thirsty for new technology and innovation. Jurigova and Tukova stated that commonalities between knowledge and services include intangibility, difficulties around assigning ownership, and the sometimes complicated nature of value recognition (Jurigova & Tukova, 2016). In the study, the researchers acknowledged that the aspects which made services and knowledge similar made management of the service sector more challenging, but also stated that those aspects led to greater economic rewards (Jurigova & Tukova, 2016). In an economic analysis of business sectors in KBEs, the researchers determined that knowledge-intensive services were valued higher than manufacturing industries (Jurigova & Tukova, 2016).

The shift in focus from industrial processes to knowledge-based services altered traditional thinking about management best practices (Jalaei & Samimi, 2014). Rather than following management strategies designed for capital intensive firms, providers of knowledge-based services are finding competitive advantage through increased organisational flexibility (Jalaei & Samimi, 2014). Due to a lack of constraints created by costly manufacturing infrastructure, service-based businesses are better able to change working processes, products and design to follow consumer trends. The study results suggest that the service sector would benefit from an increased academic focus on knowledge-based management styles which prepare students for nimble and adaptive corporate styles (Jalaei & Samimi, 2014).

In 2002, Stewart argued that management of knowledge-based firms was fundamentally different from management in older style economic models. In the study on training and management in KBEs, Stewart states that training is no longer the responsibility of a “training department”, and that managers should shift the responsibility for career-long learning to themselves and their employees (Stewart, 2002). Furthermore, informal learning and work-based learning must occur on a constant basis, and employees cannot rely on separate “training sessions” or workshops to improve their skills. In a quickly moving, knowledge intensive industry, both managers and employees must be open to on the job improvement and instruction. In many instances, Stewart argues that corporate structures create barriers to progressive learning styles, and those barriers must be removed in organisations are to remain functional and nimble (Stewart, 2002).

In 2014, Muthusamy and Dass studied the paradox firms face in remaining nimble while expanding. The researchers assert that organisations often struggle to grow larger without losing the dynamic, innovative, nature which originally created their competitive advantage (Muthusamy & Dass, 2014). The researchers examined firm transactions, integration, and coordinating with the international economy to determine that firms can benefit from disaggregation. While retaining the benefits for a large firm, disaggregation allows for easier management and more nimble business operations (Muthusamy & Dass, 2014). Additionally, disaggregation increases responsiveness and allows firms to take advantage of business opportunities which require rapid responses (Muthusamy & Dass, 2014).

How Clusters Affect Research & Development

The previous chapter contained a discussion of cluster economies and how they can be beneficial for accelerating growth, particularly in tech sectors. In this section, a discussion

of how clustering affects research and development will be presented. While it is difficult to precisely evaluate how well clustering encourages R&D, some of the most fertile locations for innovation have been cluster areas, such as high-tech areas in China or Silicon Valley in the U.S.

Clusters are most effective when they have been purposefully formed rather than “just happened.” India is one economy where purpose-built clusters have been created successfully due to government initiatives; Bangalore is a leading example of a purpose-built cluster which has developed rapidly since India’s liberalisation reforms began in 1991 (Karna, Täube, & Sonderegger, 2013). These authors noted that the presence of companies in such a purpose-built cluster impelled them to create specific divisions tailored towards fostering innovation and R&D. Their conclusion was that not only were innovation networks being created within specific companies, they were also being created across organisational and even geographical lines. In other words, cross-fertilisation of ideas was taking place informally as a result of companies’ proximity to one another within the cluster (Karna et al., 2013). This finding has interesting implications: it might be thought that the spread of innovation would not be geographically dependent, given that most communication is electronic, and distance does not matter. However, Karna et al. (2013) did observe this cross-fertilisation effect, which could be due to the formation of informal, social networks within the close mutual proximity of the cluster.

Furthermore, Mrinalini, Nath, and Sandhya (2013) examined foreign direct investment in R&D in India during the prior decade. They found that the presence of high-tech clusters had encouraged such investment, as a significant portion of that investment had been directed within them. Companies were building facilities within these clusters specifically because of the advantages such locations offered (Mrinalini et al., 2013). These authors also observed that the formation and encouragement of the growth of clusters

demonstrated a commitment to technological growth and innovation on the part of the government and thus made those clusters a magnet for foreign investment (Mrinalini et al., 2013).

Cambridge is the leading high-tech cluster in the United Kingdom, being centered around a world-class university and having attracted dozens of high-tech firms (Probert, Connell, & Mina, 2013). Probert et al. examined the effects of R&D service firms on the level of innovation within and without the cluster. An R&D service firm is a firm that is purposed toward the development of research and the facilities needed to foster it, without an end goal in mind—as opposed to the R&D division of a manufacturing firm that produces an end product. These authors observed that R&D service firms contributed both directly and indirectly to the growth of innovation (Probert et al., 2013). One effect they noted was that technology initiatives could be de-risked, meaning that they could be outsourced and thus, failures could be mitigated. Also, such firms could be employed when a business did not have a dedicated R&D division and did not want to devote the resources to create one (Probert et al., 2013).

Increasingly, cluster economies and cluster sectors are being developed at the national policy level. These clusters are seen as a way to “catch up,” in the case of developing countries such as India, or a way to gain an advantage, as in developed countries such as those in Western Europe. Piekut (2013) compared R&D expenditures in tech clusters in various European countries. They found that investment in R&D was greatest in Finland, Denmark, and Sweden. They also noted that those levels of investment were sometimes higher than in even Japan or the U.S. Piekut also found high levels of R&D in developing Eastern European nations, particularly Slovenia. They observed that Estonia, the Czech Republic, and Hungary were catching up in this area. The conclusion that Piekut reached was that the extent to which R&D investment was occurring in a given European country

depended on how pro-business the economy was and crucially, government attitudes toward and investment in R&D.

Clusters, in addition to endogenous interaction (within the cluster), also form innovation networks with other clusters (Tomasello, Perra, Tessone, Karsai, & Schweitzer, 2014). Tomasello et al. identified three types of R&D partnerships: alliances within a firm, such as sections of an existing business; relationships among closely connected or related independent firms, and long-distance relationships, whereby one partner is isolated and/or new to the industry. The researchers, in attempting to model the formation of such relationships, concluded that endogenous relationships formed more easily than exogenous ones, which supports the general rationale given for the formation of clusters by authorities and stakeholders (Tomasello et al., 2014).

The value of cross-fertilisation of ideas, the formation of R&D networks, and the ease of interacting with related firms are recognised in the business world. In France, the question has been whether the government needs to offer incentives for firms to join existing clusters, which could involve relocation disruption and expenses (Fontagné, Koenig, Mayneris, & Poncet, 2013). These researchers concluded that in France at least, such incentivizing was not necessary, as firm realised the advantages of being in a cluster. In particular, the boost to R&D was noted. Therefore, the government should focus on the creation of sector clusters rather than encouraging firms to join them, as that will happen naturally (Fontagné et al., 2013).

Implications for Ireland. Ireland's transition to a knowledge-based economy will necessarily involve major investments in R&D. The above studies suggest that creating a climate that naturally fosters innovation and cross-fertilisation of ideas is the best and most efficient way to bring that about and that clustering accelerates that process. The benefits of clustering include:

- Informal cross-fertilisation of idea
- Encouragement of foreign investment
- Formation of dedicated R&D firms within the cluster
- Innovation networks
- The fostering of pro-investment government policy

These findings strongly suggest that Ireland could benefit from the formation of industry sector clusters. In particular, the efficiency of co-location of related industry players could help Ireland to have a disproportionate impact in the sectors where it chooses to compete.

Summary

For many national economies, manufacturing still accounts for a large portion of GDP (Yavaş, 2014). Once the backbone for traditional capital based economic models, the manufacturing industry in KBEs evolved from a low-tech model to a high-tech model which relies more on knowledge as an input (Spirkova & Stehlikova, 2015). High-tech manufacturing better suits the needs of a highly-educated workforce and is shown to be less sensitive to economic recessions than traditional low-tech manufacturing industries (Ken, 2014). Among other inputs, increased usage of knowledge-based engineering supports the manufacturing sector as it transitions to a high-tech model provide (Tiuca, Rusu, Noveanu & Mandru, 2015).

The Irish economy was largely supported by agriculture and low-tech manufacturing industries until the late 1990s and early 2000s when the economy became increasingly supported by high-tech manufacturing and service sectors (Hazelkorn & Massar, 2011). Ireland's national policy of supporting higher education led to a highly-educated workforce which subscribes to the national narrative encouraging innovation (Lolich & Lynch, 2016).

Additionally, Ireland was ranked as one of the top 20 countries in the world for research and development. However, compared with other top ranked countries, Ireland's research and development budget remains relatively low (Madrak-Grochowska, 2016).

It seems that much of the resistance to forming a KBE, both in Ireland and worldwide, has been due to mistrust in the viability of knowledge as a saleable and exportable product. As it is intangible, many traditional economists and commentators consider it highly risky to base a nation's economy on it. Also, Ireland in particular has a cultural memory of the perils of over-specialisation: the potato famine of the late 1840's. Over-reliance on a single crop produced mass starvation and forced emigration. Ireland remained a net exporter of food (mainly to England) throughout the famine years. Perhaps this still contributes, even today, to a national mindset that is antithetical to relying on a single, export-based commodity (in this case, knowledge) for the nation's livelihood and rather to have a broad based diversified economy. This national mindset may have been reinforced in the recent economic downturn where an over-reliance on the construction industry and real estate trading led to the end of the 'Celtic Tiger' era and subsequent national economic turmoil.

Still, though Ireland has a strong presence in certain manufacturing sectors and is a world leader in the production of certain products, researchers seem to generally agree that the production of human capital is Ireland's most valuable economic endeavour. Aside from the growing indication that information will be the single most valuable worldwide product, the adaptability that comes from a highly educated workforce will stand Ireland in good stead during future economic cycles. This realisation is what is driving current Irish economic policy. The realisation is that Ireland is naturally becoming a KBE and that policy initiatives should turn toward recognising that inevitability and fostering its growth.

Chapter 4: Methodology

Research Design

A qualitative case study research design was implemented to investigate the necessary policy initiatives and requirements to develop a knowledge-based economy within the unique system represented by Ireland's small-scale economy. The rationale for this choice was that the case study approach provided the opportunity for detailed study of the modern phenomenon of a knowledge-based economy using real contextual evidence from those working directly in the field of interest (Yin, 1994). The original methodology proposed a holistic single-case design with the unit of study as the multi-national company operating in Ireland. The research proposal was to explore how these companies would use the existing advanced manufacturing system to build a knowledge economy within the country. However, the availability of the actual collected data demonstrated the need to shift from an analysis based upon a single-case study design to a thematic analysis. This change occurred because while the detailed interviews provided a rich history of information for analysis, the supporting materials necessary to complete a full case study analysis were not available.

Rationale

This study used qualitative thematic analysis of interviews as its method. The design was originally to be a single case study, with the idea being that such a narrow focus would allow for the collection of confirming secondary data, but that approach proved to be impractical. However, this study still essentially used the single case approach by considering all of the interviewees as a single case, though they did not all work for the same company. This means that the "case" is "managers and CEOs of advanced manufacturing concerns in Ireland" rather than "Company X, an advanced manufacturing concern in Ireland." This is a

valid approach for a case study when the sample is homogenous, as is the case here (Yin, 2014).

Epistemological position of the researcher. There are many types of data to be gathered in order to understand a problem or situation, and many ways to gather such data. Therefore, the researcher must take a view that the particular approach he uses will be optimal in answering the review questions and achieving the purpose of the study—or at least, the best available given the time and resource constraints of the researcher. The concept of what sources of data/information to use is often referred to as epistemology. The researcher must make an epistemological choice when planning the study. These choices include the following approaches:

- Pragmatism, which is based on both observable phenomena and subjective interpretations, with a philosophy of using what is available
- Positivism, which is based in using only observable data and verifiable facts, emphasizing causality
- Realism, which focuses in explaining data via context
- Interpretivism, which focuses on details and subjective interpretations of the data—seeking to find underlying meanings in that data

Also, epistemological approaches can be broadly classified into empiricism and rationalism. The former allows for more subjective and situation-dependent interpretations than does rationalism, which states that the data must be presented and analysed with a minimum of subjectivity and interpretation. The qualitative approach tends to be more empirical, whereas the quantitative approach tends to be more rationalist.

Therefore, the epistemological approach used in this research was empirical/interpretivist. The very nature of the interview-based approach means that the researcher will be interpreting the data, not just reporting it. This is exemplified in the coding

and thematic analysis process (Yin, 2014). It is very important to note that the researcher plays a critical epistemological role in this type of research because he is the only one who will have conducted and heard all of the interviews and thus, the only one who has been directly exposed to all the data. Of course, later researchers could read the interview transcripts, but that does not afford the same experience—again, the interpretivist model assumes that the researcher will form subjective impressions both on the spot and after reflection.

Subjective versus objective data. The first choice the researcher must make, in virtually any study, is whether to gather qualitative data, quantitative data, or both. There is no “perfect” data source and no ideal way to gather and analyse it; ultimately, the researcher must decide *how* he wants the question(s) answered. It is possible to quantify subjective data by using surveys and questionnaires that ask respondents to assign numbers on a scale to their responses, as with Likert-scale responses, wherein the participant is asked to indicate (for example), agreement or disagreement with a statement on a scale of 1 to 7, 1 to 5, etc. Using such an approach is an attempt to quantify the subjective.

The research questions for this study are essentially subjective in nature, as they ask for recommendations, predictions for the future, assessment of possible outcomes, and so forth—all complex and subjective concepts. The data collected were, as a consequence, “messy”—the researcher needed to conduct several stages of thematic coding and analysis to organise and present it, a task that would have been much easier had the data been in quantitative form. Furthermore, qualitative coding in and of itself adds a further layer of subjectivity (Yin, 2014), in that the researcher will almost certainly have a distinct, even unique view of the data. In quantitative research, by contrast, the researcher simply plugs the data into equations and reports the results; no element of subjectivity is involved. This means that no qualitative, thematic analysis-based study can ever be precisely replicated—not even

by the same researcher at a future date, since a person's mindset and point of view change over time.

Philosophy and approach. The question, then, became: what form of data should be used? The first choice was qualitative or quantitative. The researcher wanted to obtain the viewpoints of experts in the field—those who were directly involved in Ireland's transitioning economy and would be in the future. This was a specialised group of individuals with unique insights and experience. Therefore, the potential existed for them to offer particularly valuable data—a potential that was realised. Several of the viewpoints expressed by multiple interviewees were surprising and would have been difficult to predict. This depth and detail could only have been afforded by the collection of qualitative data.

The next choice was design. The case study approach was chosen with the case being Irish policy makers and the managers and CEOs of manufacturing companies in Ireland. The case study approach is best when one wishes to examine in detail a group, setting, place, organisation, etc. wherein a situation has occurred, is occurring, or will occur (Yin, 2014). Furthermore, when conducting a case study, one should employ a sample of persons who are involved in the case and the situation to be studied. Given that the study was about the transition of Ireland's economy from advanced manufacturing to information-based, it was only logical to talk to stakeholders in that transition.

The homogeneity of the sample was both a strength and weakness methodologically. It was a strength, because it allowed for the collection of data from only persons who were extremely knowledgeable about the situation. It was a weakness, because collectively, only one point of view was expressed (which is not to say that there was always consensus). The study could be replicated, employing other groups of stakeholders; for instance, government regulators, owners of advanced manufacturing firms, or information technology educators.

The researcher did anticipate these factors and concluded that the depth and richness of the data that would be gathered outweighed any concerns of methodological weakness.

The philosophy for this research was both exploratory and descriptive. It was exploratory, because it asked a question about the future and why certain outcomes would happen, had not happened, or could happen. It was descriptive, because one aspect of the situation uncovered by the literature review and corroborated by the interviews was that the very definitions of some of the terms used in the study were not agreed upon or universally defined. For instance, “advanced manufacturing” and “a knowledge-based economy” appear to mean different things to different people, which certainly includes the participants in this study. And since the ultimate goal of this study was to form policy recommendations for Ireland’s economy, a fundamental first step is to clearly define critical concepts and terms, to avoid confusion and later disagreement.

Data Collection and Participant Selection

I conducted seventeen interviews and collected a large, complex data set. All of my interviews took place face to face. Prior to each interview, I emailed participants and gave them the background to my study. I emailed a sample list of questions to the participants in advance. Each interview was scheduled for approximately one hour, with some interviews extending to up to two hours. At the beginning of the interviews, I reiterated the purpose of the interview and assured the interviewees that their feedback would be confidential, and their names would not be associated with the content.

In the course of the interviews, a free-flowing, semi-structured, open-ended approach was employed to ensure that no pertinent information would be missed, which could call into question the validity of the study. It should be noted that nine of the interviewees were known to me personally. The interviews took place in the period from 2012 to 2015 and I continued to collect data until I felt that new sources could not add any additional data value to the

research question. The following table presents information on those persons interviewed, their job title, their industrial perspective and their organisation focus.

Table 4.1: Interviewee List

Title	Perspective	Organisation Characteristics	Location
Managing Director	Industrial Policy	SME outward investment	Nationwide
CEO	Industrial Policy	FDI inward investment	Nationwide
Former-CEO	Industrial Policy	FDI inward investment	Nationwide
Former-Special Adviser	Industrial Policy	Government	Nationwide
CEO	Industrial Policy	Representative body	Nationwide
CEO	Industrial Policy	Representative body	Nationwide
General Manager	Manufacturing	SME sector	Rural
General Manager	Manufacturing	SME sector	Rural
CEO	Manufacturing	SME sector	Rural
CEO	Manufacturing	SME sector	Rural
CEO	Manufacturing	Irish MNC	Nationwide
CEO	Manufacturing	Irish MNC	Urban
Site Director	Manufacturing	Foreign MNC	Rural
VP and Site Director	Manufacturing	Foreign MNC	Urban
VP and Managing Director	Manufacturing	Foreign MNC	Urban
VP and General Manager	Manufacturing	Foreign MNC	Urban
VP and General Manager	Manufacturing	Foreign MNC	Urban

Interviewee Selection Criteria

The respondents were selected based upon the need to collect a diverse grouping of perspectives. The selections were made based on the following four categories:

- Perspective, be it from a creation and implementation of industrial policy perspective or be it from a perspective of consumption of industrial policy within the area of manufacturing in Ireland.
- Location, be it from a national viewpoint as a policy maker, policy implementer or a representative body, from a rural viewpoint as the individual

tasked with running a manufacturing facility in a rural location, or from an urban viewpoint as the individual tasked with running a facility close to a large urban population centre.

- Organisation Characteristics, with the goal of gathering data from indigenous and foreign investment companies, from small to medium enterprises and large multinational companies (both Irish and foreign direct investment) and from both inward and outward focused development agencies.
- Gender, with the goal of achieving some gender spread although the manufacturing industry has traditionally not been seen as a gender-neutral work environment.

The selection criteria and statistics are represented in the following table:

Table 4.2: Interviewee Selection Statistics

Perspective		
Industrial Policy	35%	6
Manufacturing	65%	11
Location		
Nationwide	35%	6
Rural	29%	5
Urban	35%	6
Organisational Characteristics		
SME outward investment	6%	1
FDI inward investment	12%	2
Representative body	12%	2
Government	6%	1
SME sector	24%	4
Irish MNC	12%	2
Foreign MNC	29%	5
Interviewee Gender		
Male	88%	15
Female	12%	2

Developing the Interview Protocol

A limitation of the semi-open interview question technique is that the discussion tends to be limited to the topics introduced by the questions. This issue is mitigated by having the questions be semi-open or less structured, but the effect is there nonetheless. Therefore, the researcher must strike a balance between specificity in the questions he asks (to make sure that answers to the research questions are generated) and allowing participants latitude in their responses.

This problem can be mitigated by using an existing validated research instrument. However, for asking these specific questions, there was no such instrument. Therefore, the researcher had to construct one. The instrument was offered for expert review: three faculty members were consulted and shown an initial draft of the questions. The researcher modified the questions upon receiving advice from them.

Another way to validate a researcher-constructed instrument is to conduct a field test of the instrument. However, the same practical considerations that precluded a single case study also made a field test impractical. The participants were busy executives, and the choice would have had to be made after conducting the field test with 3-4 participants between forcing those participants to repeat the interviews or proceeding with the rest of the study after excluding them. The relatively small size of the sample available made this approach not feasible.

However, the interview questions did yield good data. All of the participants were forthcoming and ready, even eager, to share their insights. The researcher's supposition that these participants would have strong opinions on the subject proved to be true. Yin (2014) recommended that the researcher not have any preconceived notion of how the qualitative inquiry process should go other than the necessary step of constructing the interview protocol or deciding to use an existing one.

The interview protocol used may not be suitable for future research except for a near-exact replication of the study, because its questions assumed sophisticated knowledge on the part of the participants. Certainly, the study could be conducted again with a similar group of participants and the same questions asked. It is recommended that future researchers studying Ireland's transition to a knowledge-based economy peruse this study's findings as a springboard for further studies, qualitative or otherwise.

Presentation of the Findings

The researcher proposed a qualitative research case study methodology as the suggested method of data collection and analysis. The rationale for this choice was that the case study approach provided the opportunity for detailed study of the modern phenomenon of a knowledge-based economy using real contextual evidence from those working directly in the field of interest (Yin, 1994). The original methodology proposed a holistic single-case design with the unit of study as the multi-national company operating in Ireland. The research proposal was to explore how these companies would use the existing advanced manufacturing system to build a knowledge economy within the country. However, the availability of the actual collected data demonstrated the need to shift from an analysis based upon a single-case study design to a thematic analysis. This change occurred because while the detailed interviews provided a rich history of information for analysis, the supporting materials necessary to complete a full case study analysis were not available.

Setting. The context of the data was qualitative research about the concept of the knowledge-based worker and economy, which has been a part of the dialogue on this issue for several decades. Ireland's particular context was that it differed from other similar economies, because unlike other countries, it kept its foundation of advanced manufacturing with national and multinational companies. The main research question asked what policies are necessary to develop a knowledge-based economy, what contribution the existing

advanced manufacturing base provides in creating and sustaining this type of economy, and what existing policy initiatives within the specific context of Ireland could help develop this kind of economy. The chosen interviewees all work within the context of advanced manufacturing, and the researcher confined the data to the in-depth interviews and any supporting literature.

The study focused on twelve interview questions. These questions focused on answering the study's three main research questions. The proposed research questions included 1) what policy initiatives are required to develop a knowledge-based economy. 2) What is the contribution that a base of advanced manufacturing can make in the development and sustaining of a knowledge-based economy? 3) In the context of Ireland, what policy initiatives are best positioned to assist in the development of a knowledge-based economy?

Data collection. To accomplish the task of answering these questions, the researcher analysed qualitative data from 17 semi-structured and in-depth interviews taken from manufacturing companies' CEOs and Managers and relevant government agency representatives. The researcher structured the interview schedule based upon the participant's availability. Industry experts and academics also provided feedback on the interview instruments in order to improve the data's validity and credibility. Interviewees provided expertise regarding their perceptions about advanced manufacturing and its potential for building a knowledge-based economy.

The research method involved posing these questions to the chosen participants, selected using a purposive sampling technique to answer the questions and achieve data saturation. Choosing this method of sampling ensured that the number of cases yielded the right amount of information regarding what takes place in the industry. The target population included those professionals working directly within an advanced manufacturing and knowledge-based economy context. These questions drew upon participants' expertise

and experience with working in the unique advanced manufacturing system in Ireland, their success and making that work within their business, and what policies they see as necessary to increase the level of productivity. The first round of interviews captured the necessary in-depth data for coding and analysis. The researcher proposed the design of the study to ensure a holistic approach to coding and analysis and to lead future study efforts. Notes from the interviews also provided organisation of the researcher's thoughts about the study throughout the data collection process.

The researcher maintained confidentiality of the participants by collecting signed consent forms and keeping their information private. The analysis used a numerical system assigning numbers to each interviewee to ensure each participant's information remained protected. The researcher did not give identifiable data in the analysis and write-up, but only offered general demographic information for each participant. Only the researcher accessed the participant's personal information, and the information stayed protected according to confidentiality procedures.

Data analysis. The researcher downloaded the interview transcripts and collected notes into NVivo, and then completed a first round of coding by separating them into different nodes according to their assigned interview number and the date of the interview. The interviews received an assigned number based upon the initial interview date in order to organise them chronologically. This initial step started the categorisation and the synthesis of the interview information. Table 4.3 below shows the interviews ordered chronologically and their assigned identification (ID) number. The researcher used the interview identification numbers as a reference during the write-up of the interview summaries and for referencing any direct quotations.

The coding also involved creating summaries of the individual interview write-ups and researcher notes in order to provide individual portraits of the participants to help answer the research questions. The interview questions included the following:

1. Ireland has a current base of advanced manufacturing that probably doesn't exist in other European countries. Why do you think Ireland has managed to retain this much advanced manufacturing?
2. How have you been successful in your business at keeping an advanced manufacturing facility in Ireland?
3. What changes would you recommend to future government policy to increase the attraction of Ireland for advanced manufacturing companies?
4. In your experience, what policies has the Irish Government put in place to enable R&D and advanced manufacturing to collocate, and how could they improve them?
5. What kind of skills would you like to see in the graduates of the future?
 - a. What changes would you like to see in academic policy and curriculum and government policy?
 - b. For advanced manufacturing, what kind of skills and curriculum would you like to see?
 - c. Can you find the different types of skills in Ireland that you need to be successful growing your business?
6. Apart from education, what other kind of policy initiatives could government introduce to increase the attractiveness of Ireland as a manufacturing location?
7. If speed is vital, do you think there is any inherent advantage in being a small country, like Ireland, with physical closeness and tight relationships enabling speed?
8. Are there capabilities that you have derived from manufacturing that have allowed you to deliver new customer solutions and enhanced value to the company?

9. Would you say that manufacturing has a PR problem with Irish students?
10. In Germany, they use apprenticeships a lot more widely in terms of manufacturing.
Do you think that's something that Ireland should adopt?
11. In your opinion, what is the contribution that advanced manufacturing can make to a knowledge economy.
12. What do you think are the characteristics of advanced manufacturing and what makes a company an advanced manufacturing company?

Table 4.3: Interviews by assigned ID number and date

<u>Assigned ID Number</u>	<u>Date</u>
1	14-Mar-12
2	16-Jul-12
3	24-Sep-12
4	2-Oct-12
5	15-Oct-12
6	3-Dec-12
7	7-Dec-12
8	1-Feb-13
9	3-Mar-13
10	26-Mar-13
11	27-Mar-13
12	21-May-13
13	31-Jul-13
14	13-Nov-13
15	16-Dec-13
16	17-Oct-14
17	8-Apr-15

This analysis referenced the Saldaña coding system. This system was a method of qualitative inquiry using short expressions or words to give meaning to a collection of language-based data, including detailed interview transcripts (Saldaña, 2009). It used a first and second cycle coding method including summary review of the transcripts and then single words and paragraphs during the first cycle (Saldaña, 2009). The second cycle coded the

same units and longer portions of the transcripts, and the researcher reconfigured some of the initial codes to develop the themes in the analysis (Saldaña, 2009). Thematic coding guided the analysis of the interview, the coding emphasised the examination of patterns in the interview data including word and expression repetition by interviewees. These patterns developed into themes that related to the development of advanced manufacturing in Ireland and the policies and organisations present to be able to build a knowledge-based economic system.

After summarising the narratives, the second level of coding included word frequency searches based upon the research questions and the emerging themes from the first level of coding. The following charts depict how much each interview referenced each of the initial thematic categories.

Figure 4.1. Advanced Manufacturing-Coding by Item

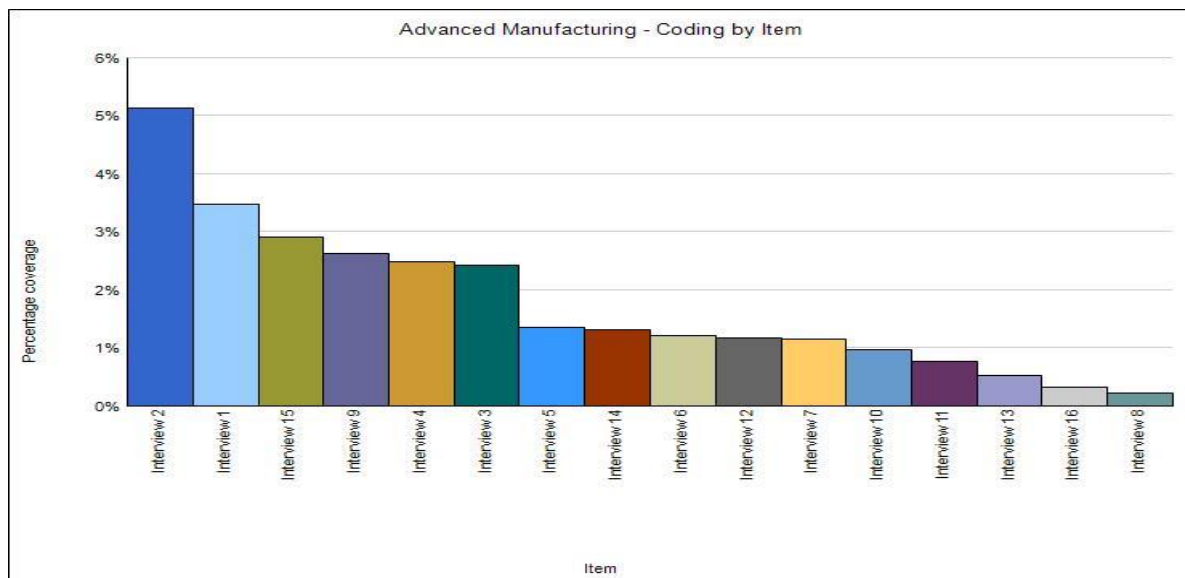


Figure 4.1. Critical Skills-Coding by Item

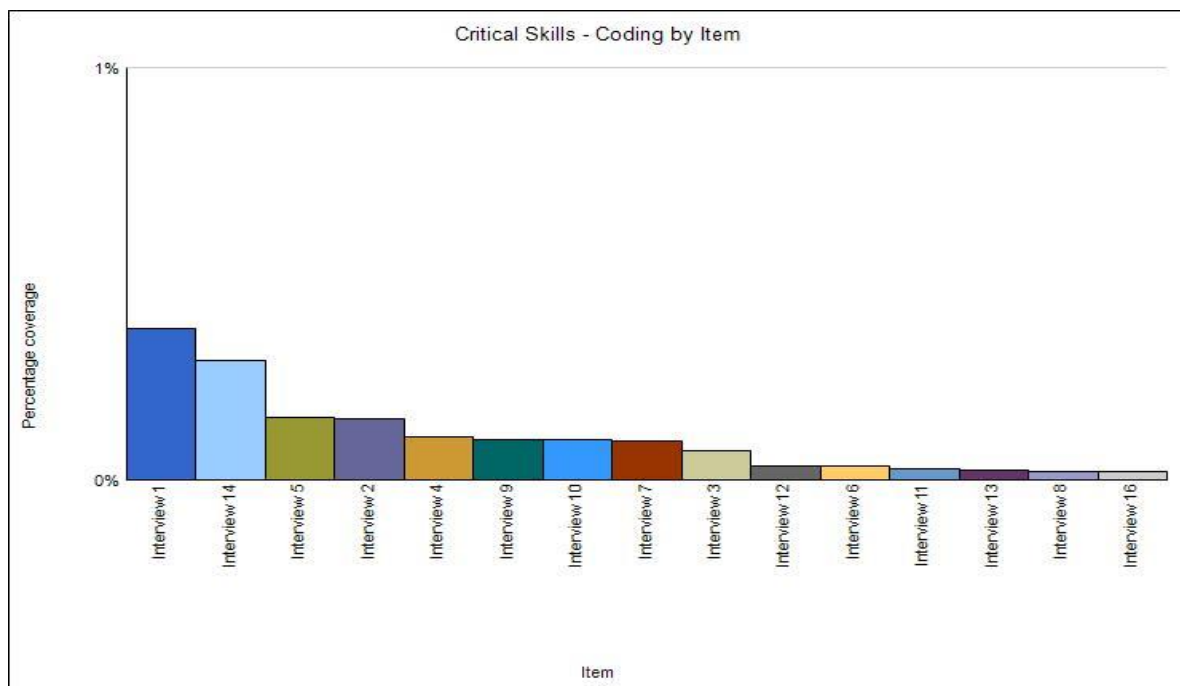


Figure 4.2. Education-Coding by Item

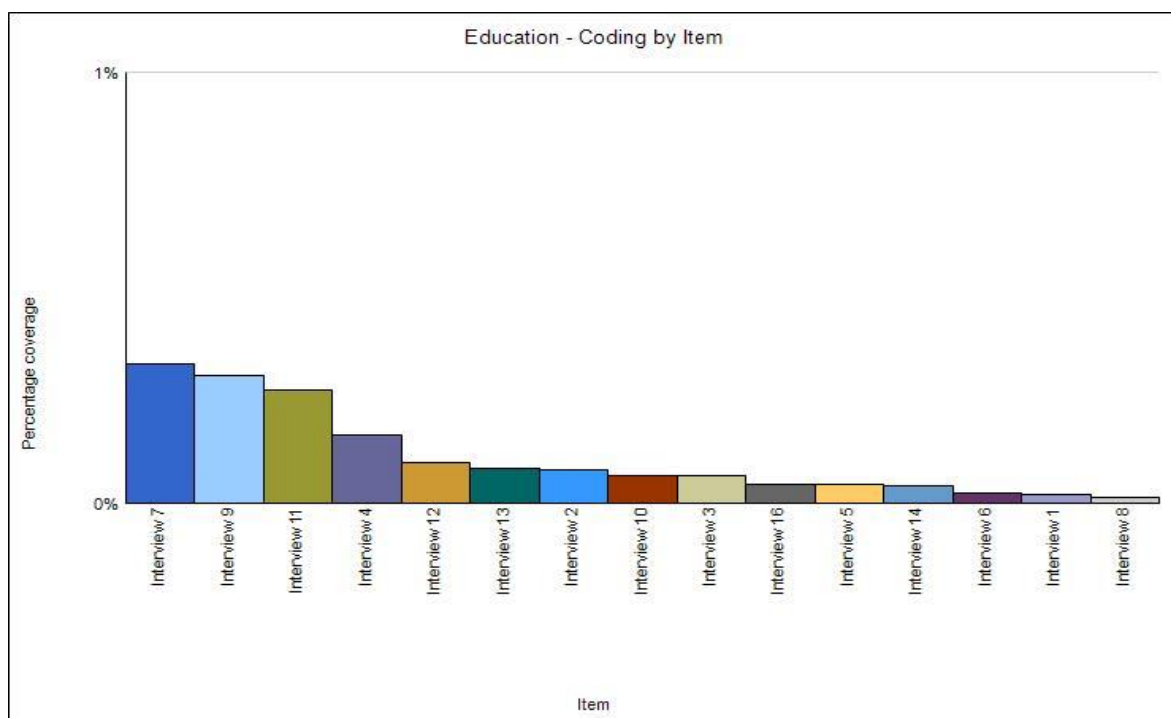


Figure 4.3. Government Policies-Coding by Item

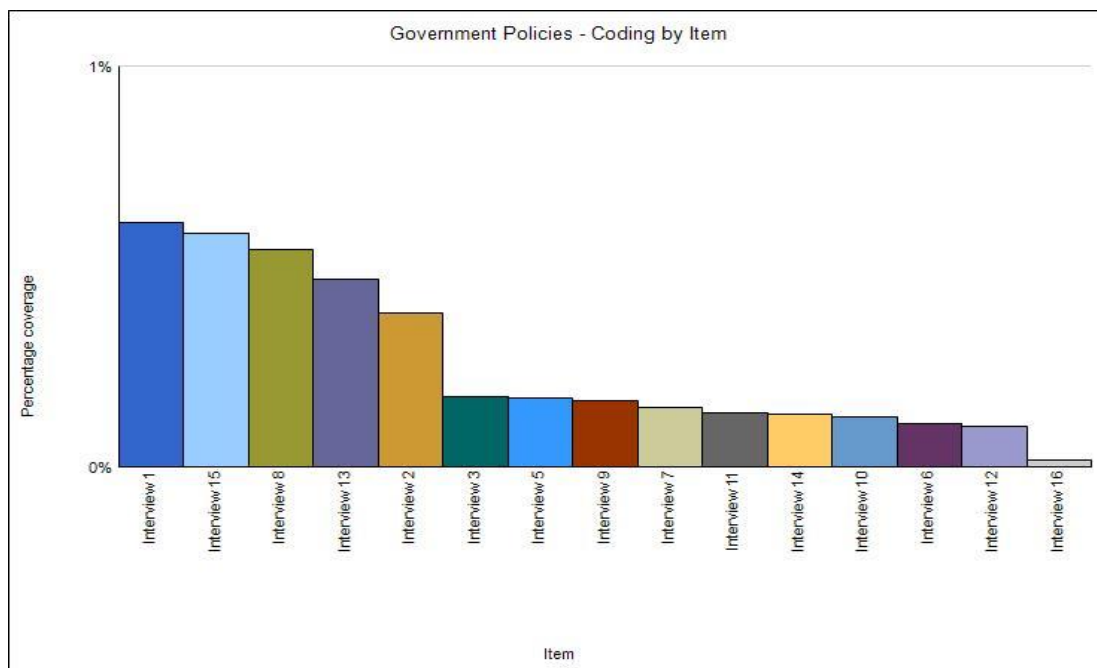


Figure 4.4. Innovation-Coding by Item

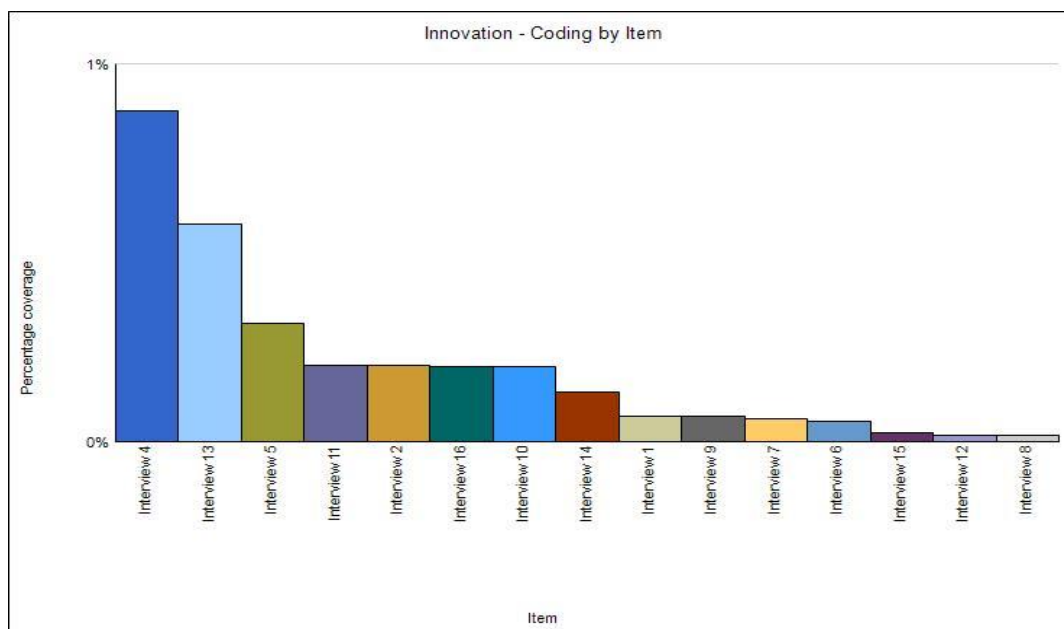
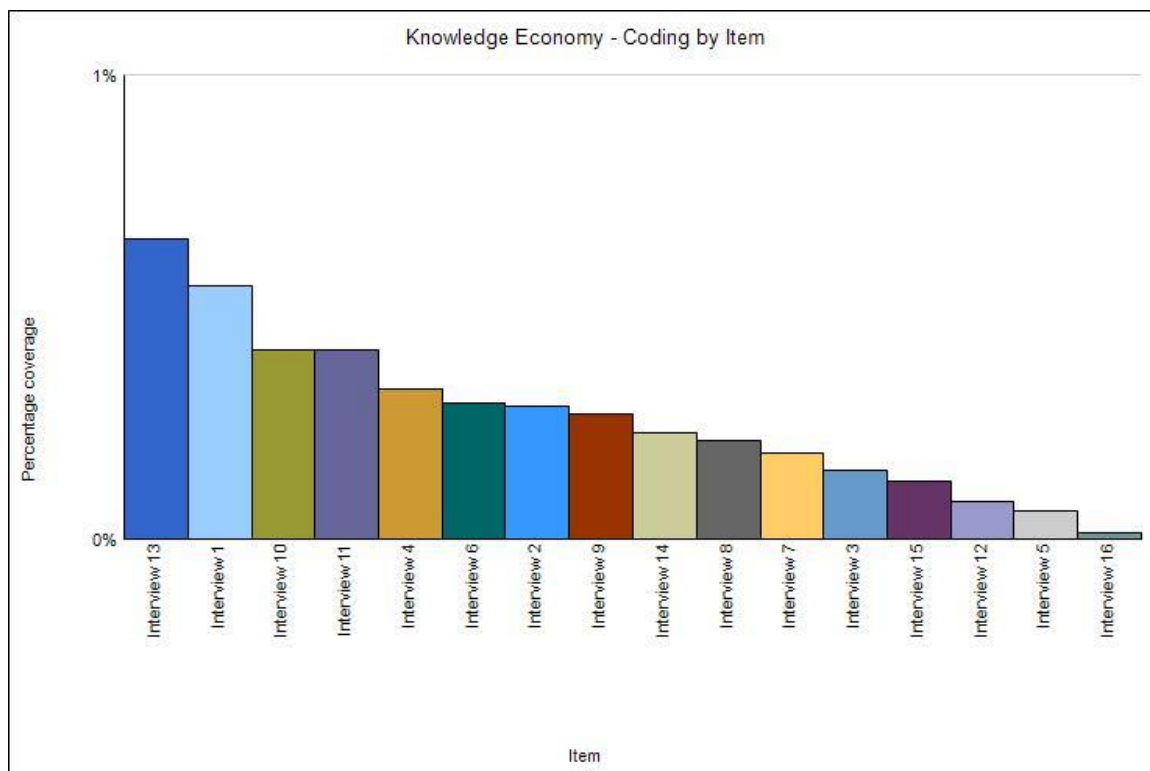


Figure 4.5. Knowledge Economy-Coding by Item



These thematic categories evolved into three overarching categories including the development of advanced manufacturing, policy environment, and the building of a knowledge-based economy. This section provided a narrative analysis of the thematic categories in order to help frame the context of the study and to answer the research questions. The comparison of the interview data with the prior literature, and the individual participant's narratives showed any overlap in information between the interviewed participants. The narrative noted, with a specific citation any direct quotations from an interviewee. The narrative denoted these distinctions with the individual interview ID numbers. In addition, other contextual information and evidence was not included, because it was not available for review. Triangulation of the data occurred during the final summary and comparison of the individual cases to the previously discussed knowledge economy themes including the definition of advanced manufacturing, knowledge and innovation, human

capital needs, social context, and government policies. The summary provided recommendations that helped to answer to the original research questions.

The Development of Advanced Manufacturing

The development of Ireland's foundation for their current system of advanced manufacturing was a significant focus during the discussion in each of the interviews. The answers regarding advanced manufacturing resulted in the creation of a theme about the growth and defining of what advanced manufacturing meant within the context of Ireland's creation of a knowledge-based economy. Each of the participants provided a similar understanding of what defined advanced manufacturing. Its progression included several factors ranging from a company's movement towards automation to the availability of the range of skill sets required to develop advanced manufacturing within different sectors of business. The interviewers demonstrated consensus on the factors involved in a company's use of advanced manufacturing, especially in the context of Ireland.

Definition. The definition of advanced manufacturing was the manufacturing process moving forward and advancing beyond older outdated techniques.

We actually came up with a definition of what advanced manufacturing was, you know, it was less of certain things and more of other things moving forward and recognised that right across the sectors they all had a challenge to do it because the fact of the matter is in the rag trade today because of advanced cutting tools, advance stitching tools and whatever else, they are quite complex systems and machines that need to be controlled but what they can do is generate significant volumes of output whereas if it was manual and it was an individual, you know, sewing all these things together it would take much longer and in particular seeing in the clothes trade if there intricate little designs that you are trying to stitch by the way onto a piece a clothing in the past we had to manually get in and do it, not they've got advance robotic type

systems and things like that can do it and the output that a robot can achieve versus what a person can achieve and a lot of those cases can be significantly greater so basically it was open to all industries. (Interview 1)

Interview 2 categorised advanced manufacturing as being well-informed about the cycle of manufacturing and building in the necessary research and development components. It depended upon the business model, and the company would have to look at the amount of needed capital, the price of logistics, and potential depreciation of investment. Advanced manufacturing gained its definition from a combination of research, development, and manufacturing.

Big shifts in R&D associated with manufacturing or often what we would call D&M: Development and Manufacturing collocated. The D part of it involves an enormous amount of process development. So, the manufacturing model has definitely gone from pure basic manufacturing to sophisticated manufacturing and now, in nearly all cases, with Development and Manufacturing collocated. So, what that does is it brings a core of the Irish operation into contact with the new fundamental research happening in the company. (Interview 9)

The most important factors involved knowledge building, innovation, and improving infrastructure. Advanced manufacturing drove the knowledge economy, because

Manufacturing makes a huge contribution to an economy, particularly advanced manufacturing because of the focus, the knowledge intensity, to give you a case in point, I was over in UCD recently and [the manager] was showing me showing me a piece of equipment that he had been given by some Japanese maker and the work that he was doing with some of these research students was to work on the control systems and the like on this particular piece of equipment. The actual machine is probably valued maybe half a million, so pretty pricey. The point is that here was the research

team extending their knowledge on this machine with a view to possibly improving aspects of it but the real value is in terms of the capability they are developing for when this machine was deployed perhaps in a place where very high precision is needed in the machining of a piece of metal or plastic or whatever. So, you could see the way that it was focused on the machine which was drawing in the knowledge and further adding to the knowledge, by virtue of the work that they were doing. Now you expand that learning at scale into the actual manufacturing companies themselves, and you see how manufacturing becomes a magnet for knowledge and for the improvements in knowledge. (Interview 10)

Advanced manufacturing existed in all industry sectors, regardless of company size, product, or overall structure. The differences lay in how companies controlled or advanced automation, processes, and quality control.

Advanced manufacturing included having a fully automated system in place and knowledge-intensive workers to manage the process correctly in order to ensure future success. The forward-thinking mind set was at the core of a knowledge-based system. Interview 3 noted that they developed their advanced manufacturing system by building the core business and moving outward. This was characterised by minimised costs and maximising of available capital, and they developed a research and development unit that integrated the necessary knowledge processes. To create this kind of system, one needed reduce labour content, to carry low inventory, and create localised research and development in order to keep the manufacturing close by (Interview 2). Advanced manufacturing included a constant refining of the overall research, development, and manufacturing process.

Interview 6 offered a detailed example of how their company practised and moved towards this definition of advanced manufacturing. The company filled a niche in the market

by expanding their manufacturing system. This company practised this definition of advanced manufacturing by extracting the greatest value from the manufacturing process through the use of increased technology and the improvement of the production of milk.

It's about can you make your business more competitive by applying the technologies or the processes that are being involved in other sectors where, you know, so whether it's about yield measurement, data capture, you know, the use of all our farms so starting at the farm we have the GPS coordinates of every farm that we collect from. When the truck stops the truck knows where it is. There is a sample of the guy's milk taken from his tank. This result for the previous days test when he was collecting which was probably two days beforehand are printed for him, downloaded off the back of the truck and left. That's giving his protein, fat all to determine what he is paid for. That is downloaded off the back of the truck and the truck uploads the sample for that. We are tracking where the truck is, the stops per trip, the efficiency. We have all the trucks privatised as well. The drivers own them but we own the trailers and we own the kit in the back, so we are tracking where it is, the efficiency of the route management, the farmers per route, the trips per route, the upload per stop and gallons, litres per trip. All that. (Interview 6)

They used technology to streamline the process and refer things back to the farmer; including testing the soil and ensuring balancing of nutrients. They improved their production and costs by remaining in Ireland for production, and they offset any costs with better technology. These steps demonstrated the development of a company's definition and movement towards advanced manufacturing.

Critical skills. Advanced manufacturing included the movement towards automation and improved technology, but an important requirement in its development was the ability to hire the necessary skill sets required to meet the oncoming changes. All the participants

discussed similarities across sectors regarding skills and equipment. Every company had the potential to go on the same journey to build a better level of manufacturing and the skills necessary to improve change. Interview 1 cited the example of the ICT sector as perhaps being further ahead of other sectors, such as pizza manufacturing, but each sector demonstrated the same potential for developing a certain level of automation. Interview 1's example was the food industry; this industry required advanced specialists to ensure the high quality of food and methods for improving freshness.

Some businesses also required certain skilled labour, including expanding farms. These businesses needed engineers and others with the right skills for process management. This included people with the abilities to build teams, problem solve, and refine improvement initiatives (Interview 6). Advanced manufacturing was a mind-set and a workplace where things were innovative, and the process continued to improve.

It's not just doing things repetitively, it's constantly and that's what we hear about the oldest Toyota factories in the network, in the Toyota network have the highest number of innovations per day from employees suggesting improvement to the process.

(Interview 4)

These skillsets especially required being innovative, and this worked well in Ireland.

I think you need, like from my experience lately with the Japanese they are very good at taking something and making it, you know, robust and, you know, reliability and that kind of stuff. I think that that is not the real definition of R & D. I heard somebody before saying that R & D the real definition of research is that, you know, 50% of your people think it won't work! You kind of need to be at that if it's real research and you kind of need the attitude where the people have to be supportive in realising that an avenue that they go down might fail and there is a good chance it will and that's a cultural thing. (Interview 17)

Overall, characteristics of advanced manufacturing included but were not limited to innovation, competition, efficiency, capital, and knowledge. Advanced skillsets played a major part in the development of advanced manufacturing, especially in Ireland.

Policy Environment

The policy environment also played a significant role in the building and development of advanced manufacturing and a knowledge-based economy in Ireland. Some of the most recent government policy lessened its alignment with any aspirations to build up the knowledge-based economy. In 2012 the Irish Government, through the Department of Jobs, Enterprise and Innovation released a research prioritisation programme in order to create solidified thinking about the issue. This list of 14 areas of recommended priority areas of focus were as follows: Future Networks & Communications, Data Analytics Management, Security & Privacy, Digital Platforms, Content & Applications, Connected Health & Independent Living, Medical Devices, Diagnostics, Therapeutics - synthesis formulation, processing and drug delivery, Food for Health, Sustainable Food Production and Processing, Marine Renewable Energy, Smart Grids & Smart Cities, Manufacturing Competitiveness, Processing Technologies and Novel Materials, Innovation in Services and Business Processes.

But while the government attempted to move towards efficiency and development, they did not act quickly enough about it. Government thoughts were not cohesive, programmes were duplicative, and funding was short. The Irish had the right policy to help build a knowledge economy, but they lacked the necessary skills to coordinate and carryout these policies.

The Irish government showed some support for advanced manufacturing becoming a part of the knowledge economy. Different interest groups demonstrated a stake in building manufacturing, and many nations acknowledged the necessity of it in order to keep

economies alive. However, there was a differing in opinions depending upon the industry as some sectors did not see the value in manufacturing and keeping it domestically. This created a gap in expertise within the country, because the manufacturing was outsourced, and human capital was not always readily available (Interview 1).

Education. This policy environment influenced the movement towards a knowledge economy and support of advanced manufacturing. This was the case regarding support for education. Policies regarding education did not support the growth of necessary skillsets in academia, because without such support and development with students in each generation, the expertise in areas such as advanced engineering slowly disappeared. Universities also moved away from promoting the necessary training, and that placed serious harm on the economy, as only a few still offered the right courses. Advanced manufacturing kept the Irish economy standing. Immigration policy in Ireland did provide opportunities for bringing in the necessary human capital, especially with the ease of movement within the European Union. However, existing policies still created certain barriers to recruiting from other countries (Interview 1).

This presented problems for some companies, because the current policy for the education system in Ireland only recently improved. The education system in Ireland started teaching children to think more innovatively than previously. Children were taught to problem solve in groups and to express their opinions. There was the introduction of a new cultural phenomenon, teaching interaction and communication skills. The mind set was improved consideration for new ways to do things. People needed to learn awareness and the capability skills to do well in business. This type of education addressed the missing managerial skills needed to improve the move towards a knowledge economy (Interview 4).

Certain government policy decisions also harmed manufacturing, because there was a shift away from company apprenticeships. That was particularly the case for the motor

industry where they lost workers and saw higher costs as salaries had to go up in order to attract the necessary skilled workers.

There was no doubt that apprenticeship schemes are absolutely vital to manufacturing industry to ensure that have a high competency base. Without that base, it's very difficult to attract some manufacturing companies in if there is nobody who's able to operate the latest milling and turning machines. And if he finds someone who is trained to do that he's going to have to take them from some existing industry which means he's going to have to bid a salary level up to get them. So that obviously was a collapse which wasn't taken sufficiently seriously by government at the time.

(Interview 15)

Government policy was slow to react to the issue, because there were no incentives to push students to the maths and sciences. These policies were necessary to encourage the overall education process and for movement towards advanced manufacturing as an attractive option for students. The Irish government needed to improve the relationship between universities, industries, and government to expose students to what manufacturing actually represents, creating internships and work opportunities. Interview 2 offered the example of Singapore.

Singapore has a great Japan/ Singapore Institute where they send the final year engineering students for four months to one of the top manufacturing plants in Japan where they are exposed to high-end manufacturing to change their opinion of manufacturing. So, you change the mind-set by creating these opportunities to expose these young students to show them why manufacturing is important. (Interview 2)

Ireland provided great opportunities for this, because of the existence of higher technology companies in the country. The potential was high to improve the image of manufacturing. Other countries, such as Germany and the United Kingdom already employed the use of apprenticeships and curriculums encouraging the movement of students towards advanced

manufacturing. They also needed a stronger entrepreneurial track in universities, and to teach innovation and communication skills. This would help match the Irish mentality for working hard and seeing the big picture approach to knowledge building (Interview 16). Governments should also create incentives for companies to take on graduates and create a new pool of manufacturing candidates.

Apprenticeships were important, because they helped to redevelop skills lost in the current market. They would be a way of addressing the public relations problems that manufacturing had within the community. Education was a key concept, because providing education offered the opportunity drive innovation, research, and development. The Irish education system also needed to facilitate the prioritisation of innovation, communication, and sales skills. These scenarios reiterated the importance of rebuilding apprenticeship schemes and government policies to promote the training. Apprenticeships remained an important component of building manufacturing in Ireland and any manufacturing economy. Having the specialised skill set for every industry drove the knowledge economy.

Government policy. Irish government policies noted to benefit the building of advanced manufacturing included the tax policy and a better supporting infrastructure (Interview 7). Having better local sourcing supported by the government would also provide a distinct advantage for the company. The government needed to encourage individual entrepreneurship and business development. Keeping manufacturing in the country would happen through being able to build the economy and ensuring a lean quality to manufacturing. Overall, the government needed to standardise processes, policies, and the understanding of a smart economy. The system changes were successful as noted by the “US Department of Commerce statistics that they publish each year, we found the return on investment in Ireland was 25/30% and we were able to exploit that” (Interview 8). There was clear evidence supporting the move toward the knowledge-based economy. Ireland also

developed a tax situation that worked with joining the European Union and presented a means for enticing investors.

Our mission was very simple. How can we devise an alternative to the export sales relief which was zero tax on export relief and which would not be caught by the treaty and which would be economically possible? There were various options that came out of that and ultimately the government of the day, I think Des O'Malley was the Minister, made the decision that we could take the risk of going from zero to 10% but we would have to manage that and that would apply to all manufacturing irrespective of whether it was Irish or foreign and irrespective of whether it was export or not. Then internally we would basically guarantee that. We would say that was guaranteed for twenty years. (Interview 8)

They made sure that this system did not discriminate between export and sales at home. They also ensured that they guaranteed a tax rate for twenty years, which helped alleviate fears domestically and internationally about the trade situation (Interview 8). In other areas, there was a need to have short-term approaches to policies as well. Ireland found a way to ensure that manufacturing, including software, did not get included in a corporate tax hike.

So, then there was another calculation done and again I think Ireland did brilliant in this. We said we would marginally increase it. It is a big giveaway to drop from 38% tax to a low tax for everybody, so they did a marginal increase at 12.5% across the board and basically the [European Union], apart from saying that you have to introduce it next year, they couldn't do anything about it. (Interview 8).

Another successful Irish political initiative was the so-called 'Tallaght Strategy', whereby the Fine Gael opposition party would not oppose economic reforms proposed by the Fianna Fáil minority government in the national interest. This symbolised an innovative approach to the problems facing the country and this helped to improve financial recovery

during the worst of the Irish recession of the late 1980's. The Tallaght Strategy introduced predictability and reliability into the system, which helped keep companies in the country and moving industry forward. They worked to create a document to help strengthen the weakened economy and to help create "more free markets, supporting industry, low corporation tax rates, great opportunities to save" (Interview 13). This was important for helping to create an environment favourable towards building the knowledge-based economy. Other good policy development included moving towards building up management capabilities, focusing on successful sectors to build upon, and creating deeper inroads into innovation and science development. The country needed strong research and development and real improvements made in actually moving to implement policies on building this kind of economy.

Many report recommendations, especially those regarding manufacturing, were not fully implemented due to the prevailing civil service culture at the time. Interview 9 gave the following example:

The biggest manufacturer in Ireland by way of employment was Fruit of the Loom making t-shirts up in Donegal. Intel were only breaking ground then, and the financial services initiative was only underway about a year and a half at that point of view, so they were a big player with 4,500 people up there. At that time, some of the other bigger manufacturers were much more capital-intensive and, in their day, were advanced manufacturing, but clothing was never really that advanced at manufacturing. It may well be that one company had far better equipment than another. There was another company called Unify. It is interesting because both of them were in Donegal, the remotest part of Ireland. And they had about 600 people in Letterkenny at the time working shifts 24 x 7 and they were doing industrial yarn or polyester, very high value and in a massive facility, I'd say, half a million square feet up in Letterkenny. They lasted a good few years longer than Fruit of the Loom did

because they were very much at the capital-intensive end of that business. But of course, in time that petered out, as things do. Because, if you look at the history, the cycle of foreign direct investment, the non-sophisticated investments eventually leave, even the initial Intel activities in Ireland. (Interview 9).

The point here was that there was not enough innovation taking place and policies pushed forward. Without the balance between invested capital and sophisticated research and development, the manufacturing and knowledge economy would eventually fail.

Advanced manufacturing also did not necessarily focus specifically on intense capital investment into machinery or specific qualifications, but it meant having a strong component of innovation throughout the advanced manufacturing process. Interview 11 said that the government's research priority areas were important, but there needed to be better coherency in the concept. Policies needed to focus on a broad education system in order to create the right type of knowledge economy. A broad education system was important, but that there should be better exposure to the manufacturing system and the entrepreneurial base. The missing elements included lack of exposure and teaching about the potential of starting one's own business.

The Irish government created new policies to draw upon the educated workforce in Ireland and to reduce the excess capacity of the human capital issue. This connected to foreign direct investment.

“Multinationals looked at Ireland and went ‘We can put our assembly stuff in there. We’ve got all these smart people who don’t get paid very much’ so that really got it started. The big question always for everybody then was whether Ireland be able to move the value chain so can we continue to stay competitive in what we are doing. That’s where the productivity piece when comes in, that we imported our productivity improvements through the multinationals. (Interview 13)

The interviewee noted the importance of building productivity, which rested on having strong research and development and process innovation (Interview 13). In addition, they considered the role of crisis in pushing industrial policy. Public services enhanced productivity and the cost needed consideration. The stability of government and societal cohesion helped keep investment up in Ireland as well. Companies saw when costs went down, and they took the chance to invest, because those other stabilities held up.

Research and development were the basis of a knowledge-economy and advanced manufacturing. From the policy perspective, the encouragement of development and manufacturing should push for collocation, because development capability depends upon research and manufacturing combined. Besides the research and development tax credit, there needed to be further investment by the government and private sector into training and research infrastructure. These investments included training and recruitment of specialised skills.

The best model was creating scaled up policy by creating a national research centre and placing it near industry manufacturing facilities. Data collection was also a key policy initiative, and the funding for these initiatives comes from collaboration with research entities and policy alignments. Overall, a clear national strategy would be necessary to develop a knowledge economy, and it needed to include education and training directives. There was an existing national strategy for manufacturing, but that fell under the implementation deficit. The national prioritisation strategy remained static for the moment, but it needed to change. This included relaxing visas for priority skills, improving education initiatives, building infrastructure, and carrying out policy. Ireland should be offering places to foreign graduates in order to help build the country's international and national reputation. Attracting these students improved the possibility of building the education centres in the country (Interview 9).

Building a Knowledge-based Economy

Human capital. Having a trained workforce with the necessary skills to create a knowledge-based economy was necessary. Ireland offered a situation where the intellectual capital existed to meet the demands of advanced manufacturing. However, the last several years harmed the balance as students chose different sectors to move into instead of the ICT and IT sectors creating a skill shortage (Interview 1). These were the people needed to create the automation systems and processes necessary to move the advanced manufacturing system forward and into the new economy. Ireland needed students with backgrounds in system architecture, IT, programming, and software. Gaps existed in every sector.

Some companies focused on building relationships within the communities in order to find the necessary workforce and also to encourage potential workers to choose the right university track. Companies also practised hiring locals, because they thought that promoted loyalty. However, they found difficulties with training and staff competency. The company needed employees with traditional manufacturing skills, but no apprenticeships existed to help recruit the right type of individuals. This required companies to change their recruitment strategy.

We looked at the HR strategy and revamped it to try to bring the skills level back up. Because of the age of the workforce, every year another tranche of them go and as they go we try to replace them with higher level people, but it can be difficult to find those people. Particularly in working with steel - like trained welders. In certain areas, you don't specify skills, but you are looking for people with a certain level of intelligence that can for instance adhere to procedures and be able to correct mistakes and identify areas for improvement. But also, you need these people to have a high tolerance for repetitive work. (Interview 14)

There was a lack of education for particular skill sets and the necessary competencies. They wanted to keep work in the local economy, but the skills did not exist.

The education system in Ireland did provide for the general needs of some companies, but there was still an overall lack of skills in leadership and initiative. “In terms of traits, they have good level of energy and creativity, take instruction well, but they need leadership. The Irish are good followers, but not necessarily good strategists and leaders” (Interview 14). Companies continued to require qualified staff to help them to design the right software and technology for their companies. As part of the education issue, the Irish education system did not provide enough human capital or the right traits and skills to meet the growing demand.

With this new tech, there will be a bit of a refocus here as well. The production guys will be probably absorbed into more of a service side because we won't have a need for production, so they will be maybe involved with reverse logistics or, you know, something like that. The engineering side is going to have to beef up, the R & D side, in the software side. A couple of years ago trying to get a software guy was incredibly difficult and that has, actually the last time we looked it was software people that we got a little bit easier. (Interview 17)

The human capital problem needed to be addressed before they could fully move forward. Improving educational opportunities and offering apprenticeships was ideal.

Manufacturing makes an essential contribution to a country and it is essence for any country to retain a manufacturing base. First and foremost, manufacturing is a great source of jobs and of jobs for people with lots of difference types of skill sets. Lots of businesses have good ideas out there and the value of the idea is most useful to the country when it results in job creation and then the product makes it to market. Why not tag the knowledge-based economy with manufacturing? You get much more benefit when the two are working smartly together rather than having manufacturing

as a separate thing. If you are not manufacturing, you can lose a lot of knowledge by not working the iterations. You lose in terms of the transferability of the knowledge.

(Interview 14)

Interview 6 also discussed the complications they faced in recruiting talent. They noted the need for encouraging students to go into operations and manufacturing. There was a missing piece to the need for general management. People saw manufacturing work as lower level. They needed engineers and others with the right skillset for process management. This included people with the skills to build teams, problem solve, and refine improvement initiatives.

Some policies in Ireland affected the companies' growth, because while capability existed within the existing workforce, students and universities did not provide the necessary skills to run certain aspects of an advanced business.

So, for instance in power supplies that has all shifted so power supply design has shifted to Asia really. Now we may need it in here as part of our advanced manufacturing, so universities wouldn't be running extensive courses developing power engineering experts because there's not that much demand for them but for the pockets you need in a certain ecosystem bring them in, you know, because one of the things I've discovered from micro enterprise up to EI and here at [High Tech Company] is that we can solve a lot of our own skills problems. For instance, we bring a lot of multilingual talent from Europe and we have enough money on our own to do things like behind me here, do things like educate or transform the skills of our existing people. I'm sure that your people at [High Tech Company] can do it as well. The growing small and medium enterprise can't do that, and they don't have the money. When they get good guys, they get taken by us so Sean O'Sullivan's idea of

say bringing a brilliant design engineer from outside the EU and then build the ecosystem around him or her. (Interview 5)

There needed to be the availability of human capital to serve the needs of businesses in the country. This included developing courses to teach the required capabilities to new students and also to open other avenues for companies to recruit qualified staff.

Culture. Several interviewees noted that Ireland was a good model for advanced manufacturing, but that it struggled more recently. Ireland lost some of their momentum by separating the entities driving the building of the knowledge economy and advanced manufacturing. Separating entities, like IDA and Enterprise Ireland, made them lose focus and structure, and they struggled to get this back. There was also an issue with certain policies, including having certain unqualified civil servants doing jobs they could not handle.

So, we need to get back to basics. Let's say foreign direct investment creates a certain amount of jobs in the economy and a certain amount more people to service them and so forth but equally what you have on the indigenous side, if you take a [company] and we are here 18 years today and have a couple of hundred people employed on site here and paying our taxes. If that model could have been expanded upon you end up having a start-up culture in the country and lots of start-ups. (Interview 12)

However, there was a missing cultural aspect to building entrepreneurship, because people feared failure. Elsewhere the fear of failure would not stop enterprise. The process also took a great deal longer than in other countries, making it a slow start for companies. Irish culture and policy had the fear of failure embedded in it. The only way to change that came with pushing the teaching of innovation and entrepreneurship in schools.

For this participant, advanced manufacturing meant capability. A company had to keep innovating or they would not stay in business.

Every manufacturing process in a high cost place like Europe has to be advanced. It cannot be any other way because it won't exist. I can go to Malaysia and I can employ people for \$2 an hour, so why would I pay €15 an hour or \$20 an hour, why would I pay 10 times the rate here? So, manufacturing cannot exist if it is low tech, high labour content. All manufacturing must be advanced if it is to be viable in a developed economy. Advanced and advancing. Manufacturing has to stay at an advancing stage. It is like a moving target upwards on a continuous basis. We have to continue to manufacture faster, quicker, cheaper, faster than our competitors and the only way we can do that is to continue to grow. If we stop growing, we have no machinery left to continue to take cost out. Growth creates cost reduction. So, growth is critical to our success and I can say that to every manufacturer. (Interview 12)

The Irish context provided a good place for advancing manufacturing, because there was such a problem-solving nature. This was not the case in several other contexts such as Poland or Malaysia. This was still the case even though there was that lack of drive towards entrepreneurship within the overall Irish context. The country just needed to keep moving toward that boost in educating students about the importance discussion and capability.

Collocation. Clusters and grouping were also important as the merging of ideas from indigenous companies, universities, and the larger multinational corporations introduced the beginnings of the knowledge-based economy. The combined effect of the entities all existing in one area meant growth opportunities and improvements to courses and planning. The introduction of the big corporations also influenced local education, because students saw the benefit in working for these industries. That helped the smaller companies, because there was no problem getting local qualified people to come work for companies. This helped the public relations problem, because often individuals did not consider manufacturing as a good

choice of employment. However, the cluster and the well-established brands along with the collaboration helped to improve that problem.

Having a cluster of research and development was important to address this problem. In particular, the pharmaceutical industry benefitted with collaboration, because the presence of the clusters increased the ability for companies to meet regulatory standards. Ireland still had a strong record of accomplishment with meeting manufacturing standards, and Ireland positioned itself well for pharma and biopharma industries, because of that standard. These industries also exemplified the knowledge-based economy, because they are capital intensive and highly skilled (Interview 13).

Collocation of research and development as a key factor in retaining the manufacturing base and driving the economy forward. Ireland's best option for furthering industry success was with moving forward in research and commercialisation of products, because of the Irish culture and mentality. Companies created value specifically with development and manufacturing, because being able to see the whole picture was something done inherently well in Ireland. Placing all of these factors together into one grouping offered integration that helped to create a system based in knowledge building.

So, on the first point I would say my view would be that to be successful at R & D you absolutely have to have, at least your early stage manufacturing collocated, aligned, integrated, everything. In my opinion if there was a place where Ireland Inc. has less chance of success, it's in pure research because we just don't have the Ivy League researchers. Ireland's best chance of success is not in research, it is in what I would call commercialisation which is taking ideas, translating them into products, real products that people need and actually getting them out to the market. Now maybe after that where you do your volume manufacturing is somewhere where the

labour costs are low but for me that commercialisation of ideas and taking them to market, that's the piece of the value chain where Ireland can succeed. (Interview 11)

Ireland's context needed the arrangement of combined skills, knowledge, and manufacturing in order to find success in a knowledge economy. This needed support and coherent implementation strategies from all sectors, including government labour policies (Interview 15). Manufacturing collocated with universities for research and development drove the growth of the whole economy.

Innovation. The base of advanced manufacturing required the presence of innovation in order to move forward. Constantly creating and bringing forward new ideas and technological advancements was how companies remained competitive. Many companies in this context sought innovative partners and individuals in order to create a system of advanced manufacturing for themselves. These characteristics were inherent in advanced manufacturing and served as the basis for the knowledge economy.

Innovation within each of those sectors is absolutely required so characteristics for me of advanced manufacturing are the ones that you and I would always trot out but I have been seeing increasingly that they have to be applied in settings that aren't necessarily high-tech in the classic sense so what are they? Right they were as we've described them in the past they've been a large capital investment, we describe the equipment as like thoroughbred racehorses that almost have personalities for which you require highly specialist skilled operatives which moves into the need for them to be trained in advanced techniques whether it's physics, mathematics, science, technology and that begets the need then for the engineering and the sophisticated management disciplines that go in about that. That's how we've up to now characterised advanced manufacturing. (Interview 4)

Innovation as part of advanced manufacturing was the factor that companies looked for in a business partner. Buyers wanted to see the constant movement of new technology and ideas coming forward from a business. That enticed them to consider their products over other companies.

If you have an indigenous company coming in with a new technology whether it's process or product or business model innovation, that's what overseas companies cannot get enough of and that's essentially what they are acquiring in Ireland. They are doing some positioning probably through companies and licensing in technology from others. (Interview 10)

With the regular influx of new ideas and information into the market, a company quickly lost their audience without the presence of innovative thought and planning.

No, now we are at the edge and when we go out to those places and the only thing that will get you into a meeting is called innovation. That's the thing. If you have that technological edge of your product or service, they want to hear from you and they don't really mind whether you are Ireland or Iceland. I think the game has changed a lot this year. (Interview 10)

Some companies focused most of their research and development on innovation. Interview 17 noted this approach involved concentrating directly on technology building and the aspects directly influencing manufacturing. In particular, their company looked at the next important aspect of innovation, 3D printing. This company saw it potentially disrupting the manufacturing industry again, and they took steps to ensure their continued viability on the market. This reinforced the point of companies needing to reinvent themselves and continue moving forward in order to keep the knowledge economy growing and to stay relevant. They created their own knowledge economy system by taking care of the research, development, and manufacturing within their own system.

Applications to Professional Practice

The proposed research questions included 1) what policy initiatives are required to develop a knowledge-based economy. 2) What is the contribution that a base of advanced manufacturing can make in the development and sustaining of a knowledge-based economy? 3) In the context of Ireland, what policy initiatives are best positioned to assist in the development of a knowledge-based economy?

For question one, the data indicated that companies needed to be innovators and inventors. Companies had the ability to direct their own research into what areas they thought most beneficial. The policy initiatives necessary to build a knowledge based-economy included supporting education policies and systems throughout the country and promoting programmes necessary for driving advanced manufacturing. These included engineering degrees, mathematics, and software development. Governments needed to offer tax and education incentives to companies to entice them to start in the country and then to stay. They must promote funding and interest in research and development, including potentially reinstituting apprenticeship programmes.

Moreover, there needs to be a national consensus on policy. Certainly, the government can impose policy to some extent, but the populace needs to be “on board” with that policy for it to be effective. Notably, in any economic transition, there are winners and losers. The losers in this situation could be the very companies that the participants work for, if advanced manufacturing is to some extent replaced by a full-fledged KBE. Yet, one fairly unanimous opinion voiced was that the transition to a KBE was not only desirable but inevitable and that government policy should be aimed at facilitating that transition.

It is not hard to sell the public on the value of higher education. However, it is somewhat more difficult to secure and ensure funding for it. While there is a broad consensus that Ireland needs to foster and replenish its supply of human capital, it is not as clear as it

might be that universities are “factories” of human capital and that therefore, their creation and support is a societal investment, just as building a steel mill in 1950 was. The difference today is that government in Ireland should be a full participant in the process. Many respondents noted that necessity.

Advanced manufacturing contributed to the development and sustaining of a knowledge-based economy by introducing innovation and advancement. Advanced manufacturing was the backbone of any economy and offered the right environment for the economy to grow by placing the focus on refining processes, supporting advanced technologies, and reducing labour costs. Advanced manufacturing introduced increased knowledge and control, because companies required constant reinvention, recruitment, and advancement in order to survive. These aspects created an environment where a knowledge-based economy can grow. It is important, though, to consider that advanced manufacturing is a stepping stone to a full KBE. While a KBE will still have some advanced manufacturing components, the products of advanced manufacturing will not be primary in that economy. Several respondents articulated this thought even as some expressed misgivings about how the situation would play out.

In the Irish context, the best policy initiatives to assist in the development of a knowledge-based economy included focus on education, cohesive planning, and incentives. Some sectors fell short of recruitment needs, and several participants recognised the necessity of creating policies to promote collocation of facilities, universities, and businesses in order to create the necessary skills sets. The education policy factor was the most important, because the Irish context offered plenty of opportunity for innovation and creation. However, the Irish mentality about failure, the movement away from related manufacturing studies, and perceptions about the knowledge-based industry hurt the system. In order to meet the demands of the increasing knowledge-based system, the government needed to implement

policies to promote the teaching of entrepreneurship, communication, and collaboration skills. The government also needed to continue low cost tax incentives and promote enticement of the country as a location for multinational companies.

Furthermore, several respondents mentioned a national and societal mindset that was not conducive to innovation and entrepreneurship. This mindset was present mostly in the past, when Ireland created innovation-unfriendly policies, but it still lingers, according to the respondents. Part of that mindset was a distrust of a purely technology-based economy. Many people, they observed, feel that Ireland must produce “hard” goods that are valued on the export market to insulate it against downswings in the global economy. However, the review of the literature in Chapter 2 showed that it was just such a dependence on manufactured goods for export that caused Ireland to be hit so hard by the global recession of 2007. Though KBEs have not been in existence for long enough to say for certain, it is quite possible that an economy that produces primarily knowledge and information would be well insulated from economic downturns. Much as restaurants are seen to be recession-proof businesses because everybody, no matter what, has to eat, so could KBEs be considered recession-proof because no matter what, everybody needs information and information processing.

The contributions that the advanced manufacturing sector can make, according to the respondents, are that the expertise present in the advanced manufacturing workforce can be employed in the KBE. A KBE is all about employing robotics, automation and software to produce goods; the needed skills can be translated to the production of knowledge and information as goods. Again, this is only relevant if the advanced manufacturing sector is considered as a precursor to the KBE.

The existing policy initiatives are well positioned to assist in the transition to a KBE, but according to the respondents, more action is needed. More government funding has to be

allocated to education and the fostering of innovation and technology. The nation cannot rely on the private sector to do this by itself.

As Ireland's KBE depends and will depend on close trade relationships with its European partners, it is interesting to consider what might happen after Brexit, the United Kingdom's exit from the European Union. These interviews were conducted well before Brexit was even an issue being discussed, so it was not mentioned by respondents. One consequence of Brexit will be that the border between Ireland and Northern Ireland will no longer be open and that British and Irish citizens will not have the right of free passage in each other's countries. This could have a negative effect on Ireland's KBE, as Brexit will damage the relationship between the two countries.

Recommendations for Action

The research provided by this study will be applicable to several aspects of the building of a knowledge-based economy, particularly within the context of Ireland. Company heads and executives provided insightful information that may benefit the advanced manufacturing community and academics studying this contemporary phenomenon. The findings from this study show that one builds a knowledge economy through the constant seeking of innovation and process improvement. As the findings demonstrate, there are challenges to these improvements depending on the represented sector, government policies, the availability of necessary human capital, and the existence of the right improvement processes. Constant investment of capital, time, and building perceptions about advanced manufacturing are required. Professionals working in this context must share this important information through professional networks, and academics studying knowledge-based economies should use this information to improve research and development programmes. The researcher will also share the findings of the study with relevant academic and company leadership.

In addition, the results of the study contribute to the discussions regarding building advanced manufacturing within a variety of contexts. Those working in this industry can apply the information to help support best practices and future research. Using different means for sharing the findings also improves the prospects for relevant professionals to gain access to the information. Publishing the study in an approved research database also offers access to academics, students, and others interested in policy initiatives necessary for building a knowledge-based economy.

Recommendations for Further Study

The discussions and implications revealed during the analysis provide the foundation for future research into the necessary policy initiatives to create a knowledge-based economy within the context of Ireland. Future research will only improve the understanding of the issues faced by companies and government in creating this new kind of economy. An expansion of the case study with an in-depth focus on a particular company working to build advanced manufacturing and pursuing advancement of this kind of economy would also offer valuable insight. An expansion of the case study into other contexts would also improve the development of policy initiatives and make the information more applicable to other systems.

The focus of the research had limitations, specifically as it tried to look at the issue from the perspective of multinational companies, but the interview focus was more on the individuals interviewed. This created a change to the initial unit of analysis and methodology. The sample and interviews provided rich information on advanced manufacturing and building a knowledge-based economy. However, there was company specific information that did not match the study's research questions. This offered some information providing a case study approach for a specific company, but not enough information existed. Including more government perspectives about the necessary policy initiatives to build the desired economic system would enhance the study. This study offers a new perspective on the right

focus areas in order to best develop a knowledge-based economy, but more information is necessary. There is still a lack of direct understanding about what advanced manufacturing is and the necessity of a smart economy.

Reflections

The initial proposal to complete a holistic case study did not take place as planned. The interviews provided even more information than expected, and they evolved from semi-structured interviews in some cases to in-depth narratives in others. Some of this depended upon the individual interviewed. Most participants were willing to share a great deal of information about the manufacturing industry and the history regarding Ireland's journey towards a knowledge-based economy. The in-depth sharing was not a surprise, because the interviews were anonymous. This helped remove any potential barriers for gathering a robust amount of information. The data collection and analysis process took longer than expected due to the availability of participants and certain time constraints. There was also difficulty in collecting the expected company data, and this required a shift in the method of analysis.

Summary and Study Conclusions

This data analysis confirmed that advanced manufacturing played an important role in building a knowledge-based economy. Ireland offered a unique context for studying this phenomenon, because of its history in building up advanced manufacturing and position as a hub for multinational companies. Noticeable gaps in the research still existed, because each company and individual interviewed provided a slightly different context for viewing the research questions. The information also expanded beyond the initial research questions and offered insight into other focus areas necessary for creating a knowledge-based system. More research will be needed to help refine the findings of this study and to explore the growing phenomenon. In conclusion, the government and all sectors should continue or implement use

of these initiatives to improve advanced manufacturing processes and all other related areas to build a knowledge-based economy.

Chapter 5: Research Approach

This research was focused on understanding how an advanced manufacturing base can be used to help develop a national knowledge-based economy. The country in which the study was set is Ireland, a nation that is as well positioned as any in Europe, because of its advanced manufacturing capability and infrastructure, to transition to a knowledge-based economy. The source of information was managers and CEOs of manufacturing companies and policy formulation agencies in Ireland.

The research questions were as follows:

1. What policy initiatives are required to develop a knowledge-based economy?
2. What is the contribution that a base of advanced manufacturing can make in the development and sustaining of a knowledge-based economy?
3. In the context of Ireland, what policy initiatives are best positioned to assist in the development of a knowledge-based or ‘smart’ economy?

My initial choice in selecting the research method was whether this would be a quantitative or qualitative study. The nature of the above questions suggested the latter. Concepts such as policy initiatives and development of a knowledge-based economy are not numeric or quantifiable. Also, the research questions asked “what” rather than “how much.” There were no hypotheses or other suppositions made, or to be tested, prior to the conduct of this study.

A single case study initially seemed best. I found that at the company I initially chose, participants were readily available and quite willing to participate in the study; however, other data on the company, which would have been necessary for the in-depth examination appropriate to a single-case study (Yin, 1994), were not available. Such data are also necessary for triangulation (Yin, 2004). Also, data for a single case study should be gathered

from a variety of sources, such as company documents, observations by the researcher, etc. (Baxter & Jack, 2008).

The research method I ultimately chose was in-depth semi-structured interviews of company managers and CEOs (multiple companies), followed by transcription and thematic analysis. There was little supporting literature available that directly dealt with the research questions and/or could be used to supplement the interview data. However, this was not an insurmountable problem. The interviews provided rich, detailed perspectives. The participants were quite willing to share their views; as they all were professionals in the field; the data they supplied and the insights they shared were valuable.

I interviewed the 17 participants from March 2012 to December 2015. I asked them the following questions:

1. Ireland has a current base of advanced manufacturing that probably doesn't exist in other European countries. Why do you think Ireland has managed to retain this level of advanced manufacturing?
2. How have you been successful in your business at keeping an advanced manufacturing facility in Ireland?
3. What changes would you recommend to future government policy to increase the attraction of Ireland for advanced manufacturing companies?
4. In your experience, what policies has the Irish Government put in place to enable R&D and advanced manufacturing to collocate, and how could they improve them?
5. What kind of skills would you like to see in the graduates of the future?
 - a. What changes would you like to see in academic policy and curriculum and government policy?
 - b. For advanced manufacturing, what kind of skills and curriculum would you like to see?

- c. Can you find the different types of skills in Ireland that you need to be successful growing your business?
6. Apart from education, what other kind of policy initiatives could government introduce to increase the attractiveness of Ireland as a manufacturing location?
7. If speed is vital, do you think there is any inherent advantage in being a small country, like Ireland, with physical closeness and tight relationships enabling speed?
8. Are there capabilities that you have derived from manufacturing that have allowed you to deliver new customer solutions and enhanced value to the company?
9. Would you say that manufacturing has a PR problem with Irish students?
10. In Germany, they use apprenticeships a lot more widely in terms of manufacturing. Do you think that's something that Ireland should adopt?
11. In your opinion, what is the contribution that advanced manufacturing can make to a knowledge economy?
12. What do you think are the characteristics of advanced manufacturing and what makes a company an advanced manufacturing company?

This was a researcher-constructed interview protocol. As such, it was not a validated instrument at the time of the study. This is in no small part because this specific issue has not been the target of past research. I do feel that the answers elicited by these questions provided valuable, in-depth data. Future researchers should and probably will employ different interview questions if they choose to perform further qualitative studies along the same lines as this one.

The Interview Questions Selection Process

There were literally an infinite number of ways to compose and structure the interview questions. First, I limited the number of questions to 12, because the plan was that the interviews would take 45-60 minutes each (though allowed to go slightly over if

necessary) and thus, there would be 4-5 minutes available for each participant to answer each question. There were some sub-questions as well, which were designed to elicit short answers.

Research question 1 asked about policy initiatives. The non-governmental participants, though holding high positions in their companies, were not directly involved in formulating government policy. Nonetheless, they had (and could be expected to have) strong opinions on the subject. Also, it is reasonable to think that these executives of major companies have some influence on policy, or at least have the chance to offer their input. Thus, interview question 1 asked about the situation of advanced manufacturing in Ireland, with the premise that participants might be able to tell me why Ireland is a leader in that field. Questions 3, 4, and 6 asked directly about government policy. Questions 9 and 10 asked about societal policy, i.e., what the country as a whole should do. These questions were designed to provide perspectives on research question 1.

Research question 2 asked how an advanced manufacturing base could be used to foster the growth of a knowledge-based economy. Questions 4, 5, 11, and 12 dealt with this question directly. Research question 3 dealt with the particular characteristics of Ireland (i.e., advantages) in its potential to develop a knowledge-based economy. Questions 6, 7, 9, and 10 explored this area.

Interview questions 2 and 8 did not provide direct answers to any of the research questions, as those questions asked about the firm participants worked for. Nonetheless, I decided to ask this question because insight into a firm's activities and goals is valuable to understanding the situation of Ireland's manufacturing sector as a whole. The thematic analysis of the answers to these questions therefore supported that of the other interview question responses.

Participant Recruitment and Selection

The population examined for this study was managers and CEOs of advanced manufacturing businesses in Ireland. I decided to use my own definition of “advanced manufacturing” in this context, though the definition is also supported by recent literature. Specifically, advanced manufacturing is that which uses automated processes for the majority of its production.

The next company criterion was that the company employed at least 30 people. I used this cut-off point, though, because it could be possible that very small enterprises would operate differently than larger ones in transitioning to a knowledge-based economy, so I decided to exclude them. Another benefit of using larger companies was that they were more likely to be employing advanced manufacturing. I was able to locate several such companies in Ireland for participant recruitment. For the sake of privacy and confidentiality, those companies will not be identified here or elsewhere in this dissertation.

I contacted management of the companies I selected and asked them for permission to solicit participants for the study. I sent an email explaining the purpose and goal of the study, what would be required of participants, and ethical procedures and safeguards that would be used. Although the manufacturing facilities were in widespread locations throughout Ireland, I considered it essential to conduct the interviews in person and I made every effort to accommodate the participants’ busy schedules to meet them face to face. I explained that the interviews would take 30-45 minutes but could go longer if the participants wished.

The sample size I used (17) was in accordance with Yin’s (1994) recommendations for multiple case studies. Yin recommended 10-15 participants for such a study, the exact number to be determined by either practical considerations (the researcher should aim for at least 10 participants, even if recruitment is difficult) or by considerations of data saturation. The researcher should stop the data collection process when data saturation, which is the

point at which no more meaningful data can be obtained, occurs. I found that this did not occur until I had interviewed 17 participants.

I set times for the interviews according to the wishes of the participants. Due to their busy schedules, this process was protracted and took more than three years, from March 2012 to December 2015. I do not believe that this extended period of data collection affected the data adversely, however. The opinions of managers and CEOs regarding the study questions are still valid data.

I attempted to conduct the interview in such a fashion that the discussion stayed focused but at the same time, the participants would feel that they had latitude to expand on their ideas. This approach is called “semi-structured” interviews and is appropriate. The respondents varied in how forthcoming and detailed their answers to the interview questions were, but all participants did provide a wealth of good data. I believe this was a result of explaining carefully to all participants what the nature of the study would be and what would be expected of them.

I audio recorded all of the interviews and immediately afterward, played back the recordings to check for clarity and accuracy. I was prepared to call back any participant to double-check information or clear up any misunderstandings but did not have to. I started my initial thematic analysis by taking notes during the playback of the interview recordings. This was recommended by Yin (1994) as part of a multiple-step iterative process; the researcher should first attempt to do thematic analysis as soon as possible after the interviews, then set the work aside and resume it after a few days. I did find that my perspectives and perceptions were different after waiting a few days and rereading the transcripts. When I did, I altered the themes accordingly.

I transcribed the interviews by typing them into my computer as I listened to the recordings. After I finished the transcriptions, I replayed the audio recordings to check them

against the transcriptions. I felt that it was important to scrupulously report the interview data without error. When I felt that I had made accurate transcripts, I began the thematic analysis.

Thematic Analysis

I conducted the thematic analysis of the transcripts with the assistance of NVivo software. I used Saldaña's coding system (2009) as my basic approach. With this method, the researcher conducts the coding process in two rounds. First, the language-based data, in this case the interview transcripts, are assigned short phrases or single words to identify the themes. Then, during the second round of coding, the researcher assigns longer phrases to the themes. During the second phase, the researcher will modify the themes assigned during the first phase. Also, in the second phase, themes are organised and ranked by criteria such as frequency of mention and patterns—what combinations of themes have occurred.

The initial thematic categories identified were advanced manufacturing, critical skills, education, government policies, innovation, and knowledge economy. During the second phase, these were further subdivided into development of advanced manufacturing, policy, and building a knowledge-based economy, in alignment with the three research questions. One significant aspect of the second round of coding was to determine if and to what extent participants agreed on fundamental terms and definitions.

For example, it was not necessarily a given that all participants would have a similar view of just what “advanced manufacturing” is. There was, however, a broad consensus among the participants that advanced manufacturing includes heightened skill sets for workers and the implementation of technology, such as automation. Similarly, policy environment was defined by participants as government initiatives meant to foster the growth of a knowledge-based economy. Lastly, participants generally agreed on the elements needed to build a knowledge-based economy; these included building human capital, changing

Ireland's culture where needed, physical grouping and clustering of facilities, and fostering innovation.

This thematic grouping and analysis was made much easier by the fact that all participants were in broad agreement about the meanings and definitions of the terms and concepts that were the basis of the analysis. Also, that consensus extended to the approaches they recommended and their observations of the current situation. Had the participants disagreed with one another to any major extent, the thematic coding process would have been more complex and more difficult. This is not to say that the data would have been any less valuable had that been the case.

I conducted a second round of coding after this phase was completed. In particular, I wished to check my open coding. It is important that themes are coded consistently by the researcher (Yin, 1994). It is impossible to eliminate bias on the part of the researcher, and it should be acknowledged that one researcher could examine the same transcripts as another; yet, they could code the data quite differently. The subjective nature of this process is both a weakness and a strength of qualitative research. It is a weakness because the data analysis cannot be precisely replicated by a subsequent researcher; it is a strength because the perspectives of the researcher become part of the findings.

Presentation of the Results

The high-level findings were presented in Chapter 4. The thematic groupings were reported. Excerpts from the interviews were given to illustrate how the coding rounds were performed. Only a small portion of the interview transcripts was replicated in that chapter with a greater amount of the data presented in Chapter 6. The actual process of thematic coding and analysis was protracted and involved carefully reading the transcripts of dozens of hours of interviews. Conclusions and recommendation are presented in Chapter 8.

Within the discipline of business administration, research is done both quantitatively, using a variety of accepted and validated instruments, or qualitatively, also using such instruments. However, the quantitative aspect of such research is usually focused on the “big picture,” as it involves larger populations than qualitative research typically does. The choice that the researcher always must make is to gather specific, focused data from a large population—such as a quantitative survey approach—or to gather in-depth, complex data from a smaller population, such as with the interview approach chosen for the present study. It was appropriate to choose the latter approach here because the population of managers and CEOs in the manufacturing sector is small—even if one considers the whole of Ireland—and thus, it yields better data to perform an in-depth study of that smaller population.

Primary Themes

Definition of advanced manufacturing. The participants were in broad agreement about what exactly constituted advanced manufacturing. Perhaps fortunately, they agreed with the researcher that advanced manufacturing was wherein the process was highly automated. It was not determined at which point a company crossed the line between older manufacturing processes and advanced processes. This was not an obstacle during the data collection process, though, as I had determined beforehand that the companies from which I recruited participants all used advanced manufacturing methods.

Critical skills. Participants noted the need for certain critical skills in the workforce for Ireland to transition to a knowledge-based economy. These included education, managerial skills, and entrepreneurial initiative. A common thread was that Ireland’s transition had been hampered by a lack of such skills in the workforce.

Education. Similarly, many participants opined that Ireland’s educational system had not produced enough skilled workers and managers for the transition to a knowledge-based economy. The transition was happening, they observed, but it was being hampered by a lack

of education on the part of the entering workforce. They in particular noted that entrepreneurs were not being produced by the educational system. Some participants attributed that to cultural values in that they believed that Ireland was not a naturally entrepreneurial culture. That view was not shared by all participants, but it would be interesting to study that possible effect at some point in the future.

Government policies. Most participants mentioned government policies as an important factor in Ireland's transition. They observed that government support for a knowledge-based economy had generally existed in the last decade but that such support had come in fits and starts. They mentioned that politics had often intersected with policy and a number of them stated that this should not have been the case—that Ireland's transition to a knowledge-based economy should not be politically based.

Innovation. This theme appeared frequently. Almost all participants mentioned the value of innovation. Several participants said that government policy should focus on fostering innovation and that such policy should include educating future innovative leaders. Several mentioned that Ireland had an advanced manufacturing base precisely because the country did things differently and had been innovative in creating that base. The "Celtic Tiger" of prior decades was often mentioned.

Knowledge-based economy. This discussion was in part definitional, as I did not provide participants with a definition of what a knowledge-based economy is. It was my understanding, based on the review of the literature, that a knowledge-based economy is one whose primary product is knowledge/data, just as a manufacturing-based economy produces manufactured goods, a farm-based economy produces foodstuffs, etc. Ireland's economy has always partially produced knowledge, but the issue at hand was whether and how knowledge would be its primary product.

The participants did not all agree on whether the transition to a knowledge-based economy had begun, should begin, or had already occurred. Several viewed the manufacturing base of Ireland as fundamentally different from a future base that “manufactures” knowledge. Some participants, though, pointed out that Ireland might be uniquely positioned to make such a transition. It was also noted that Ireland should not try to compete with larger nations in heavy manufacturing, given its disadvantage in natural resources and the availability of skilled labour. Rather, participants stated, Ireland should concentrate on educating its present and future workforce to be part of a knowledge-based, rather than manufacturing-based, economy.

Summary

This study produced excellent and usable data to answer the research questions. The approach of interviewing high-level stakeholders in advanced manufacturing firms proved to be fruitful. In retrospect, it may have been fortunate that the single case study proved not to be feasible, as the wider scope of the study as eventually conducted allowed for more diverse opinions to be expressed and recorded.

The following chapter contains a discussion of the concepts articulated by each participant, as well as the answers to the research questions.

Chapter 6: Overview of the Participants

The participants in this study were all managers or chief executive officers of companies or policy related entities in Ireland. The goal of the study was to elicit their perspectives regarding changes to a knowledge-based economy in Ireland, with its advanced manufacturing base as a springboard. The nature of the interview questions asked allowed them to share a broad range of perspectives.

Not surprisingly, the participants did not all emphasise the same points, nor did they agree with one another. First of all, it was a premise of the research and the study, not an idea of the participants, that Ireland is transitioning or should transition to a knowledge-based economy. Not all participants seemed to emphasise this concept in their answers, though some seemed to strongly embrace it. The variety of answers gathered during the interview phase suggests that the study could be replicated with a different population and produce different data altogether. That might be a fruitful direction for future research to take. Ireland is not a large country, but there are still thousands of executives in managerial positions in the manufacturing sector.

Therefore, it cannot be assumed that the opinions of this small sample of participants are representative of the whole. This is a limitation of qualitative research, in that in order to study a small group of persons in-depth, one must sacrifice the effect that having a larger sample would bring—that of smoothing out the data. The possibility exists, therefore, that these participants did not think and believe as the average manufacturing sector executive does.

It is therefore worthwhile to break down the data by individual participants. An overview of each participant's responses can provide a perspective that thematic analysis does not. That thematic analysis recounted how many times a given theme was mentioned; the following analysis will show what was most important to each individual participant. This

is an approach that is usually used in case studies and phenomenology but is also valuable for the current study.

In the following sections, each participant will be referred to by his/her code number, i.e., “P1,” “P2,” etc. It will not be possible to identify participants, nor will I mention their relative positions in a given company hierarchy but will only refer to their seniority in an organisation. The confidentiality of the data and the anonymity of all participants are paramount considerations.

After a brief description of each participant, excerpts from the interviews will be provided. While it is not necessary to include the entirety of each transcript in each review, I have included extensive excerpts where I felt that the participants’ comments and expressions of ideas were particularly germane to the study situation, problem, and purpose.

Table 6.1: Interviews by assigned ID number and date

<u>Assigned ID Number</u>	<u>Date</u>
1	14-Mar-12
2	16-Jul-12
3	24-Sep-12
4	2-Oct-12
5	15-Oct-12
6	3-Dec-12
7	7-Dec-12
8	1-Feb-13
9	3-Mar-13
10	26-Mar-13
11	27-Mar-13
12	21-May-13
13	31-Jul-13
14	13-Nov-13
15	16-Dec-13
16	17-Oct-14
17	8-Apr-15

Presentation of the data

P1

P1 was a senior manager in two cross-sector research centres. P1 referred to the concept and definition of advanced manufacturing. P1 spoke about how the research centre came about and nature of collaboration in a small country like Ireland and how this small size helped to make contact between companies that would otherwise have no reason to interact.

P1 stated:

Because it started from a need, it didn't start off about advance manufacturing. It started based on a need that the cost of doing manufacturing in Ireland was going through the roof, the cost of energy was going through the roof and when the recession hit there was concern that these companies would exit the country. In response to that a group of senior engineers and managers got together to say 'ok, we can watch this happening or we can try and get together and go after some of these challenges that we have and try and resolve them' and through the process of that dialogue we began to realise that actually the modern manufacturing facility needs to be less about hands on personnel but more about advanced technologies, automation, productivity, etc and that along that manufacturing continuum there were companies who were lower tech manufacturing companies and there were some companies who were high tech companies but that all companies wanted to head down that route and in order for them to be viable and to stay in business in a high cost economy that you are going to have to shift the emphasis more towards the knowledge and control side of it than a labour intensive, hands on, low value added type work. So, we all kind of got behind the banner and came up a definition of what advanced manufacturing meant for ourselves and once we'd defined that then some companies had climbed further up that hill than others actually had but we kind of got behind the common statement but it was initially born out of a challenge or a crisis that we felt we had. We did not close it out in terms of sectors that could participate and say it's only about ICT. We said here's the definition of advanced

manufacturing, but it can apply to all sectors, now where are you on that continuum as a company, whether you're in food or textiles or whatever, that was the question you asked yourself and then how quickly and how far do you want to go up that scale and can you learn from other companies in other sectors to try and help you close that gap.

Also, P1 noted that manufacturing was often outsourced (taken offshore) because of a lack of human capital. He attributed this to some industries not seeing the value of advanced manufacturing and becoming less competitive as a result. He also implied that protectionist practices could hurt the Irish economy. He also mentioned practices that made it harder to recruit skilled workers from other countries. P1 stated,

“The [Cross Sector Centres] involve a lot of large multinationals here based in Ireland, companies like pharmaceutical companies, biomedical companies, ICT companies, advanced engineering companies.”

When asked if these centres were Government funded, P1 stated that it was a joint enterprise, and that the Government was “putting up to an amount of €1 million per year into each centre, but in order for us to get that funding, companies have to make a substantial commitment to the centre in-kind or in cash.”

This answer led to my next question, “Have you found then because the government is contributing cash to it that they are very interested in the output or are they in any way influencing the output?” P1 inferred the opposite was true, feeling as though the Government actually stood off to the side, acting as observers but not influencing the direction of the research.

In terms of characteristics of advanced manufacturing companies, he stated that in his opinion size of company did not matter in terms of their application of advanced manufacturing techniques. He found that some clothing and food preparation companies had high levels of advanced manufacturing while some bio-medical companies that would be

considered high tech were still assembling by hand. Manufacturing facilities with more advanced process control systems, and more advanced quality control created better value, making it less of a cost burden per employee to undertake manufacturing within Ireland. Then, these companies with advanced control systems discovered they needed a change in skill sets because they needed, P1 stated, “Advanced automation engineers, advanced quality engineers, rather than an operator on the floor who is assembling bits together.” Therefore, just because the skill set changed, the head count and number of jobs did not necessarily have to go down. He also described how companies in different types of manufacturing sectors found they had more in common than they thought when they looked at their equipment sets, whether it was equipment making pizzas or microprocessors, when we “open up the doors of the machines you realise they’ve all got the same things in them, compressors, pneumatic valves, controllers etc., etc. so there’s a lot more in common than we actually first thought”. He felt that although the ICT companies were ahead on the continuum of advanced manufacturing that sectors like the food processing sector had significantly increased their engineering skillsets over what they had 20 years ago.

I asked P1 if from his answers he felt that the two characteristics that best described advanced manufacturing were the level of automation and the use of ICT as an enabler. He replied, “As an enabler, I’d say that’s true.” P1 stated, “there’s also, the different sectors would argue different things as well like for instance in order to develop some of the advanced foods that are delivered to our table today you need advanced chemists and material scientists and food specialists to be able to develop these particular types of products so it’s not just simply about having a good base of ICT”. Those industries required knowledge and scientists in addition to their manufacturing core workforce.

I then discussed with him if he felt there was enough people with the right skills available in Ireland now. He emphatically replied, “No. That’s a big problem. We have,

unfortunately over the last number of years, had allowed the balance to go wrong and that's a policy and education issue." Because of the market collapse, P1 stated they faced "challenges in the ICT sector, [where] there's a big gap there, there's a big gap in terms of students that have the ability to be able to do advanced modelling." He stated that "Advanced data analytics is critical for advanced manufacturing because you have to capture massive amounts of data and information and then turn it into information and you have to be able to model certain things that might be happening with your system ... and the ability to be able to do the advanced data modelling just isn't available in the country at the moment in sufficient numbers".

This led me to ask him what skills remained relevant to advanced manufacturing in Ireland's knowledge-based economy. In his opinion, any student with the skills to deal with a mathematical algorithm was a desirable employee for an advanced manufacturing company. He stated that focusing on "areas of system architecture, IT, [and] programming" would be the ideal field for a student entering the workforce to study.

On the subject of the cohesiveness of Government policy, P1 said that while he felt the Government was trying, and that the policy may be fit for purpose but that the implementation across departments was not cohesive enough. He felt that "the way they are funding the research is a little bit disjointed I think and we're not thinking at that level about the cohesive strategy, we're not stating 'here's the Government vision, here's the mission statement, here's the strategic objectives and this is what we're going to do with them'. P1 also highlighted the issue of the implementation gap in Irish policy. He spoke about how the government policy is created centrally but then the policy implementation bodies each have the ability to interpret the regime to their own ends. 'It tends to be the government policy comes out and makes the dictate and then each of the different departments will take what they want it to mean and they'll try to apply their interpretation, so it tends to be a bit pillared

or stove piped and there's not enough cross departmental, cohesive thinking going on at the moment". He felt that the Government "have the right intention and I think what's good about Government policy and the Government today is that there's a willingness and an openness to listen to what industry has to say albeit they might move slowly".

P1 cited the 2012 Research Prioritisation Report as having classified advanced manufacturing as foundational and stressed the importance of protecting its inclusion against vested interests. He stated that there was a push to have advanced manufacturing removed from the report because "advanced manufacturing is sorted now because the cost of doing manufacturing in Ireland should come right down now with lower wage demands". He was thankful for the future of the economy that it was retained in the report "and woe betide us if we allowed it not to be kept up there, upfront and centre stage and that Europe itself through the KETs programme has acknowledged that advanced manufacturing is critical for economies to survive in the future". However, he stated,

Now that's all changed all of a sudden because we're beginning to wake up and realise that the thing that's keeping this country standing today is the advanced manufacturing sector, in fact, when we look at what happened for the whole services sector and the way it collapsed. In terms of the manufacturing being an anchor tenant for companies, he stated that "because the building is there you are manufacturing and producing something, then services come in and wrap around that, so it becomes the foundational stone of a lot of what would be the knowledge-based economy, the services industry so it's an entity that brings and causes a gathering to come around it".

In terms of spatial clusters, P1 felt, "co-locating in the one region has massive advantages...there's nothing that will replace" real time interaction. Ireland and its people were well suited to clusters he felt "because we are all within two hours of each other on this

little island of ours and we all kind of got to know each other so we've broken down barriers that exist that allows us to be able to work with one another whereas if you have a pharmaceutical facility, on the east coast of America and an ICT company on the west coast they'll never get a chance to really build up the opportunity to get a relationship going to try and figure a way to do business, to create new products maybe together or look for solutions together so the fact that we do coexist geographically in a small island is a massive help".

He stated that he felt manufacturing wasn't being promoted as a career well enough and that "further work needs to be done to get that message driven in across society actually and right down through all layers in Government circles about the importance of manufacturing and educating society and the country about the importance of it". To finish up I asked, do you think Ireland has the right cost base to be successful in advanced manufacturing? P1 stated that Ireland does, and "it certainly has the advanced manufacturing base actually for it to be successful." If Ireland had graduates with the right type of skills, Ireland could offer, "the best value for money," he stated, "I think we've got a lot of the right things there, so I do think we can compete on the global stage."

P2

P2 was a senior manager in a multinational advanced manufacturing company. He began by explaining to me why it was essential for countries to retain a base of advanced manufacturing. P2 stated:

Now the way I look at manufacturing is: when a company is faced with the need for transformation, your best chance of transforming is if you have basic manufacturing then you move to advanced manufacturing then you move to D which is the development phase and then you move to R. And I noticed over my years in companies, that it's very hard to sustain innovation without building in from the core of manufacturing.

P2 stated that it was vital for Ireland to retain a base of manufacturing, but that it could not retain anything but advanced manufacturing companies because Ireland's cost base had become too expensive for basic low-tech manufacturing because "financials of those kind of companies means I will take to the lowest cost geography, I would have consolidated volumes and hope to improve my profit margin. And you see many companies have done that. And in those kind of manufacturing scenarios Ireland should not compete because it'll just go, and you're holding on and ... it will leave because it's basically sheer volumes that drive the profit margin. The flip-side to that is high-value companies, high-margin, high-road companies, right. And these kinds of companies, the customer wants to pay for the IP, for the IP these companies provide because the customers value that IP.

P2 spoke about the need to be vigilant about keeping the costs low to keep manufacturing in the country and then build extra value-added service (what he referred to as 'plus-ones') around the core manufacturing. He felt Irish manufacturing entities should "figure out how to deliver a most cost-effective model or delivery model that empowers a channel partner. So, if the classic model, says, "I can deliver a product within a week." Now, that's just manufacturing. Now you move to the next part of that, to advanced manufacturing and say, "Well, you know, we talked about I want to be a "High-Road" company so I want to create these plus-ones." Now, I'm going to say, "I have the marketing guys and the R&D guys, and I have an ecosystem here, I can deliver a plus-one into a channel partner to enable innovation, so customers have a choice in three months. I have a full solution. You know, one week is pure manufacturing. I build a product, I ship it. But in three months I design a plus-one from R&D, develop it, with market focus, and start to ship it. It's just like Gillette doing a Mach 3 razor but now with aloe vera on it. Now, that's a huge value proposition".

This participant also emphasized the shift—what was referred to as a paradigm shift in Chapter 1—in the approach of Ireland’s manufacturing sector. He noted that advanced manufacturing required a significant amount of investment capital, including funding for research and development. P2 cited the example of Singapore. That country sends its engineering students to Japan at the end of their schooling to gain hands-on experience in the manufacturing sector. He stated that such a program changed these students’ opinions of high-end manufacturing. He implied that Ireland might benefit from doing something similar.

When questioned about the education policy in Ireland and whether we had the correct policy initiatives to close the skills gaps, P2 expressed concern because “the new economy is going to be driven by solutions that require a huge software bias. You know, this is the new economy, and we struggle here in Ireland. The policy problem with the country really is, that there doesn’t seem to be a huge integration between industry, universities and government. So, we start to look at what is the next mountain that needs to be climbed as a country, and it is to make sure we have the right talent and competencies”.

P2 went further to state that we need to not just move into the area of advanced manufacturing but that companies in Ireland should push beyond that to get to know the customer. He stated that “in advanced manufacturing we should not just think about manufacturing and shipping the product, we should think about customer intimacy. And how do you get customer intimacy in this new world? It’s about looking at the whole system of manufacturing, understanding how you can leverage “the cloud” as well in a manufacturing system so you can build in customer intimacy. So, the future for me in advanced manufacturing is about the customer. We can understand the customer; we can be predictable about how products perform out there, and we can actually get more intimate with the customer to make sure they’re given the right solutions. And it could actually happen by creating an end-to-end solution for manufacturing, right up to the point where the customer

gets the product and uses the product, you have that intimacy with the customer. But, if you look at today, in Ireland, I think we need to develop the fundamental core: mechanical, electronics, business, that's core - you've got to have those skills".

P2 spoke about the need to develop the business and leadership side of the Irish business also. He stated that "it was vital to show leadership and expose my directors to overseas postings to get them to develop, to get them to learn. One of my R&D managers spent three years in San Diego, because I knew I wanted to bring R&D in here. You start building your leadership. It's a journey, it doesn't happen overnight. And you invest about three years of training and development in a manager, if you bring them back after three years and you create the opportunity. They come back more well-rounded and well-connected".

The final topic that P2 covered was the quantification of the contribution that advanced manufacturing can make to a knowledge economy. P2 stated that contribution existed in "the transformation between manufacturing and advanced manufacturing, D and R, really. And I think if you take away manufacturing, it's a struggle to get a D and R. It is because you build the competencies through manufacturing. Let me give you an example of knowledge kind of build: to become a development organisation you need prototyping activities. Prototyping is critical. You must know how to ramp the product; you design the product to ramp it. You must know the channels etc and without any manufacturing background, it's a struggle. And so, why would you even do it here then, if you didn't have any manufacturing? So, I believe there are no specific advantages to doing pure development or research in Ireland unconnected from manufacturing".

P3

P3 was a senior manager in a bio-medical device company. We began by discussing the characteristics of advanced manufacturing. P3 gave three unique characteristics from his business perspective on advanced manufacturing:

I would say firstly quite a degree of vertical integration. So, in our case here that means taking raw resin right through to plastics or fairly raw state metals through to coronary stents. I would say secondly the discipline of process development - so you have product development, and you have manufacturing engineering but in between the two, process development is something that takes something from R&D into a manufacturable state, something that we didn't appreciate as a discipline as recently as five, six years ago. We didn't appreciate the idea of developing a product and then not just throwing it over the wall to manufacturing to make. The other thing I would say is convergence. In our case, pharma and mechanical coming together, more specifically on drug releasing stents. In 2003, we hired our first chemist. Now we have 60 to 80 chemists in-house.

P3 felt that the current generation of Irish manufacturing leaders had been well facilitated by the work of the IDA and they had utilised the advantages they were given very well to expand their mandate in Ireland. He summarised the technique and the attitude very well when he stated that "We were your classic, keep it simple, manufacturing, low cost, maximise the grants and the tax and we managed to grab more and more manufacturing, set up an R&D unit without telling anybody in a time when there was a very entrepreneurial kind of spirit in the company and all of a sudden they had advanced manufacturing, fully integrated, R & D happening and the guys in the US were finding out about it when they were cutting the ribbon!"

When asked about whether he perceived a skill shortage in certain areas, P3 touched on the advantages of belonging to a cluster and said that they had planned ahead years ago and collaborated with other local companies with similar skill needs and they jointly developed new modules for the local university. He stated that they don't have problems recruiting because "We are the biggest locally and also, we partnered with [the local university] to create the biomedical engineering degree so they come from that to us. Ourselves and [a nearby bio-med company] sat down locally with the college 12 years ago and said, 'your graduates are good, but they need this, this, and this'. It was a local initiative".

P3 spoke about the importance of not just focusing on the next big thing but that you had to remain excellent at your core business. He stated that "it was about bringing in people from the electronics industry who know how to do manufacturing and bringing Six Sigma and Lean manufacturing to bear, proper process development disciplines, proper training curricula, to create excellence in manufacturing". "The one thing I'd say though, is that the IP, the tax, they are all terribly, terribly important because if you can't do the knitting you can't actually be excellent at the core thing then none of the other things carry any weight at all. If you are not excellent at the manufacturing what's at risk is the top line and you can lose it overnight".

P3 spoke about the ability of the Irish team to bring down barriers and get things done in Ireland that seem to be a problem for other locations within the company. He stated:

There is something uniquely Irish about our ability to network and what we tend to find is that outside of this site, R & D don't get on well with process development, who don't like manufacturing, who don't like quality either. So there are fiefdoms. As head of the site here I run let's say 70% of what was going on in the site but R & D for example might have a reporting line outside of here and what we would tend to do is we would meet as a campus team and we'd say, 'You know what, we are not going to get the programme if we can't

deliver, and we can't deliver if we don't collaborate.' So, we have this campus approach to doing business that is probably uniquely Irish.

P3 was adamant that he fundamentally believed that manufacturing and R&D had to be co-located to be successful but was not certain of the role of universities in delivering innovative R&D solutions. He stated that:

I fundamentally believe R & D and manufacturing should be collocated but as to whether that's in a university or in-house is debatable. Our model here has it in-house. Our experience is that universities are difficult because they are on a different agenda in terms of the commercial acumen, what they can deliver, when they can deliver it. There is always an issue with IP - publications versus inventions. We've not been successful in coming up with a case that says to the corporation we need to put money into this topic and you need to allow us to outsource to a university. I think from the product quality perspective what you design you've got to be able to manufacture so that hand off is really important. From an Irish perspective, your ability to stay alive as a manufacturing unit is dependent on your ability to not be making the cash cow products. You've got to have the high-tech stuff and the best way of getting your hands on the high-tech stuff is transferring it from R & D. So, our R & D unit here will do their pilot testing on lines that will eventually become manufacturing lines. Fast feedback, possibility to collaborate, funding mechanisms, all of that makes it a lot more financially lucrative to end a product in Ireland if you have already done the R & D here as well, once you consider grants and R & D tax credits.

P3 finished by responding positively to the contribution that advanced manufacturing can make to the economy. He stated that "Well I think the value add in advanced manufacturing is enormous. From employment numbers alone, you know, there's 2,000 people of the 3,000 actually making the product here but, you know, for the 3,000 people that are working here there's probably another 3,000 outside of here in high-tech supply

industries, developing competencies in testing, providing testing services, design service, so my impression is the economic spinoff from manufacturing is way higher than for services. I mean this is a med device city so there are thousands of stories of people leaving this plant and plants like [a nearby bio-med company] and setting up here a supply service or their own startups. We have a start-up around the corner here that is filled with our ex-engineers, funded by an Israeli entrepreneur, an ex-cardiologist, that came up with a technology that we then went and bought. That's full cycle It's kind of come full circle, this idea of knowledge growing outside of the multinational".

P4

P4 was a senior manager in an ICT company. P4 began by defining the characteristics that he attributed to advanced manufacturing. He stated that they were:

A large capital investment, equipment like thoroughbred racehorses that almost have personalities for which you require highly specialist skilled operatives which moves into the need for them to be trained in advanced techniques whether it's physics, mathematics, science, technology and that begets the need then for the engineering and the sophisticated management disciplines that go in about that. That's how we've up to now characterised advanced manufacturing.

P4 went on to clarify that he felt we needed to be more inclusive when we speak about advanced manufacturing. He stated that "there's a danger in talking about advanced manufacturing in a way that it's kind of elitist and it sort of misrepresents the nature of the work that people are doing. I mean they are out there today in the factory trying to figure out how to use a few litres less of a chemical. Despite our gross margin it's just a raw material, I mean, could that applied to a few buckets less of feed, could that be applied to a few litres more of yield?". "It's not just doing things repetitively, it's about constantly improving and

that's what we hear about the oldest Toyota factories in the network, in the Toyota network have the highest number of innovations per day from employees suggesting improvement to the process. I mean that's counterintuitive and to me and yet it represents advanced manufacturing and they are essentially assembling cars. Innovation engines don't come from, innovation doesn't come from machines, the innovation would come from the people that are trying to figure out how to mix and marry them all the components together for a better result".

P4 also mentioned that only recently had Irish education turned toward innovation and creativity. He implied that a lack of such education had made it more difficult for the Irish manufacturing sector to innovate. He mentioned that in order to transition to a knowledge-based economy, Ireland would need people with the requisite managerial skills. P4 also viewed innovation as paramount.

P4 finished up with a story to confirm that he believes that manufacturing has a PR or image problem and that is stopping smart young people from considering it as a positive career option. He said "It was for years regarded as the thing that you did if you didn't do well in school and it was the place that you'd end up if you weren't careful and the famous story from here on an Open Day when we had people able to come to see the factory from the outside and we had a clean room, a window tour if you like set up for people who walked by and grandfather was heard saying to grandson as they waved in at people inside in the clean room, these very highly skilled people that we've talking about dealing with very advanced equipment doing some really amazing products, grandfather was seen or heard advising grandson as they waved in the window at these people saying 'now son, look what will happen to you if you don't do your leaving cert' and so it was such a cultural norm that a job in a factory was, but is that because the factories that we had in those were exactly that, they were dark and dreary places and not very pleasant work environments and certainly weren't

cradles of innovation, they were sweatshops. We have to change that image to attract our best and brightest into manufacturing”.

P5

P5 is a senior manager of a large US electronics’ manufacturer based in Ireland. He mentioned that particular skill sets may not be taught in Irish universities because of lack of domestic demand. He specifically referred to electrical engineering. He said that it was probably unrealistic to expect Ireland to be able to train every kind of specialist that would be needed for the knowledge-based economy but that as Ireland is part of the European Union, it would be easy to attract skilled specialists from the rest of Europe to fill those niches.

The people they employed in Ireland embodied the three T’s: tax, talent, and a trusted record of accomplishment. P5 admitted this was true and that there was a way about the Irish to want to get along with everyone; the Irish personality contained outgoing, network building, innovative kind of thinking that remained important.

Because there was no Irish market, one of the initiatives of his company was to create a reason for executives and customers to come to Ireland. They built an Executive Briefing Centre where they bring customers and partners each year. This allowed them to have a good experience and got the Irish subsidiary company away from the complacency of not appealing to the customer experience side of business.

P5 continued to discuss the talent issue in Ireland by stating that he felt manufacturing and the trades associated with it had been lost in Ireland. He felt Ireland, at the primary and secondary school level, was not creating flexible people with the mind-set to work collaboratively in teams of innovation. P5 stated, “There’s not enough focus on innovation at that level.”

P5 maintained that compliance in policy on the manufacturing side of things remained very important. He claimed that he did not find issues with asking the government for help

because he had built good personal relationship within government circles. He felt the IDA was at the top of the class with multinational experience and was a big help with that.

On the subject of IP laws, P5 explained:

Well you look at for instance if China was manufacturing something, what's the risk that they can reverse engineer it? That seems to be more of a real threat in the next couple of years, so if you go back to either development or research or advanced manufacturing, where your IP is on the table right and is it protected. For instance, we manufacture here the enterprise products and that's serious IP stuff, and I think that is something that, even though our costs are still high, that's a value play and proximity to manufacturing. In general, with the IP and the tax you could build a very, very strong business case in my opinion.

He also agreed that Ireland had a PR problem with manufacturing. He claimed it was something he felt had been lost from the Irish mentality or consciousness. He felt the IDA event he had attended for raising awareness of manufacturing in Ireland was just a "box ticking exercise." He wanted the IDA to focus more on growing manufacturing in the indigenous sector.

P6

P6 was a senior manager in a large indigenous dairy based manufacturing entity. P6 began by discussing how "new technology is the enabler of new business models and allows... lots of industries to become part of the knowledge economy."

P6's business depends on the performance of health-based research and uses their analysis to discover where market gaps exist. One such gap had led them to remove the calcium from milk and formulate new vitamin and mineral compounds for health and wellness products. The large-scale manufacturing happens mostly in the United States because that is where the mass market is and only a minority occurs in Ireland. He said his company needed to continually upgrade its machinery, integrating new technologies and

high-tech equipment such as those that filtered the different molecules apart. P6 stated that they refined the protein from the milk until they had a 90% pure fat free protein, and then introduced this product to global consumers. He stated that he worked with the research side in conjunction with the manufacturing side of the business on this concept; due to their introduction of new technologies they could separate varied ingredients from one another and morph them into new compounds and products. Now with investment in new technology he stated that anything could be possible. His company took these new technologies and techniques and applied innovation to running the production in their factories and that these new technologies and innovation made manufacturing in Ireland more achievable.

I expressed how wide an array the topic of manufacturing actually covered, and how I had been advised to speak to him because of the way the company had applied new technologies to extract greater value from their agriculture based products that was the very definition of advanced manufacturing. He agreed and explained that it was about increased productivity and continually making the business more competitive through new technologies measuring yield and capturing data. For instance, his company could track all their milk collection and delivery trucks through real-time technology, monitor the efficiency of their routes, and the quality of the dairy product being collected from the farmers.

The manufacturing process started in farms where they needed to first test the milk's protein content, which drives the payment amount the farmer receives for his milk. P6 stated that new technology was driving a service component to his business whereby, if required, they could provide additional services such as testing the farm's soil, tracking the rate of the grass' growth that helped feed the farmer's animals, and even analyse the quality of the feed the farmers were using. P6 stated, "We have various programmes; the point being that technology has enabled us to expand our business and add value to the farmers, and we are then seen to be adding value to their business... we can up-sell on that basis."

He admitted that the advantage of having production in Ireland was the lower cash cost of production which resulted from utilising Ireland's natural resources and climate advantage in growing grass to feed the national dairy herd which produced the core raw material for his products, i.e. milk. Despite seasonal fluctuations in grass growth, P6 still felt it made sense to manufacture in Ireland because their raw material cost remained lower due to the competitive nature of the milk production market in Ireland. This seemed to be echoing T.K. Whitaker's ascertain of more than 50 years ago that grass was Ireland's oil!

P6 stated that they now employed less people, but that the people now working for them were higher paid due to their increased technological skills; the technicians they employed needed to know just as much about the product they were manufacturing as they did about the factory and the equipment they were working with. The company also required dairy scientists for aspects of their production process, which required them to hire chemical engineers. Many of their employees were now derived from pharmaceutical backgrounds both from college and previous employment. They recognised that having large pharma companies in Ireland was good for their recruitment and that they needed to work hard to compete for talent. He admitted that not many people wanted to go into manufacturing as a career and that manufacturing might have an image problem and be perceived as a dirty work environment. He stated that his company was planning to create a graduate recruitment program where they would be willing to hire anyone, despite what that person's background was or what was on that person's CV, if that person was interested in training to work in operations. P6 felt that too many of the potential employees that were approaching them were wishing to go into marketing or sales when most of what they produced and needed actually involved manufacturing skills and experience.

P6 spoke about the company enacting more process improvement, getting everyone, including management involved, which also built team togetherness, initiatives, confidence and building the team's leadership skills.

The company had conducted research into large global manufacturers and the production and innovation methods they used. He agreed that there were agricultural clusters developing related to food production being coordinated and driven by government agencies such as Teagasc. They employed graduates from University College Dublin and provided input on the content of relevant courses there. P6 stated that through their broader supply chain of associated farmers and other local dairy workers they indirectly employed over 200,000 people in Ireland. He stated that over a third of the people employed by the company were involved in manufacturing. The scale of their operations encouraged them to stay and the large number of jobs that they influenced in a small country like Ireland, gave them the advantage of being able to get access to relevant Government Ministers and discuss issues with them whenever they needed.

P6 would like to see better management of intellectual property in Ireland. P6 stated:

A fair bit of IP comes from the universities. They probably need to get better at working with the private sector around licensing, and ownership, and the sharing long-term benefits of their research. Some of them tend to be too protective and a bit all over the place when you are trying to put a deal together to use their IP.

He concluded by saying that the Irish farmers were very efficient at agriculture production and that their milk business would be expanding into more long-term partnerships globally.

P7

P7 was a senior manager of a bio-medical company. P7 noted that the transition to a knowledge-based economy in Ireland was well under way and that two government policies that had been effective so far were a reformed tax policy and an emphasis on developing

infrastructure. He felt that Ireland being an English-speaking nation also really helped when communicating with a US head office. He noted that standardisation and the transition to a “smart” economy would be needed but that “Manufacturing was still the bread and butter of the country”.

P7 described how he did not have a problem recruiting in his location because the multinational company had sent in experienced managers from the companies’ global network to start up the facility. They were experienced and had a good workforce, so they were able to grow output, grow productivity and take cost out of the manufacturing process. He was also lucky in recruiting a few key Irish managers who had experience overseas and in Dublin and were looking to move back to their home town. He felt that this would also mean they were unlikely to leave the company in the near future, so he could build his next generation of management team around the local hires and then gradually phase out the overseas senior managers.

When P7 was asked to describe characteristics that make the Irish workforce successful in the company he stated:

There is a couple of things. I have written it down there as flexible. I mean our folks here are way more flexible and younger and probably both of them go together than workforces like for example in Germany and the US. The other thing that management is always very, very focused on is this whole union thing. We are a new plant, a young plant, with no unions. It’s also very easy here to ask somebody to work longer, to work Saturdays, to work Sundays and of course you pay them. But its very, very flexible and it’s not this thing ‘it’s not my job’.

As a non-Irish leader in an Irish manufacturing entity P7 was able to give me some very good insights into how the Irish people within and between companies worked better together for the good of each other and the country. He stated:

Yeah how should I say, they speak up probably more than Japanese would, but they are not as controversial as probably Americans or Germans would be. So from that perspective I think it's much easier to deal with the Irish and again I'm obviously from the outside so don't take that personally but I think they are easier to deal with. On the other hand if there really was a big issue they would let you know so they can raise and articulate issues. The other thing when we talk about what is the success of this country and how can we sustain it I think there's a lot of initiatives now that are around continuous improvement. The whole operational excellence, Six Sigma and everything there's more and the opportunity to benchmark in this country. This country is relatively small yet it's so diverse from a manufacturing perspective. We had I think probably in the meantime three or four benchmark visits in the last two years to [a large retail brand manufacturing company]. We drove down to some Pharma company because... one of our folks who used to work there and so he just rang them up and we could actually go in there. So, I guess what I'm trying to say is there is so much benchmarking going on that there's almost like an Ireland Inc. And I think that is a huge advantage that we are having here and that it helps us to be successful so it's not a competition where you want to beat somebody else but there's a competition where you say 'You know what, they are doing all this great stuff. Let's do it as well'. I think there is initiatives again by the IMDA, about operation excellence forum where they do stuff together. Where they have quarterly meetings and things like that. It's way more open than it would be probably in other countries. So, while probably our headquarters are fighting and have law cases and everything we actually open the door and allow ourselves to talk... I mean last year we presented at one of those things about our behavioural standards and it was, yeah, we found that in a benchmarking trip to [a competitor bio-med company] and then our VP of all of operations she said, 'how is that possible, I mean they wouldn't let you in'. I

said, ‘no they did’ and she just couldn’t understand it so I think they realise it but they still can’t understand why this is happening.

When asked about a policy initiative that he would like to see implemented P7 spoke about how better local sourcing (supported by those infrastructure improvements) would improve the economy’s efficiency. P7 said “I think that is something, if we could use this part of manufacturing that we are doing or probably that your company is doing and actually use that to build a local supply chain foundation below that for those easy things like moulding, carton manufacturing and really help them to become world class so if we were able to have world class suppliers in this country that could supply that knowledge based manufacturing that would help us to sustain manufacturing in this country.

Touching on another point with relation to the Irish workforce characteristics, P7 seemed surprised that either some of his employees or someone in the local area hadn’t had the entrepreneurial idea to start serving his local supply chain needs.

P8

I conducted this interview with P8, a senior manager in a government policy driving agency, on February 1, 2013. I interviewed him from the standpoint of conducting an analysis of Irish industrial policy. I asked for his impressions on Irish industrial policy, him having lived through it and being at the heart of shaping it from his time with the [government agency]. He explained that the [government agency] was founded in 1970 as a separate entity when he became first employed there as the manager of planning and strategic planning. Because of this experience, he was heavily involved in industrial policy for about 20 years. P8 admitted, “In a way, the [government agency] and its predecessors have been at the heart of the whole industrial policy development.” He also admitted that past internally focused

policies of the pre-Second World War era had failed, and the countries policy makers had to “reverse the engines.”

He explained that the basic theme of the policy changes focusing on increasing the productivity of industry, repealing the 1934 Control of Manufacturers Act, and beginning to encourage free trade, with the important milestone occurring with the signing of the Anglo Irish Free Trade Agreement in 1965. Because Ireland could no longer sustain the same type of closed and protectionist economy as before, P8 claimed, Sean Lemass, in the Fianna Fail majority government of 1959, had to encourage “competitors in the Irish economy” through charm, persuasion, and a clear understanding of economics. P8 explained that Lemass “carried the people with him. He understood the future. And he understood the importance of economics.”

The prelude to the [government agency] being set up as an advisory board occurred in 1949 with the Industrial Development Act passing. P8 stated:

It marked one of the earliest explicit attempts to promote foreign investment in the western world. It had a board and in fact, by the time the new [government agency] was established, they had succeeded in supporting about 450 foreign companies with about 30,000 plus employees.

P8 admitted that at the start of the [government agency], as J.J. Lee’s (1990) book suggested, there was a lot of negativity toward them by the Department of Finance and The Revenue Commissioners office. P8 explained that the [government agency] ended up as an industrial promotional body operating within the constraints of Civil Service and while there was also a “parallel civil service body that said – well you can’t have a promotional body that is also accountable for paying out the money.” This caused some issue and was not a sustainable situation; therefore, in 1969 George Colley, the Enterprise Minister at the time, combined everything into one body, equipping it with many of the required policy and financing tools to deliver on its brief. P8 stated, “That [government agency] was completely

independent. It covered everything. It incorporated what was a small industry division, multinationals, everything” This organisation included everything that became [another government agency], which was eventually broken off into a separate entity in 1993 and was chartered with growing indigenous industry.

The [government agency] remained in touch with the international marketplace, according to P8. This was just one of the things that made [government agency] special and interesting so that people were coming to Ireland to examine them and see how they were working. The others were that people could not replicate the [government agency] institutionally, creating the expertise in the public sector, and the political and administrative system fully supported them. The factors that created this special agency were George Colley as a forward-looking Minister for Industry and Enterprise, a strong majority Fianna Fail government which could push policies through, a poor economic environment which was creating a will to push things through and create employment, and the long track record of the [government agency] as a learning organisation with a head start on the competition in terms of attracting FDI. P8 stated, “The [government agency] resulted from the combination of people and the unique culture that was created. The [government agency] ended up as a mixture of people from the public sector and people from the private sector, and it created an amazing combination of talents, experience and skills.”

P8 explained that Irish government bodies had developed almost a national competence in attracting FDI to Ireland. The core resided in the promotional institutions, and thus the [government agency] had influenced modern Ireland profoundly. It was still reflected in the fact that even in the depths of the recent economic crisis, no one, P8 claimed, wanted to increase the corporate tax and that had “complete 100% political support across the spectrum.”

P8 stated that after 1969 and the establishment of the [government agency], the Managing Director “set quantitative targets for everybody in every sector and targets for creating employment or winning projects.” P8 felt that the [government agency] was achieving its objectives but that the closing of many factories in the late 1970’s cast a bad light on its achievements. As a result, in 1982 the Government commissioned The Telesis Report - A Review of National Industrial Policy. P8 felt that this report insinuated that the [government agency] and its MD, had become too powerful and overly responsible for setting industrial policy; however, P8 felt that the [government agency] was making good progress and still represented good value for money as an agency.

At the end of 1980, P8 became a senior manager in the [government agency], and he set about reviewing the entire industrial policy landscape. He took some of the recommendations of the Telesis Report into account and combined this with a new perspective on industrial policy. P8 felt that this led to many changes, such as shifting promotional focus of Ireland from grants, incentives, and advanced factories to being the home of intelligent, youthful Europeans and by promoting the growth of internationally traded services. He also assisted in changing how the [government agency] did business with companies and bestowing grants upon them. He explained that they enlisted the help of the Irish Export Board to schedule and attend visits of the overseas companies with the [government agency], which aided them in assessing a company’s likelihood for success.

P8 continued that in 1981, the [government agency] aided in passing an employment act, “The Industrial Employment Amendment Act where we got the specific right for software companies, who weren’t actually manufacturing anything, so that we could give them a grant based on the quality of the job.” He wanted to focus on how a job could add value to the economy rather than just subsidise the creation of any job, irrespective of the company’s future prospects. P8 stated that in reality,

Because of the unemployment situation we were expected to be creating jobs, but our real test was the type of jobs we created. So, I went out on a limb. I gave a speech at the Bi-Centennial of the Dublin Chamber of Commerce in 1983 where I set out that philosophy. My philosophy was to incentivise high value, high volume, high productivity, high value added, and high-income companies, and effectively allow job creation to happen as a residual, and I made the case that the total impact of an industrial investment cannot be seen simply within the factory itself, but its total impact on the economy.

This concept was a great example of the multiplier effect and represented a large change to existing industrial policy at the time. Another large change to industry policy that P8 outlined was the 1982 Corporate Tax Rate change which resulted from:

various options that came out of the government of the day, I think Des O'Malley was the Minister, and he made the decision that we could take the risk of going from 0% tax to 10%, but we would have to manage that, and that would apply to all manufacturing irrespective of whether it was Irish or foreign, and irrespective of whether the output was for export or not. Then internally we would basically guarantee that. We would say that was guaranteed for twenty years.

P8 explained that then the European Commission was pressuring Ireland to move from its 10% corporate tax for manufacturing. Rory Quinn was the Irish representative at the tax negotiations and he wanted to keep the tax rate at 10%, and he got the Europeans down to 15%; the current rate of 12.5% came because the negotiations were stuck and so they split the difference. P8 admitted that there was no other science behind this.

P8 explained that in 1987, the 'Tallaght Strategy' where the opposition supported the minority government so long as it implemented the right type of policy was hugely important as it guaranteed industrial peace and how it allowed a person to pencil in modest wage increases of 3% per annum. During the financial crisis that occurred around this time, Charles Haughey, former Taoiseach of Ireland, realised he needed to develop positive initiatives to

break the cycle and one positive example of this was the setting up of the Irish Financial Services Centre in 1987.

Once P8's time as a senior manager at the [government agency] came to completion in June 1990, he opposed the [government agency] splitting into two separate organisations focused on indigenous and inward foreign investment, but it happened despite his objections. He felt that this resulted in fragmentation across the board and weakened the strong culture of hothouse talent that the agency had developed since 1969. P8 loved the spirit of innovation and implementation this culture had embodied and feels that this was lost in the split into two agencies.

The smartness and implementation of Ireland's policy up until 2000 created a sense of invincibility that ultimately ended in the agencies losing focus and competitiveness and they took the eye off the ball. P8 felt the setting up of Science Foundation Ireland in 2003 was a good development because "it recognised the fact that we had to have deeper routes in innovation and knowhow and science." The 2008 Smart Economy document, P8 stated, came from the Brian Cowen government, and he expressed dislike for it. He felt it developed into more of a catch phrase or a slogan. P8 felt the Action Plan for Jobs created in 2012 was the document that best represented the current Irish industrial policy.

P8 added that the policy implementation deficit in Irish civil and political life did exist, which was not a recent development. P8 stated:

Going back to the original Programme for National Recovery in 1987, this came out of a disaster, and it helped the country, guaranteed industrial peace, and nominal wage increases. But what happened subsequently was for the sake of industrial peace, a higher and higher price was paid each year in terms of perks, allowances etc.

P8 explained that this resulted from policy makers not making tough decisions and that in general Irish policy makers and politicians really only responded well when faced with

a crisis. When there was no crisis, then political and local considerations took over from the national economic interest and this slowed down the correct implementation of good policy.

P9

P9 was a senior manager of a state industrial policy organisation. P9 noted that research and development and development and manufacturing were now no longer separate endeavours. This participant implied a seamless transition between what he termed basic manufacturing and more sophisticated manufacturing. The concept articulated by P9 was that rather than simply adopting new practices, advanced manufacturers needed to create them (in-house) as well.

P9 mentioned that Fruit of the Loom, a major clothing manufacturer, had located a plant in Ireland and that plant had been very productive and successful. However, they did not convert to advanced manufacturing, and the facility—which was large—eventually shut down. He also mentioned [an ICT companies] now closed assembly and test facility in this context—foreign investment that was at first substantial but was not kept up because the manufacturing facilities and processes became outdated and the process was moved to a lower cost geography.

P9 articulated that it was now clearly understood from a policy perspective that in terms of co-location of functions, that it was now perhaps more important to incentivise the co-location of the development part of R&D with manufacturing. P9 stated that:

One of the big shifts is R&D associated with manufacturing or often what we would call D&M: Development and Manufacturing collocated. The D part of it involves an enormous amount of process development. So, the manufacturing model has definitely gone from pure basic manufacturing to sophisticated manufacturing and now, in nearly all cases, with Development and Manufacturing collocated. So what that does is it brings a core of the

Irish operation into contact with the new fundamental research happening in the company. So the further back you can go in terms of taking new products in and creating the process and scale-up, the more you create that as a test bed, and, therefore, you deepen your roots with core R&D. And bear in mind that it is the core R&D that is going to produce the future products and determine what the facility will need, so we find that very little comes in nowadays without having the development function coupled with manufacturing.

Another concept mentioned by P9 was the need to invest in both industry specific training and also in broadly educating the next generation of students. He also observed that Ireland had a growing reputation internationally as a learning centre and that that reputation should be used to attract talented foreign students. Those students could presumably be offered positions in the new knowledge-based Irish economy. On the concept of investing in training and infrastructure, P9 stated:

Well outside of the tax initiatives one of the most innovative policy initiatives would be investing in training and research infrastructure. For example, in the Grange Castle site, which is now owned by [a pharma company], we have just invested €60 million in an institute called NIBRT. It is the National Institute for Bioprocessing Research and Training. This facility which was built up in the grounds of UCD and is a joint venture with UCD, DCU, Trinity and the Institute of Technology in Sligo. Biopharma is incredibly complex to make.... the challenge is how you actually make that drug at commercial scale. Creating the process development may be as complex as the invention of the new drug. In addition, you need very specialised skills for it so. So, the policy initiative is first of all, how do you make these complex biologics and the second one is can you train the staff up to actually do that.

On the topic of investing in the training infrastructure, P9 continued:

Well the whole idea is that the research centre would be national. However, as you know with academia in Ireland it is hard to get them working together.... The whole idea of bringing these

four universities together is to make it a national centre of expertise. Like there may be biopharma expertise in Galway, but how can they do it in partnership with NIBRT rather than them going off individually on a tangent. Well we need to have national strategies rather than individual [government agency] strategies. So, in terms of my previous point on research and training centres, what we are working with are two national ones, the national strategy for medical devices and a national strategy for business process outsourcing. We need to bring a much more cohesive national approach.

P10

P10 was a senior manager of a state industrial policy organisation at the time of the interview. P10 told an anecdote about how a company had purchased an expensive (half a million euros) device to help with control systems in manufacturing. He observed that the research team of the company needed to adapt the technology of that device for the company's particular needs. P10 articulated an interesting concept, that the device drove innovation, and that the innovation the device produced (to adapt it to the company's needs) in turn drove further innovation. He implied that feedback by a company's research team could go back to the manufacturer and be used to make later versions of the device that were better suited for its eventual end use. Also, P10 saw innovation as a way to build capital, human and otherwise. This is an important finding of this study that is perhaps outside the realm of the research questions: that innovation in advanced manufacturing is an iterative process.

I spoke with him about his views on manufacturing and its contributions to Ireland. My first question began with how P10 felt about manufacturing's contribution to Ireland's knowledge economy. He explained that all successful companies, anywhere in the world, needed a strong manufacturing agenda in order to maintain strength. P10 stated,

“Manufacturing is a vital component of a model economy.” For him, “Manufacturing is, in essence, like an innovation engine”, which was why it remained so important to Ireland’s economy.

He continued to say that the [government agency] did not subscribe to the idea of a purely services driven economy. Manufacturing became, as he stated, “a lesser priority,” as Ireland’s Celtic Tiger boom drew focus to property and banking endeavors, and Ireland forgot about manufacturing. He continued, “The vast range of skill sets that’s needed for manufacturing and career opportunities,” creates a valuable opportunity for Ireland through developing the adaptable learning skill sets required in manufacturing, skill sets which will continue to be a needed factor in Ireland’s economy. Ireland’s manufacturing base, for P10, emerged from three categories of companies: food industry companies, pharmaceutical companies, and information technology companies. All of these industrial categories required and achieved excellence in manufacturing at some point in their supply chain and business agenda.

I asked P10 to clarify how the manufacturing and services agencies differed from a policy perspective. He replied, “Governments address policy priorities in terms where they want to go with the economy.” He stated that the [government agency] had experienced substantial growth in the past ten years, and the agency “has been a focus by government from a PR stand point of view.” He stated that adding a service aspect to manufacturing was useful in that it aided in monetising manufacturing. P10 stated that manufacturing “plus the services” meant that the Irish entity was “not isolated” as a company, and that successful co-location of manufacturing plus services including research and consulting could help secure the future of the company in Ireland “but certainly... it would depend out in the field how you would deploy the after services.”

He suggested that “supplying coherent solutions to the market is essential and... there are much better margins in supplying solutions than there is in supplying a product.” He expressed the viewpoint that integrating manufacturing into a service economy was preferable.

He expressed his opinions on that when trying to create a company, focus was essential and initially it was preferable that companies that specialised in one product to become expert solution providers in their chosen space. He expressed that the “old style startup companies” seemed small in the amount of labour employed and total sales acquired for the effort expended but that if done properly “the capability that they can harness often time [is] like you are looking at a much bigger entity.”

P10 spoke about the success of the [government agency] was looking for in terms of supporting startup companies, like the example of “medical supply companies from Germany,” and how sometimes the policy can look disjointed but just because it “appeared fragmented doesn’t mean that it isn’t building capability nationally from which you can obviously build upon in the future.”

P10 spoke about the 2012 Research Prioritisation Report and he agreed that they utilised the basic prioritisation thought process; however, in his experience some of the best innovation actually came out of companies that did not fall into that list of 14 priorities. I asked him whether he felt that apprenticeships provided an important part of the skills development for Ireland and he replied, “If they are aligned to the sectors where we have a competitive advantage from growth then I’m all in favor of apprenticeships.” However, he reiterated the need for developing innovation skills in the workforce, not just specific trade skills, and that the people tasked with “corporate venturing” within FDI companies were looking for “innovation.”

P10 stated that “trade sale is the strategy now on a worldwide basis.” This was because serial entrepreneurship seemed much diminished in the economy according to him; instead, serial investors had developed, “investing in others or teaching others how to do it.” On the subject of the Irish education system in terms of learning practical business skills, P10 claimed, “If we had our way, we would have a business entrepreneurship module in every University Degree... no matter what you’re going to be.” He claimed that Ireland’s fear of failure and other national issues such as feeling comfortable with success were responsible for the lack of entrepreneurship in the Irish economy.

On the subject of whether manufacturing had a PR problem, he felt that careers in manufacturing were “very poorly positioned by the food companies as a very attractive career in a very sound industry.” Because of this PR problem, Ireland faced the lack of skilled trades-people needed to properly and efficiently find success in manufacturing. As he stated:

There’s nothing like announcing 500 or 1,000 jobs. That is the *crème de la crème* still sought after today, by many politicians. What I would say is that, looking back on my career, FDI is a bit like borrowing. You are essentially borrowing jobs on the international market and we are buying them on the international market for a certain price which is very good for the economy and so forth but like borrowing you can do too much of it. Borrowing is very good because it leverages up your returns so the way you preserve your shareholding is to use other people’s money. In return, they get an interest rate payment, but you are essentially not diluting your equity. Therefore, in a modern economy, a modern direct economy, FDI is very important in terms of leveraging the ability to use other countries and other companies’ money”.

P10 continued that the high quality in management in the indigenous companies meant there was a chance to have good leadership growth in the future, that the “40-year economic transformation journey” was ending and “we are coming to the maturity phase of that journey now as a country.” Therefore, now was the time to step out of Ireland’s traditional comfort zones, embrace Ireland’s search for innovation, which could be

discovered through FDI and their influence on the economy, and that for the future “innovation was the name of the game now in manufacturing as well”.

P11

P11 was a senior manager of a high-tech manufacturing firm. P11 said that Ireland’s government had made efforts to foster research and allocate capital to advanced manufacturing, but those efforts had not been focused and coordinated. As a result, goals were not being met. P11 recommended that the government focus on training entrepreneurs and encouraging direct investment. P11 also stated that Ireland’s future would be not in research but rather, commercializing existing innovations. Excerpts from the interview are given below.

Upon questioning P11 on how advanced manufacturing could contribute to Ireland’s knowledge economy, she replied that she was concerned that manufacturing was being undervalued in Ireland. P11 noted that her manufacturing company locally employed about 700 people in diverse roles, P11 stated, “I think the advantage that you get by operating end to end is that we do the concept design, development, and manufacture and you actually bring products and/or service... through to commercialisation and therefore we have a complete understanding of the real value for the end user.” She expressed that the contribution that manufacturing made was by providing large employment numbers, facilitating more effective cost control on products, contribution to the government through tax and reputation, and a positive social impact.

P11 stated that investment by FDI companies formed the first part of what was to be the local med-tech cluster. [Two other med-tech MNCs] were first to come and were followed by others, which enabled the local cluster to form and grow and then it began to attract the attention of the local university. P11 said that when her company became involved

in medical devices around 1988 to 1989, the local university was focused on producing appropriately trained graduates, and there was an already thriving medical cluster, so they experienced no problems finding skilled and qualified people to employ. Despite the PR problems that manufacturing was having in the rest of the country, the med-tech cluster inspired awareness of how good a career in manufacturing could really become.

I asked P11 about her opinion on co-locating R&D and manufacturing, and she agreed that it remained important to have “at least your early stage manufacturing co-located, aligned, integrated, everything, with your R&D.” She felt value was truly created on the Development & Manufacturing side more than the Research & Development side. She felt Ireland would best served by focusing on commercialisation of the research and not by conducting the pure research; that they could take early stage products and figure out the value they held for the market, all the while tweaking them until they reached perfection, which she felt was more in line with the creative and collaborative side of the Irish personality and psyche.

P11 admitted in seeing a large difference in the Irish staff versus staff from other countries. In P11’s opinion, Ireland’s “education system is much broader, and I think people just end up with broader exposure, and therefore maybe end up as broader thinkers, more open minded.” Most of her product-building employees obtained Leaving Cert level qualifications. They also had many qualified technicians and a lesser number of engineers. P11 believed in the importance of a broad education system to the creation of a knowledge company.

She also discussed how manufacturing was truly about innovation, not necessarily the capital intensity of the equipment or the qualification level of the individual. She spoke about how making innovation part of everyone’s job resulted in empowered and intelligent product builders who helped tweak the process and deliver productivity improvements.

In relation to the 2012 Government policy initiative to identify 14 Research Priority areas, P11 felt they had created too many areas of research, which did not allow focus for improvements in any one area to develop national competence, but then also did not allow openness for the creation of novel big ideas either. She felt this would be a difficult policy to implement.

I asked her to speak a little on the regulatory system in Ireland, and if policy had helped or hindered her business. She felt the regulation was unavoidable, although her company had not experienced a significant impact from government policy. She did not see how policy helped or hindered the company. P11 stated that operating in Ireland “from a manufacturing perspective, it’s definitely reasonable. But just reasonable.”

P11 also stated, “Convergence can happen in Ireland,” but that there may be a lack of convergence between the various colleges and education institutions. She felt that government policy on forcing the universities to collaborate is the right thing to do. P11 speculated that universities had a “siloed effect” because they had been established for so long, compared to the relatively short age of the Irish industrial base.

She admitted also that the Irish people were better workers than entrepreneurs. She attributed this to a fear of failure in Irish society. P11 also stated, “A lot of people spend their whole working lives either in a kind of civil service job or in a secure large FDI company type job. They just don’t get exposed to entrepreneurship as they don’t have any entrepreneur role models.”

She stated that Ireland needed to have a global perspective now. They needed to build new relationships with Asia and Africa because of the market saturation in the United States and Europe. P11 expressed no worry in Ireland’s abilities to build these new global relationships, stating, “I think it’s a very strong Irish trait, we have that ability to go out and

embed ourselves in these communities and become known or get recognised in a positive way.”

On the current Government Jobs Initiative policy, P11 echoed the familiar concerns about the policy implementation gap and was worried the jobs policy was too localised and would suffer from the negative impacts of Irish politics being too localised, because “we have a less national view.”

P12

P12 is a senior manager of a medical supplies processing and packaging firm. P12 mentioned two cultural factors affecting the Irish transition to a knowledge-based economy. One was negative: the lack of an entrepreneurial spirit. One was positive: the problem-solving nature and attitude of the people. He recommended, as did several participants, that the Irish higher educational system include more classes on entrepreneurship.

This interview sought a better understanding of the manufacturing industry and how this industry affected, or could affect, Ireland’s economy.

P12 started by recounting how he became involved in a study on manufacturing before. He recalled how the Minister from DJEI had taken him and a few other leaders from indigenous Irish industries and asked them, “What can we do to increase the number of indigenous industrial jobs in the country?” Once again, it was stated that manufacturing had, as P12 stated, “been forgotten about.” P12 spoke about startup companies, middle growth companies, and mature companies and how each one of those companies maintained varied strategies to success; therefore, his group of researchers focused on discussing, start-ups, scaling, on-going maintenance, and growth, international growth of the companies, and what services they would offer.

I wished to discuss how advanced manufacturing could add to the knowledge economy in Ireland. He let me know he did not care for the words “advance manufacturing,”

as it seemed a redundant term because manufacturing must be advanced enough to stay successful and ahead of the game and he felt that ‘advancing manufacturing’ as a constantly moving target was a better phrase for the future of manufacturing in Ireland.

P12 stated that he would like to see Ireland return more to its roots, in terms of supporting startup companies, that Ireland was focusing too much on “crossing T’s and dotting I’s.” The administrative burden was too heavy in order to obtain funding for a small business, and he worried this was causing a significant issue for new entrepreneurs to overcome; thereby, negatively impacting the ability for startups to grow.

He felt this stemmed from a fear of failure residing in Ireland’s culture, what P12 described as being like “We backed that company, and it failed, and we don’t like failure.” This fear stopped the effective growth of new business in Ireland and encouraged the Irish peoples to look for jobs with a briefcase and suit instead. The Irish people, P12 stated, “will come up with three or four solutions,” and they have, “fantastic self-motivation, taking the initiative, and brilliant problem-solving skills, you just don’t those skills get abroad.” That was why foreign investment had been so high; however, those hard workers he spoke of were all working for him; they were not “all entrepreneurs,” P12 stated.

He also stated that the PR issue in Ireland was hurting the manufacturing economy. “You need to consider,” P12 stated, “that you are far more than just manufacturing.” P12 commented:

I think that would be a natural outcome of doing something else. That is getting entrepreneurs running proper businesses because I believe that we have a huge gap in, like for instance the print industry ‘That is a dying industry, we won’t support it anymore.’ If you want to get a new print press and you are in a print industry, we are not going to give any support for it, which is just wrong. Of course, there is a market now element to print. They are all print, there is market there and for the government to turn around and say ‘Ok that is a sector we are no longer going to deal with’ just shows how ridiculous the State is about selecting sectors rather than business. If you

are a great entrepreneur and you are a brilliant printer, why can't you get that entrepreneur support, get him up, and get people employed in print. Even if it is a dying industry in IT, it is still a huge growth area in marketing promotion. For instance, there have never been as many trade shows, and at every trade show, there are huge big printed banners behind every stand, so print is still huge and growing. He stated that he would encourage start-ups to find value in the value chain themselves, and fill in the gaps, make businesses, and grow them. P12 discussed how he felt that "the Irish company needs to accept the adoption, and the adopting multinational needs to put resources into support and not just lip service because some Government Minister or IDA executive pushes it." There needed to be a "tangible agreement," P12 continued. He even suggested targeting for local sourcing and making it a requirement. That way Ireland would benefit from foreign involvement, instead of creating thousands of jobs like with the IDA, forcing their indigenous staff to hit those numbers, and not having a specific plan for hitting those numbers, as P12 claimed. P12 also felt those competing multinationals were "predominantly here for the tax rate," but he felt "there was money to be made from multinationals" because this method "shortened the supply chain," resulting "in a much more stable economic environment."

I asked how he does research for his manufacturing company, and P12 admitted that his company "adopts project half way down the road, so if they are already well established, we might just take the design and get it ready for manufacturing." I said, "You keep moving on, finding gaps in the market, expanding the business?" To which P12 replied, "That makes sense. It is simple ROI." P12 stated, "If it is scalable, and you can make a margin on it, then it is an awful easy decision." He also stated his company does not search out R&D funding because they simply did not do much of it there.

P12 shared his belief in the importance of clusters. These likeminded groups inspired one another to innovate in that specific theme of manufacturing. P12 stated, "What I'm saying is grow existing, that is how you are going to keep manufacturing growing."

I asked him if he felt regulations in Ireland helped or hindered, and P12 stated that he felt regulations were a requirement because it lent a sense of responsibility and showed that responsibility as credibility. “Credibility is everything,” P12 further stated, “so anyone that is fighting regulation, they are trying to take shortcuts.”

He also spoke about Ireland becoming an education hub. He spoke about how students should have to pay for education they received in Ireland. Maybe that way, P12 stated, they would stay in Ireland because they would have more incentive to stay; Ireland was losing too many good people to other countries. Therefore, Ireland needed to create incentives to keep the innovation and their own people in their country. There simply was not enough people to do all of the jobs. Positive incentive meant everything to P12, and he truly felt this avenue would lead to success.

P13

P13 was a senior policy advisor. P13 referred to the Tallaght Strategy as an example of how the Irish government had implemented an economic stimulus program in the past. He reported that the initiative had encouraged free markets, lower corporate taxation, industry-friendly policies, and incentives to save. He said that a similar approach could be used to help Ireland transition to a knowledge-based economy. Specifics mentioned by P13 included fostering management capability, innovation, and science development, focusing on the most successful sectors, and devoting more resources to education and training.

P13 also mentioned the need to encourage foreign direct investment. He noted that in the past, advances in productivity had resulted from importing technology and innovation via large multinational companies. He noted that research and development were needed to enhance productivity. He also stated that technological innovation had to come from within

Ireland as well as without. He mentioned the pharma and biopharma industries as particularly good fields for the knowledge-based economy to develop.

P13 spoke about the policy development environment in Ireland. He particularly focused on the Smart Economy document from 2008. P13 described it as a brave move by Brian Cowen, the leader of the Irish Government at the time, to desire to put in place a plan for what his advisors thought should happen with the Irish economy, ‘to catch the next spate of growth to reposition the economy.’ P13 expressed his admiration for the Taoiseach for having that conversation and driving that policy initiative because in reality during that period as Ireland entered into a grim recession it was very hard to start a dialogue about medium term economies because really people only cared about the very short term. This again speaks to the Formulation – Practice gap that exists in Ireland policy making. In most cases the policies have been well thought through but because the policy makers are reliant on the local and political implementation, vested interests can chose to implement just the parts of the published policy that suit their agenda.

P13 felt that the Celtic Tiger era was not a mirage and that the policies implemented up to that point in 2001, 2002 worked well. He stated:

The internal factors were firstly that we had a very well educated workforce. We had put money into education, and had a well-educated, underemployed population so therefore large excess capacity and when combined with then the industrial policy around low corporation tax and going after foreign direct investment that was what worked well. Multinationals looked at Ireland and went ‘We can put our assembly stuff in there. We’ve got all these smart people who don’t get paid very much’ so that really got it started. The big question always for everybody then was whether Ireland would be able to move the value chain so can we continue to stay competitive in what we are doing. That’s where the

productivity piece when comes in, that we imported our productivity improvements through the multinationals.

P13 continued that research findings from Griffith, R., Redding, S., & Simpson, H. (2004) have shown that:

your productivity not only depends on having strong R&D and innovation stock within the country, but also your ability to absorb technology and knowhow from abroad and use the process innovation as a direct function of your own innovation or R&D stock. So, it's seems obvious, that you need smart people doing smart things. So basically, they showed it in their papers in around 2001 using OECD panel data so actually, there is evidence of that. There is very strong economic evidence often ignored by macro-economists who don't look at productivity, they are one step above. The second literature is quite interesting in that it says that everything else being equal companies in close proximity to R&D centres or universities tend to be more innovative.

P13 gave some excellent perspective on the internal workings of government policy making and how the approach is not evidence based. He stated that:

It's a weakness even out of our current project programmes and economics. I don't think we talk enough about micro measures to stimulate growth. ... Enterprise were talking about it but it was very much the agencies doing their thing and Enterprise were very much treated as a second class department to the Department of Finance. The Department of Finance refers to all the departments with the exception of the Taoiseach's department, as line departments. So that tells you alot and it was my view that Enterprise was left to do the economic development piece, but it was happening on a very narrow level where [one agency] looked after multinationals and [another agency] supposedly looked after the rest, but of course, it wasn't looking after everything including the non-exporting companies. So the complaint I have I guess is when you start looking for the evidence around what policies

might work, what's working at the moment, what isn't working, the evidence base was not there.

P14

P14 was a senior manager in a plastics manufacturing firm. P14 reported a shortage of skilled domestic labour in the manufacturing sector. She attributed this to the failure of the apprentice system, a lack of leadership training in the Irish educational system, and above all, a failure to see the problem of labour shortages until it became acute. She stated that overall, the Irish education system had failed to produce the needed amount of human capital. P14 said that the knowledge-based economy and the advanced manufacturing sector should be implemented together. She noted that manufacturing was and had always been a good source of jobs. She also mentioned the role of innovation in job creation. Excerpts from the interview follow.

P14's company was an "Irish subsidiary in place for about 40 years" with "German roots and a German culture." In the early 1970s the IDA attracted them to Ireland as an inexpensive offsite outsource. Now, P14's company offered a wide range of products, and "they have invested heavily in over the past few years."

P14 stated that there was not a huge reason to begin a business in Ireland, except for "cheaper labour, the corporate tax rate for manufacturing, and the IDA incentives." A previous employer of P14 believed that hiring people locally would gain the company loyal employees.

"Tax," P14 stated, remained "important but less so now and the reason they stayed was because of the human interaction ... and are viewed as the little sister of the German subsidiary." P14 insisted that the Irish subsidiary have succeeded for them, so keeping her company funded and operational was logical.

P14 also discussed the gaps in training competency for staff because of an undefined methodology residing from “the Irish entity as a subsidiary of a MNC.” Her company required traditional manufacturing skills; therefore, they looked for qualified and skilled people to employ. These people needed to have the appropriate skills to achieve employment such as thoughtfulness to detail, experience, high tolerance for redundancy, and creativity. P14 stated that recently, they had morphed the way they sought employees by revamping their HR strategy to raise skill levels.

To the posed question, “Is innovation important in your industry, in your workforce?” P14 replied:

Yes, innovation is of course important. The old parent company in Germany is the centre of competency and has a certain development aspect to it. And over the years we have tried to take elements of expertise over to Ireland, but pure R&D sits in Germany. It wouldn't make sense for them to assign R&D to Ireland. To get a leg in, we build huge bonds with the headquarters. I have hired and changed the skillsets here. The production manager is now an engineer; the quality team onsite liaise directly with the German technical R&D team and have built a really strong relationship with them. The way it works is they are looking after the pure R&D, and we are operating very close to them working on the fringes of what they do. You have the knowledge in one place and the production in another, and our challenge is how do you marry the two. Frankly, the gaps I recognised early on: the guy sitting over there behind the desk doing the drawing and defining the product for the market, he sometimes doesn't understand the issues on the production line. So, I saw that as a gap that we could exploit, and we built really close relationships with the headquarters research team, so now we have workshops with them and work in really close, daily interaction with them.

I asked P14 how she viewed the importance of colocation of manufacturing and R&D. P14 claimed that her company always attempted to make their client feel as though they were sitting in the same room with them. P14 stated, “The fact that we are small means we have agility, and we can drop everything to deliver what it is priority.” They also had an open

methodology toward communication, which facilitated in them remaining non-unionised during difficult times. P14 further stated, “The German entity has a Works Council, and they communicate through this, and it seems to be a big distraction for management at times over there. With a smaller entity like ours, my door is always open.”

In terms of training skilled workers, P14 attested that they trained some moulders in the IT department in Athlone. Her company also bought into upskilling and in-house training as the correct approach; however, placing the skills into the corresponding niche proved difficult. P14 also discussed how the Irish had good innovative qualities and were hard workers; however, they lacked the ability to lead and become strategists.

P14 felt that smaller businesses were not of interest to the IDA, stating:

We can go chasing them, but most of the initiatives aren't followed through and implemented. . . There is great opportunity to investigate and follow new initiatives like that, which I could potentially add to my business here, but I don't have the resources to follow this. We are an IDA client because we fall in under the MNCs, but if we go to the IDA, we find that we are not big enough to get their attention . . .

P14 felt that there was an absence of a national standpoint on how the large number of small companies actually existed in Ireland. Because of this, P14 posited, “There was no strategy for them.” It was a shame in P14’s opinion because small companies were what drove innovation in Ireland, and those small companies might come up with wonderful ideas, but they lacked the resources to properly implement them.

She also felt that sharing of information in a cohesive manner was missing from the framework. It became less frustrating for her company to start with training people from scratch than recruiting them from universities, as those people were only trained in a general sense and training them properly actually added costs. P14 stated, “It’s a very lonely place running a business like ours, you have to be very resourceful to find solutions and help.” Her

company would need to use business buzz words and be included in a big enterprise document to garner Enterprise Ireland's attention.

P14 stated that there was no one in Government to speak to about protecting her business in Ireland. She wished they had learned how to raise the efficiency level of the supply chain in Ireland as well. These things would be a huge benefit, she stated:

In terms of Government policy, energy costs are still a problem and local rates payable are too high... Ireland's labour policy is not conducive to our industrial aspirations particularly if you are talking about the lower end of manufacturing. For the people at that lower skill level we have a lot of social welfare traps; they remove an incentive to work.

P14 stated that in regard to doing business with Ireland, in general, she liked the amiable attitude of the Irish; however, the availability of broadband needed some improvement, as it affected Ireland's communication infrastructure. She also expressed disdain for the lack of multilingual employees, lack of verbal skills, needing more accountability in regard to rates, and that the road networks were not that wonderful. She felt these things needed reparation better to bring small businesses to where they were really needed: local villages.

P14 stated, "Apprenticeships are vital, and this area absolutely needs to be overhauled." She posited that maybe a shared apprenticeship system could somehow be set up for multiple small businesses to pull from when they just had one project, for example. This could represent a successful university collaboration with small businesses.

P14 stated that manufacturing remained an essential contributor to Ireland mainly because of the jobs it could create. P14 stated, "If you are not manufacturing you can lose a lot of knowledge by not working the product and process iterations. You lose in terms of the transferability of the knowledge from one product generation to the next."

She also expressed an issue with manufacturing's image in PR, stating that it seemed to represent a dirtier side of business. However, she attempted to educate potential employees by defining a week-long series of events that she runs inhouse, demonstrating to student's methods and potential future careers in accounting, financing, administration, manufacturing and the tool shop. She discussed how college interaction needed consideration, as employment could increase if competitiveness was introduced to the market. Overall, a lack of coordination caused the issues Ireland faced, in P14's opinion.

P15

P15 was a senior manager at a trade association focused on exports. P15 mentioned that the Irish government had erred by not supporting the skilled apprenticeship system. In the auto industry in particular, the deterioration of the apprenticeship system had resulted in the lack of a skilled labour pool to help implement automation and improvements. Lacking such a pool of labour, the industry would have to take skilled workers from other industries. P15 opined that the Irish government had not taken this problem seriously. Excerpts from the interview are given below.

P15 started by stating that part of the cause of the recession in Ireland in the late 2000's stemmed from having a too-fast growing services industry, and a faster growing element of the "international business or services as a percentage of total trade."

He felt that the social partnership agreements were partly what had stopped Ireland from focusing on manufacturing and that the rapid growth of service had helped to distract economic actors from it. He admitted he in his role his was privy to the social partnership agreements and that the "unions were continuously pressing for wage increases that matched and exceeded standard of living inflation increases," so it was not a policy mistake, but a conscious policy decision. He said that the issue with certain types of uncompetitive

manufacturing was that the goods were no longer being consumed in the local Irish market and therefore these non-exporting businesses were forced to close.

He felt that [a government agency], for instance, was not going to be able to attract low-tech manufacturing back here to cover the costs of rising labour due to the changes in the job market and wage expectations. The service industry, on the other hand, because it could absorb higher wage demands was easier to attract to Ireland. P15 stated, “But Ireland provides a good base to do international services business out of, so many of the existing companies morphed into services companies.” They felt that manufacturing did not have the capabilities of handling the wage agreements that the social partnership situation had created.

He admitted that the collapse in apprenticeship, which was focused mainly around the automotive and aerospace maintenance industries where he used to work, was not taken seriously by the government. P15 stated:

We said, OK, we don’t want to repeat the problems we have at my previous company with, a) a whole series of separate trade unions that we have to negotiate with for each trade and b) inbuilt problems in the apprenticeship structure. So, we approached FAS at that stage, and asked them to set up a dedicated training facility in Tallaght, with the following lathes and turning machines and so on and put people on a twelve-month training programme on those machines on the basis that we will give them a job if they come out competent at the end of it, and we’d then just have one union handling it. So, I think there’s no question about the importance of apprenticeship schemes for manufacturing, and their demise certainly was an issue in terms of ability to attract and sustain both new manufacturing companies coming in and the needs of existing companies.

He felt the re-emergence of apprenticeships in Ireland would be an essential ingredient to helping manufacturing in the future. He said it must be considered how higher wage costs could fit in with manufacturing, and if all types of manufacturing could continue its existence at those price levels. He claimed it was still a competitive and viable industry, that most of the job creation in the future would stem from companies which engaged in

increased automation where the employment costs would be a minor percentage. P15 stated that policy initiatives to encourage increased automation in manufacturing may not aid with the unemployment issue in the short term, but in the long haul, it could.

P15 talked about inverting the pyramid, where it used to be that there existed a few high skilled engineering jobs and many lower skilled production jobs; but that in the future Ireland's approach had to be to create employment in higher skilled jobs in the area of maintenance of the machines resulting from increased automation. He admitted that this would require a change from the past. He also discussed how there was not a cohesive policy on global distribution.

On the contribution manufacturing could make to Ireland's economy, he discussed how it would be impossible to eliminate all of the lower-tech manufacturing because then that would lead to an imbalance in society; the high numbers of jobs created by manufacturing were essential for social cohesion in terms of employment opportunities it provided for the less skilled and working-class member of the population. He felt there needed be new policy initiatives to create a comparative advantage to retain a manufacturing base in Ireland. P15 stated, "So if you look at the majority of the new IDA projects, they're either social media type companies or companies engaged in R&D activities and are both in the higher skilled services areas as opposed to manufacturing."

He also felt companies could benefit from collocation of R&D and manufacturing, but there was an issue with the R&D aspect of things. He stated that there were less policies focused on the D side and the majority were solely focused on the R side. P15 also felt the tax policy was solid and sustainable and that increased royalties would come in the future from "the innovation box kind of arrangement" that Ireland was developing.

He left me with these thoughts:

I would think, going forward, it's very much a question of how we stay focused on analysing existing global demand and where it's coming from and where the global

competition for those jobs is at the moment, and then trying to ensure that we work the best policies to support industry in sectors where there's growth. If an industry globally is going down, then there's not much point in trying to artificially prop up an industry's going to vanish eventually in any case.

P16

P16 was a senior manager of a manufacturing firm. He has had experience in working in multiple MNCs and believes that the Irish subsidiaries of MNC have a communications advantage over their counterparts in other countries.

The Irish subsidiary of a multinational corporation tends to be capable of getting on with everybody. In most corporations there is usually some degree of healthy rivalry between sites but with the Irish organisations what I think we have done is we have managed to be competitive but have a good solid working relationship with each aspect of a particular organisation in multiple countries.

P16 also believes that augmenting the development side of an overseas manufacturing business is the most important.

It's almost like becoming the translator in terms of pure research into practical. It's like first manufacturing or prototyping because what we have done here in our company is that we have grown our development arm over the last five years and it's a kind of a hedge against moving any of the manufacturing and other activities to other localities. It's very hard to move development, it's easier to move manufacturing, so we have picked development that is linked to the manufacturing so that we are developing products here that are going to be manufactured here. People don't tend to want to move that then. It becomes more logical then for the manufacturing side to stay here but that's only something we do on one side of business, on our consumable side.

He also expressed three succinct reasons why retaining a manufacturing base is essential to the company and the country.

I think it's important for a few reasons because firstly if you are purely in research there aren't as many jobs in research to support the economy. So that's a purely social and employment dimension. Secondly, if you are purely in research, you could be

losing a little bit of the practical application of the science or the engineering that you are developing. The third thing here is that most multinational corporations are driven by profit. Therefore, you know, they look favourably on organisations that are generating revenue so would they value my 15 folks doing development or my 255 folks doing manufacturing, well it's the manufacturing that makes the profit, you know, or the margin and I think that's really important. You have to have a good, solid financial base in a country as opposed to just a cost base, and then that means they tend to look at your operations more favourably.

Interestingly P16 expressed reservations about expanding any further in his current regional location and expressed his opinion that regional/ rural sites can only accommodate a certain size of footprint and then after that you have to relocate or have a second site closer to Dublin.

It's whether or not you can do your activity in one calendar day. I think that's a big factor. Invariably nobody ever does anything in one calendar day but it's the perception that you may want to do it. I have a mental picture in my head of where this facility can get to and after that rather than expand beyond that point if I had to expand activities for the Ireland operation I would probably move it closer to Dublin and have two operations rather than have a very large one here. I think there is a certain logical, supportable size here. It's not constrained by physical space it's more available resources. There are certain geographical locations whereby you really have to understand what's the catchment area and availability for all grades of employee. It's not necessarily whether or not you can get the services but it's the grades of employee and can you replenish them if there is any kind of turnover.

P16 concluded by stating that he does believe it is possible to sustain a manufacturing business in Ireland but only if it is high margin and that is essential to keep that link between R & D and manufacturing to provide a little bit more of an interesting and innovative type culture as an offering to the headquarters.

P17

P17 was a senior manager of a manufacturing firm. P17 shared an interesting perspective. He said that Japanese companies were so successful because they encouraged and fostered innovation. He mentioned their emphasis on research and opined that

researchers had to have the mindset that their research would often fail, or at least fail to produce tangible results. With this expectation, researchers would be unfettered by the need to always produce something immediately useful. P17 implied that this attitude toward research was a cultural trait of the Japanese.

P17 also mentioned the concept of apprenticeships. He mentioned that apprenticeship systems were already in place in the UK and Germany and that universities needed to teach innovation and communication skills. He also stated that the government should provide incentives for companies to hire new graduates. He also mentioned that tech innovations might reduce the demand for skilled manual workers and that the demand for software programmers had softened somewhat, while the demand for service workers had grown.

P17 started by explaining that his company was involved in quite a bit of innovation, “but the technology that we are doing itself would have a big impact on manufacturing.” He explained that 3D printing was just becoming prevalent, and some people even referred to it as “the next industrial revolution.”

His background was in mechanical engineering, and from his exposure to 3D printing while working with [a large manufacturing company], he developed an inventor’s interest in it. P17 stated:

We had this idea: could we build a printer that had a zero-running cost so completely inverse to everybody else whose real Achilles Heel was the cost of the consumables which was the big problem? We did a feasibility study with Enterprise Ireland. I went to the universities in the UK and in Ireland. My brother did some universities in the US. So, we only went to universities we didn’t go to companies, so that kind of showed you where we were thinking the machine was going to end up. We basically said if we could build a printer that worked on a very low-cost consumable would you use it, and they all said absolutely because we are teaching the concept, we are teaching the tech, but we can’t afford to buy the machinery.

The two things that mainly drove innovation was that their machine would use water based adhesive and paper. They wanted to keep it a clean concept because some chemicals were incredibly complicated and even dangerous to accidentally inhale or ingest, and they worked part time on making this concept a reality. They met with [a government agency], but because of P17's PhD, they were not too sure about them as entrepreneurs; this was not a normal trait to have a PhD. People came out to his house to see his machine, and in 2004, P17 and his brother took a big risk and quit their jobs. Because of the incentives from Enterprise Ireland, they decided to start-up in Ireland instead of the US; the US had nothing in terms of incentive start-up programs.

His company employed about 40 people who performed everything from mechanical design to software to prototyping. They also did process engineering, board design; they had a mini production line, and sales and marketing all in one company and place. They decided early on that they would outsource all of their manufacturing and focus all of their money on R&D. They had an issue with their first orders because of this and had to delay them while they waited for the machine's parts to arrive from the UK's factory, which was actually a machine shop not a contract manufacturer; this also caused a small problem. However, P17 stated, eventually the parts arrived "in boxes, and we did the full assembly and we built the first machines ourselves." Effectively, this was how they became a manufacturer.

He was not sure if education was an issue with finding skilled workers or not, stating, "Maybe... it's just our profile that has made us more attractive as an employer."

P17 stated that his company brainstormed quite a bit and liked to stay as a consulting force for their clients, stating, "We are a company that needs to make a profit, so it's a fine line between innovations, but also realising that our expertise is not manufacturing and that can be a challenge." He admitted he would like to see his 3D printing machine used everywhere, in all of the schools, but he knew that there were many obstacles to face for a

small business in Ireland. He admitted he might exit in the next few years, even though that was a complaint for new businesses in Ireland, he felt in terms of their company, having survived for 10 years already, that it might be more feasible to look for an exit. He felt that there was no well-structured VC industry currently in Ireland. P17 stated:

They are either an investor and they get equity and you ride with it and you go up and down and you take the hit, or you can put the money in on the loan, and you try to get the payment loan, but they want both. They want equity if it hits big and they want to cover the loan if it goes bad.

Important Points from the interviews

While the participants touched on a wide variety of important and interesting concepts (which was the goal of the researcher), several in particular stand out. The participants agreed that Ireland needed to:

- Locate skilled technical labourers, from within or outside the country
- Foster entrepreneurship
- Expand education in innovation
- Focus on the accumulation of human capital
- Concentrate on the sectors in which it operated best

They agreed that the causes of the lack of a speedy transition into advanced manufacturing and a knowledge-based economy had been:

- Cultural factors
- A lack of an entrepreneurial spirit
- A lack of appropriate education
- A lack of skilled workers
- Failures of policy in anticipating future needs

The insights of these professionals proved valuable in the conduct of this study. The findings could provide direction and focus for all stakeholders in the Irish economy. These testimonies show what needs to be done to smoothly transition the Irish advanced manufacturing base into one that will support a knowledge-based economy.

Answers to the Research Questions

The research questions for the study were answered by the data collected and my thematic analysis of that data. The questions were:

1. What policy initiatives are required to develop a knowledge-based economy?
2. What is the contribution that a base of advanced manufacturing can make in the development and sustaining of a knowledge-based economy?
3. In the context of Ireland, what policy initiatives are best positioned to assist in the development of a knowledge-based or ‘smart’ economy?

RQ1. Participants recommended that the Irish government do more in the field of education to foster this transition. Specifically, they recommended a focus on technology, innovation, and entrepreneurship in secondary and tertiary education; a willingness to seek talent abroad (especially within the EU). Several participants mentioned direct participation in the marketplace by government entities to foster development. Also, changes in the Irish workplace culture were noted as being needed, but no participant had a concrete suggestion as to how that might be done. They did mention the boom years of the “Celtic Tiger” and wondered how the public might be encouraged to embrace Ireland’s transition to a source of information and high technology.

RQ2. The transition from advanced manufacturing to knowledge-based necessarily would involve the dismantling of some or even most of the advanced manufacturing sector, a fact that did not escape the participants. They noted that such a transition would be painful and could result in job losses in the short term. Also, most participants felt that Ireland had a

competitive edge in advanced manufacturing and were not receptive to the idea of giving that up. Of course, these participants were all high-level employees of advanced manufacturing firms, so such opinions could probably be expected. This last factor argues for the replication of this study, but with a different population and sample.

RQ3. This question was about existing policy initiatives that were helpful in making the transition. Tax incentives, aggressive recruitment of talent abroad, government subsidies for developing IT industries, and higher education support were all mentioned. The participants were all critical, at least to some degree, of existing government initiatives in that they felt them to be inadequate.

These perspectives were useful and the findings potentially valuable. However, the sample was relatively homogenous. These were all high-level executives of advanced manufacturing firms. Replicating the study with a sample of, for instance, executives in IT and data processing firms might produce much different results. These and other observations and recommendations are the topic of the following chapter.

Chapter 7: The Need for Integration of R&D and Manufacturing: Recommendations and Observations from the Study

The study confirmed the need for certain changes to occur before Ireland could fully transition to a knowledge-based economy. Many of these changes related not so much to physical changes, such as infrastructure modifications, but rather, societal, cultural, and attitudinal changes. The Irish economy is a leader in advanced manufacturing, but it is still not a fully integrated knowledge-based economy.

Many of the abovementioned societal and cultural changes could be relatively easy to implement. The Irish workforce is highly educated and motivated. The nation's continuing membership in the European Union allows it free access to the resources and markets of Europe. The country is well situated to become a leader in information and knowledge.

The general approach that is necessary is that Ireland needs to integrate the various aspects of a knowledge-based economy rather than having them be in separate sectors that, while cooperative, operate independently, i.e., not in concert. This does not imply common ownership of these sectors (though planned economies, such as China's, do have that feature). Rather, integration is the situation wherein different entities/organisations work in concert toward a common goal/task. This study confirmed that a lack of integration leads to bottlenecks. One instance is the need, often cited by the study participants, of the Irish educational system to focus on producing leaders who would be best for managing information-based enterprises. Such an initiative would require integration between the educational system and business organisations, which has not happened yet and may require substantial changes—societal changes—to implement. The consequent lack of modern tech-oriented leaders may hamper Ireland's transition to a knowledge-based economy.

One issue that kept coming up in the interviews conducted for this research is that there was not any real consensus on the very definition of a knowledge-based economy.

There did seem to be a certain amount of consensus on the definition of “advanced manufacturing”. It seemed to be agreed that the term referred to manufacturing, the processes of which were highly automated, but required a highly skilled human dimension. What was unclear was just what constituted a knowledge-based economy. Broadly speaking, a knowledge-based economy is one whose primary product is information. It also refers to the manufacture of information processing systems, such as computers and associated data processing and dissemination technology.

Information is quickly becoming the single most important and valuable commodity in the world. Many nations (such as Singapore) have strong economies based almost solely on information processing, technology, and trading. Other nations are in a state of transition. One example of this is the United States, where heavy manufacturing is slowly dying out and the country is a world leader in information technology. The experience of the United States, though, has shown that such transitions occur with political upheaval. The current leadership US President, Donald Trump, campaigned on a promise to reinstate the prominence of low tech manufacturing as an integral part of its political platform—despite the social costs associated with low tech manufacturing and raw materials extraction, such as labour issues, pollution, and resource allocation crises. Ireland is not in that position politically or socially, but the danger exists that many stakeholders in Ireland will think that transitioning to a knowledge-based economy means eliminating the manufacturing sector or at least diminishing its importance. This does not have to happen, and it would not be beneficial if it did.

Therefore, the focus of a knowledge-based economy must be on changing from a “siloeed” economy (where providers that provide the components of a manufactured or otherwise produced good are separately owned and sometimes, geographically dispersed entities) to a “symbiotic” economy. The latter term, borrowed from biology, refers to separate

organisms that are closely joined together and work for each other's benefit. This is actually not a new concept; it has been implemented for over a century. For example, in Detroit in the United States, auto manufacturers were in close physical proximity to tyre manufacturers, steel mills, textile mills, plastics manufacturers, large skilled populations, and a robust transportation infrastructure—from virtually the inception of the auto industry in the early 20th century. In the Soviet Union in the mid-20th century, heavy manufacturing was placed in direct proximity to resources such as coal mines and navigable rivers. In more modern times, Japan, China, Taiwan, and the United States have located information technology concerns near one another in “clusters,” such as the famous Silicon Valley near San Jose, California.

The benefits of symbiotic clustering are manifest. These include efficiency, lower costs (among other factors, not having to transport components from widely dispersed areas for assembly) and attracting a skilled workforce. The universities in the area around Silicon Valley have been a major source of the skilled workforce needed to staff these information technology clusters. These clusters are also found in the technology sectors of the nations mentioned above, and many others. It seems manifest that symbiotic clustering works well in an information-based economy. Therefore, one conclusion that can be drawn from this study and the attendant review of the literature is that Ireland should adopt such an approach.

The implementation of a symbiotic clustered approach—or rather, the change from a siloed information/manufacturing economy—would be relatively easy for Ireland. The nation is relatively small with a modern transportation infrastructure. The workforce is capable and with one of the highest levels of third level participation in the world (second highest of the 22 EU countries at 43% participation). There is the caveat mentioned by several of the research interviewees that the workforce needs to be educated earlier in primary and secondary school in general skills such as innovation and entrepreneurial skills as well as a firm foundation in the STEM subjects and then continually retrained in the particular skills

needed to succeed in a career in a knowledge-based economy. The main issue, then, is forming a political and societal consensus.

These last points in the report are particularly noteworthy from the perspective of this study. Many of the traits of the Irish people mentioned above, such as an egalitarian mindset and a belief in the worth of the individual, are valuable for the establishment of a KBE. Others, however, such as a tendency toward risk avoidance and a focus on the short term at the expense of the long term, are not.

It is not realistic to expect that the Irish people can be moulded into an ambitious nation full of entrepreneurs overnight. However, as the study participants expressed numerous times, there is a need for an entrepreneurial mindset (risk-taking; long-term goals) to be taught in Irish universities, both explicitly and implicitly.

The Formulation-Practice Gap

The report above as well as several mentions by the study participants seem to indicate that the Irish government has not been lax in its role as a policy creator. The mechanisms for introducing a KBE into Ireland exist and are robust. Several participants expressed frustration, however, that existing good policy had not been implemented, or had not been fully put in place.

Reasons for that deficiency that were stated include conservatism on the part of Irish politicians, a conservative mindset in the manufacturing sector, and reluctance on the part of stakeholders to engage in or support activities that might cause them to lose competitive advantage and/or market share. This last point is crucial. The executives interviewed were all employed in the advanced manufacturing industry or sectors that support it. Therefore, they might all be negatively affected by any transition from advanced manufacturing to a KBE. Yet, virtually all of them supported such a transition, if for no other reason than it was inevitable and necessary.

The Irish government evidently recognises that as well. The question becomes, then, how to make sure that KBE growth policy is implemented. Ireland is a democracy and not all participants believe in the need for a KBE. Trade protectionist thought impedes the formation of trade links with the rest of Europe and the world. Fear of the effects of over-specialisation permeate the national dialogue. Memories linger of previous times of turmoil and unrest when trade relationships have been cut off. This last is a non-trivial consideration, as Ireland must trade to survive, and any sector, such as advanced manufacturing, in which investment is reduced in favour of something else (such as a KBE) creates a vulnerability.

For example, Bailey and Lenihan (2015) were highly critical of government policy that encouraged outside direct investment in Ireland. They expressed an opinion that such a policy led to a loss of autonomy and an increased vulnerability to outside events and forces. While their viewpoint has validity, it is in opposition to the need to create a KBE that is integrated with the European economy. Ireland is an island, but its economy cannot be figuratively or literally insular.

Weiss (2015) presented a paper in which he stated that Europe's economy was in its third post-war phase. In this phase, the key commodity, he stated, was innovation. He mentioned the Irish economy as one wherein Irish industrial policy had been oriented in that direction. As in Europe overall, high-income economies trade primarily in information rather than goods (Weiss, 2015). Therefore, Irish industrial policy should continue to be oriented in that direction: the production of knowledge and innovation rather than that of manufactured goods.

This need was mentioned by Walsh (2009; 2014) in his discussion of where Ireland's educational sector needed to be oriented for the nation's future competitiveness in world markets. He mentioned the same problems as some of the participants in this study: lack of entrepreneurial drive, a risk-avoidant mindset, and overall conservatism. Also, in the few

years since Walsh's report, there have been political/economic upheavals in Europe and the world which might reinforce the attitude toward conservatism.

The conclusion that can be drawn is that there are not so much tangible obstacles to the establishment of a KBE in Ireland as there are failures of will and belief. Not everyone, it seems, is comfortable with or welcoming of the transition of Ireland to a KBE. That necessarily impacts policy in a nation that is democratic and pluralistic. The public must believe in and agree to policy initiatives, even if the government has the nominal power to enforce such initiatives without that agreement, if the implementation of a KBE is to be successful.

Clustering and Symbiosis

Before proceeding further with this discussion, it is important to differentiate between these two terms. Clustering is a situation wherein many businesses (and associated other entities) are in the same geographical location, whether by accident or design. This happens because these concerns serve one another's needs. This effect has been seen in the growth of cities throughout history, in that those who produce goods to sell are best placed in close physical proximity to the raw materials they need and the customer to whom they will sell finished goods. This is also true of companies that manufacture components to be used in other firms' products, such as tyre companies for auto manufacturers, or chip makers for computer manufacturers.

Symbiosis, by contrast, is a much closer physical and objective collaboration. With symbiosis, the two concerns are coexisting as one, though with separate identities. The idea, as in biological symbiosis, is that each benefits the other through mutual cooperation. An example of this is what is sometimes called vertical integration, wherein a company operates several relatively autonomous divisions that are each responsible for one aspect of the

producer-to-market supply chain. Oil companies are known for this, where exploration, development, extraction, refining, transportation of the product, marketing, and retail are usually handled by divisions of the same company.

The philosophical approach is that to be optimally successful in creating a knowledge-based, tech-intensive economy, Ireland's business and education sectors must be at the very least, clustered; it might be best if they were symbiotic. This is perhaps impractical at present, as symbiosis implies a degree of cooperation not seen so far in Ireland's business sector. Also, questions of autonomy and ownership arise. Symbiosis best occurs when all the symbiotic entities are under the same ownership. However, we do have modern examples in the planned economies of socialist states—and those results have not been good overall, historically. The efficiencies granted when one entity—the state, in this case—owns and operates all sectors of business seem to be negated by the attendant absence of entrepreneurship and innovation.

Therefore, symbiosis could best occur when the symbiotic relationship is undertaken voluntarily and with the goal of increasing efficiency and competitiveness, not as part of a broader government ideological initiative. There is ample incentive for companies to form such relationships, even with any attendant loss of autonomy. Certainly, co-locating related businesses has been shown to be effective and efficient in setting around the world.

Education

While educating the future workforce was not directly a topic for discussion in this study, several participants discussed it in some depth and almost all mentioned it. They seemed to feel that Ireland's educational system was lacking in instilling the skills in students that future business leaders would need. Many respondents mentioned their perceived lack of an entrepreneurial culture among the Irish people, which presumably, they considered to be important and saw as lacking. While there was no consensus on this or any other aspect of

educational needs, it was a recurring topic that there needs to be a shift in the approach that the system uses in order to provide good managerial material for future needs. The implication in those recommendations was that such needs were not presently being accounted for.

The concept of symbiosis was not directly mentioned by respondents. There is no such direct collaboration between the manufacturing, information technology, and educational sectors of Irish society. One could easily imagine, though, such a thing as a technical institution that was in close cooperation with either of the other two sectors and had as its avowed aim to produce managers for those sectors. Such a symbiosis exists in a *de facto* way in the nations mentioned above, where higher education, advanced manufacturing, and information technology are co-located, if not on the same campus or property, at least in very close proximity to one another. The phenomenon of “tech cities” or areas such as Silicon Valley is well known. There is no reason why Ireland should not aspire to creating a similar impact.

The benefits of symbiosis and/or clustering are manifest in the educational sector. The concept of a university is that it is a symbiotic group of colleges. Also, in a university’s interaction with the “outside” world, many of the most successful, popular, and prestigious universities are located in close physical proximity to the business entities that will employ their graduates. Many graduates of such universities come from afar, become enamored of the area, and are happy to find employment there. Thus, the university and the businesses that employ its graduates are in a situation of collaboration and mutual benefit.

In Ireland, most of the major businesses, manufacturing, and institutions of higher education are located in or near Dublin. Dublin is nearly five times as large as Cork. Thus, there are limited locations to build new facilities where such facilities would have the infrastructure support that they need. Both businesses and schools tend to locate in or near

Dublin because that is where the people are. Also, as far as educational institutions are concerned, Dublin has historically and culturally been Ireland's center of learning.

What this means is that Ireland is a nation that has one primary city, also known as a primate city. Such cities are the financial, political, and population centers of their countries, often disproportionately so. The condition leads to the concentration of wealth, power, and learning in those cities, often to the detriment of the outlying areas. Ireland is certainly not the only country with a primate city—England and France come to mind, as does Thailand, a country whose largest city, Bangkok, is over forty times the size of the next largest city.

So, the question is: must the development of a clustered high-tech economy take place in Dublin, or can that happen elsewhere? Building advanced manufacturing, technical schools and universities, and tech companies in or near other smaller cities such as Cork or Galway might be somewhat easier, if for no other reason than land would be cheaper and easier to obtain there. However, that consideration would have to be balanced against the fact that most of the country's resources (especially, financial resources) are controlled by entities (government and private) located in Dublin. Thus, there might not be the political will to build knowledge-based economy clusters, companies and infrastructure elsewhere.

Development

The practical side of the knowledge-based economy transition question is: what would it cost? How much effort would it take, and how much disruption would it cause? These are not trivial considerations. Though it might seem manifest that such a transition would ultimately be of great benefit to Ireland, it remains a truism that in economic transitions, there are always winners and losers. Those who perceive themselves as potential losers will be resistant to those changes.

One somewhat limiting aspect of this study was that it focused on the perceptions of a particular class of stakeholders: managers and CEOs of advanced manufacturing firms. No other types of stakeholders—for instance, managers and CEOs of tech companies, or administrators of higher education institutions—were interviewed. The reason this was limiting is that as noted above, transition economies create winners and losers—and if Ireland does transition to a knowledge-based economy, the manufacturing sector (advanced and otherwise) may suffer as a consequence. So, the perspectives of those who were interviewed may have been skewed somewhat. However, no participant was overtly hostile to the implementation of a knowledge-based economy in Ireland. Of course, they may not have seen such an economy as necessarily supplanting advanced manufacturing.

This researcher's overall recommendation is that "tech enterprise zones" be created in Ireland. Such zones could feature related and mutually supporting high-tech and advanced manufacturing concerns in close (clustered) or even symbiotic location. Crucially, such zones could also include higher education institutions. Academia, in Ireland as well as the rest of the world, tends to be somewhat insulated from the outside world. Locating a tech-oriented university within a tech cluster zone is an exciting idea, the implementation of which could alter the way that learning, and business are intertwined, addressing the problem articulated by the study's participants.

Implementation

It is a fact of life that initiatives that would benefit society have to be "sold" politically. If Ireland is to transition to a knowledge-based economy, the political will to do so must exist. As mentioned above, there are stakeholders who will be fearful of such changes. This includes those who feel that if Ireland opts to produce knowledge instead of tangible primary and secondary goods, then it might be exposed to international trade and other crises, making the country not self-sufficient.

This fear is driving decisions made by other advanced democracies throughout the world. Japan engages in trade protectionism to supposedly preserve its domestic industries; it buys very little rice and very few automobiles from the United States, for example, even though those goods would be cheaper if purchased from the U.S. than produced domestically.

Ireland must not succumb to that fear. The fact of the matter is that very few countries in the world are self-sufficient, and therefore “protecting” inefficient industries by erecting trade barriers is pointless. Ireland may be ideally placed to become a world information technology center. Its manufacturing base has shifted to pharmaceuticals and electronics—two areas that are not resource- or energy-intensive. These sectors can and should be “married” to the information technology sector.

Comparative Advantage

The Law of Comparative Advantage, first articulated by British economist David Ricardo in 1817 and based on the economic theories of Adam Smith, states that a country should focus on producing those goods in which it has a comparative advantage. Furthermore, if it has a comparative advantage in more than one good, it should still focus on the one wherein the advantage is greater and trade that good for the other. This concept is well validated in practice but, due to its counterintuitive nature, is still not accepted by all, including world governments. It seems intuitive to think that if Country A makes Good X and Good Y better and more cheaply than Country B, then it should not trade at all with Country B and will be losing out if it does. The Law of Comparative Advantage, though, states that Country A should trade Good X (its best product) for whatever Country B makes best, even if that good is Good Y. For example, the United States makes computers and grows fruit, in each case better and cheaper than Mexico. But its comparative advantage in fruit production is small, while its comparative advantage in computer manufacture is large, so the U.S. sells computers to and buys fruit from Mexico.

Ireland might benefit from this perspective. If the Irish economy is uniquely positioned to transition to knowledge-based, then it should do so by concentrating on those sectors where it has a comparative advantage. Those sectors include high-tech and pharmaceuticals, categories wherein Ireland is amongst the world's leader in exports. Ireland cannot be self-sufficient in the majority of our needs and should not try. Rather, Ireland should do what it does best and trade with the world for the goods for which other nations have a comparative advantage.

There are political and ideological problems with getting people to accept the fundamental premise of comparative advantage. However, Ireland cannot make everything that it needs. Ireland should build and trust robust trade relationships with Europe and the rest of the world, particularly in light of the impending potential exit by the United Kingdom from the European Union. Irish goods already have a strong reputation, and economic stakeholders, businesses and policy planners should build on that.

Thus, the implementation of a knowledge-based economy, it seems to this researcher, is more an issue of educating the public, stakeholders, and policymakers on why it is important to do so and the many benefits to be gained than it is a matter of marshalling resources; those resources already exist and are available. Ireland should focus what it does best, which it does very well indeed. This can be abetted by the creation of high-tech symbiotic industries in close collaboration with educational institutions. The participants in this study all viewed the transition of Ireland's economy to knowledge-based as both necessary and inevitable. The only issue, then, is convincing the public and politicians of that.

Chapter 8: Conclusions and Recommendations

This study featured several interesting findings. One such finding was that the managers, CEOs, company founders and policy makers who were interviewed viewed the transition of the Irish economy to a knowledge-based focus as both a necessity and inevitable. This was despite the fact, hinted at by a few respondents, that such a transition might result in funding and development being shifted away from the advanced manufacturing sector, which would directly affect their own interests. Thus, these managers were showing a degree of pragmatism.

That pragmatism should be the watchword of Irish economic planners. Ireland is not a large nation. Therefore, it cannot compete directly with China, the United States, Germany, etc. when it comes to general manufacturing. What it can do is concentrate on a few sectors in which it excels. It was noted in the previous chapter that these currently include pharmaceuticals and information technology. While the former perhaps cannot be adapted to an information-based economy (to any greater extent than it already is), the latter certainly can. Presently, much of Ireland's information technology sector is concentrated in component manufacture, such as computer chips by Intel. A knowledge-based economy could handle all of the components of information processing—hardware, software, data processing and cloud integration and storage. Also, in the symbiotic approach noted in the previous chapter, it would involve close cooperation with Irish universities and technical colleges in order to produce the workforce that would be needed and present them with job opportunities to avoid any prospect of “brain drain.”

How can this best be done? This study did not uncover much specific information about how the transition might be made; rather, information was found about what was inhibiting it so far. Revisiting the distillation of participants' responses in Chapter 6, it was found that Ireland should:

- Locate skilled technical labourers, from within or outside the country. This can be done with intensive recruitment efforts, both domestic and foreign. A major aspect of this is creating a cultural environment wherein Ireland is, and is perceived by its citizens and the world, as a sophisticated tech centre
- Foster entrepreneurship: this is a matter of mindset. The government should introduce tax policies and other incentives meant to foster business growth
- Expand education in innovation; this is related to entrepreneurship. Funding should be available for research and development, and R&D should be a major department of all new and existing manufacturing and knowledge-based firms
- Focus on the accumulation of human capital; this means that Irish universities must turn out more graduates who are ready to be workers and managers in a knowledge-based economy
- Concentrate on the sectors in which it operates best; this was discussed above, as in pharmaceuticals, bio-medical devices, computer hardware and software, advanced manufacturing, and eventually, information technology and cloud integration
- Create policies and an infrastructure that facilitates the growth of local supply chains

These were the inhibiting factors noted by participants, along with some suggestions to overcome them

- Cultural factors: this is difficult to quantify and thus, difficult to address. Ireland's population must believe in itself and the nation's ability to be a world leader in the sectors chosen. There are many examples of nations that lack natural resources or large land areas but have become rich through

information exchange and trading. The Irish people, government, and stakeholders must be convinced that Ireland can follow these examples.

- A lack of an entrepreneurial spirit: This is related to the above point. If such a lack exists (and no effort was made to verify that), it can be addressed through education, particularly in symbiosis with advanced technological firms.
- A lack of specific education and skills tailored to the needs of a KBE: this can be addressed over time by the expansion of existing higher education facilities and the building of new ones
- A lack of skilled workers: The EU as well as Ireland should be sources for the best workers, who can be attracted by a favourable work climate, high wages, and a welcoming atmosphere.
- Failures of policy in anticipating future needs. This is more related to culture than anything else, as Ireland's leaders need to share a vision that is akin to the "Celtic Tiger" platform of the 1990s. There is no reason to believe that that era of explosive growth cannot be repeated.
- A Formulation – Practice gap in the implementation of policy, which can lead to good policy documentation not being implemented correctly due to political and vested interest inference

Finally, some recommendations for future studies are in order. This study employed a homogenous population; they were from one business sector and all played similar roles. It would be very useful to interview leaders of tech companies, leaders of universities, and government leaders about Ireland's potential transition to a knowledge-based economy. It would also be useful to obtain the "average" person's perspective in the issue: does Ireland need to become a technologically driven economy and society? This question could be answered by designing an appropriate survey and performing quantitative research.

To conclude, Ireland's transition to a knowledge-based economy, as the participants in the study noted, is both necessary and inevitable, and will be extremely beneficial to the country's economy, culture, and standing in the world. The only real issue, then, is how to bring that transition about. This and future related studies can help with that understanding.

References

- Al-Busaidi, K. A. (2014). Linking ICT to the Development of Knowledge-Based Economy Pillars. *Proceedings of The European Conference on Knowledge Management*, 115.
- Al-Roubaie, A., & Alvi, S. (2014). Knowledge transfer for sustainable development: East-West collaboration? *World Journal of Science, Technology and Sustainable Development*, 11(4), 242.
- Ayaydin, H. & Karaaslan, I. (2014). The effect of research and development investment on firms' financial performance: evidence from manufacturing firms in Turkey. *Journal of Knowledge Economy & Knowledge Management*, 9(2), 43-59.
- Bailey, D., & Lenihan, H. (2015). A Critical Reflection on Irish Industrial Policy: A Strategic Choice Approach. *International Journal of The Economics of Business*, 22(1), 47-71.
- Barry F. (2000), Foreign Direct Investment, Cost Competitiveness and the Transformation of the Irish Economy, *Development Southern Africa*, 17, (3), 2000, p289 – 305
- Barry, F. (2011). Foreign investment and the politics of export profits tax relief, 1956, *Irish Economic and Social History*, 38, 2011, p54-73
- Barry, F. (2013). *The Knowledge Economy, Economic Transformations and ICT: Regional Dynamics in the Deployment Phase. Case study: Southern and Eastern Ireland* (No. JRC83549). Institute for Prospective and Technological Studies, Joint Research Centre.
- Bedford, D., & Wiley, J. (2016). The Media's Representation of the Knowledge Economy. *Proceedings of The International Conference On Intellectual Capital, Knowledge Management & Organizational Learning*, 45-55.
- Bedford, D., Carlson, P., & Wagner, C. (2015). Intellectual Capital Thresholds and the Maturity of Knowledge Cities. *Proceedings of The European Conference On Intellectual Capital*, 7-15.
- Bell, D. (1973). *The coming of post-industrial society: a venture in social forecasting*. New York, NY: Basic Books.
- Born, R., & Guo, Y. (2016). Measuring Innovation. *CESIFO Group DICE Report*, 14(3), 72-74.
- Brady, A. M. (2016). The Regime of Self-Evaluation: Self-Conception for Teachers and Schools. *British Journal Of Educational Studies*, 64(4), 523-541.

- Brady, G., Doyle, E., & Noonan, L. (2013). Trade Sophistication Indicators: Balancing Diversity and Specialization. *International Advances in Economic Research*, 19(4), 425-438.
- Cohen, S. S., & Zysman, J. (1987). Why manufacturing matters: the myth of the post-industrial economy. *California Management Review*, 299-26.
- Contantin, B., & Florina, P. (2015). Challenges for the University Intellectual Capital in the Knowledge Economy. *Management Dynamics in The Knowledge Economy*, Vol 3, Iss 4, Pp 609-627 (2015), (4), 609.
- Ceptureanu, S. I. (2014). Knowledge based economy in Romania: comparative approach. *Journal of Applied Quantitative Methods*, 9(4), 51-61.
- Chang, H. (2004). Regulation of Foreign Investment in Historical Perspective. *European Journal of Development Research*, 16(3), 687-715.
- Chen, S. (n.d). The Confluence of Academia and Industry: A Case Study of the Taiwanese Biopharmaceutical Innovation System. *Review of Policy Research*, 31(5), 408-429.
- Chidambaram, R. (2014). To become a knowledge economy. *Current Science (00113891)*, 106(7), 936-941.
- Christinidis, G., & Ellis, H. (2013). Knowledge, Education, and Citizenship in a Pre- and Post-National Age. *Journal of The Knowledge Economy*, 4(1), 63-82.
- CM International. (2012) Maximising the Commercial and Economic Impact of the Northern Ireland Publicly Funded Research Base. A report from CM International for Invest Northern Ireland.
- Cooke, P., & Leydesdorff, L. (2006). Regional Development in the Knowledge-based Economy: The Construction of Advantage. *Journal of Technology Transfer*, 31(1), 5-15.
- Department of Jobs, Enterprise, and Innovation (DJEI) (2012). Report of the Research Prioritisation Steering Group. Forfás, Ireland. <https://www.djei.ie/en/What-We-Do/Innovation-Research-Development/Research-Prioritisation>
- Department of Jobs, Enterprise, and Innovation (DJEI) (2013): Ireland playing its part in meeting EU targets for high value jobs - Minister Sherlock. Irish Presidency Conference on Researcher Careers and Mobility.
- Department of Jobs, Enterprise, and Innovation (DJEI) (2015). *Enterprise 2025: Ireland's National Enterprise Policy 2015-2025*.

<https://www.djei.ie/en/Publications/Publication-files/Enterprise-2025-Background-Report.pdf>

- Department of Trade and Enterprise (1984). White Paper on Industrial Policy. Ireland: The Stationery Office
- du Feu, P.H. (1988). A guide to advanced manufacturing in electronics, London: P. Peregrinus
- Durkan, J. (2010). Fiscal Policy: Some Lessons from Crises of the Past. *Budget Perspectives 2011*, 18.
- Durkan, J. (2010). Seán Lemass and the Nadir of Protectionism. *Economic & Social Review*, 41(3), 269-282.
- Ejdys, J., Ustinovičius, L., & Stankevičienė, J. (2015). Innovative application of contemporary management methods in a knowledge-based economy–interdisciplinarity in science. *Journal of Business Economics and Management*, 16(1), 261-274.
- Elenurm, T., & Reino, A. (2013). Knowledge sharing challenges in developing early-stage entrepreneurship. Paper presented at the 211-218.
- Enright, S., & Dalton, M. (2014). The impact of the patent cliff on pharma-chem output in Ireland. *Journal of the Statistical and Social Inquiry Society of Ireland*, Xliii, 91-113.
- Ferriter, D. (2004). The Transformation of Ireland 1900-2000. London. UK: Profile Books Ltd
- Fontagné, L., Koenig, P., Mayneris, F., & Poncet, S. (2013). Cluster policies and firm selection: Evidence from France. *Journal of Regional Science*, 53(5), 897-922.
- Forfás. (2013). Making it in Ireland: Manufacturing 2020. Retrieved from: <https://www.djei.ie/en/Publications/Publication-files/Forfás/Making-it-in-Ireland-Manufacturing-2020.pdf>
- Fucec, A. A., & Marinescu, C. (2013). Cluster Analysis of the European Countries: The Europe 2020 Point of View. Proceedings of The International Conference on Intellectual Capital, Knowledge Management & Organizational Learning, 507-513.
- Griffith, R., Redding, S., & Simpson, H. (2004). Foreign Ownership and Productivity: New Evidence from the Service Sector and the R&D Lab. *Oxford Review of Economic Policy*, 20(3), 440-456.

- Grimes, S., & Collins, P. (2003). Building a knowledge economy in Ireland Through European research networks. *European Planning Studies*, 11(4), 395.
- Groover, M.P. (2007). *Fundamentals of Modern Manufacturing: Materials, Processes, and Systems*, 4th ed. New Jersey: John Wiley & Sons.
- Guinnane, T. W. (2015). *The vanishing Irish: households, migration, and the rural economy in Ireland, 1850-1914*. Princeton University Press.
- Hansen, T., Winther, L. & Hansen, R. (2014). Human Capital in Low-Tech Manufacturing: The Geography of the Knowledge Economy in Denmark. *European Planning Studies*, 22(8), 1693-1710.
- Haskel, J. (2007). "Measuring innovation and productivity in a knowledge-based service economy." *Economic and Labour Market Review* 1(7): 27.
- Hatch, C. J. (2014). Geographies of Production: The Institutional Foundations of a Design-Intensive Manufacturing Strategy. *Geography Compass*, 8(9), 677-689.
- Haugh, D. (2013). *From bricks to brains: Increasing the contribution of knowledge-based capital to growth in Ireland*. Paris: Organisation for Economic Cooperation and Development (OECD).
- Hazelkorn, E., & Massaro, V. (2011). A tale of two strategies: higher education and economic recovery in Ireland and Australia. *Higher Education Management & Policy*, 23(2), 79-102.
- High Level Expert Group on Key Enabling Technologies (2011). *Preparing for our future: Developing a common strategy for key enabling technologies in the EU*. COM (2009) 512, Brussels.
- Hunjet, A., Kozina, G., & Mulovic, A. (2014). The role of knowledge in resolving contemporary economic problems. *Economic and Social Development: Book of Proceedings*; Varazdin: 231-240. Varazdin: Varazdin Development and Entrepreneurship Agency (VADEA).
- Hvidt, M. (2015). The State and the Knowledge Economy in the Gulf: Structural and Motivational Challenges. *Muslim World*, 105(1), 24-45.
- Ibnouf, A., Dou, L., & Knight, J. (2014). The evolution of Qatar as an education hub: Moving to a knowledge-based economy. In *International Education Hubs* (pp. 43-61). Springer Netherlands.

- Ilinskaya, E. M. (2016). The influence of the cluster economy on accelerating the generation and transfer of innovations. *St. Petersburg State Polytechnical University Journal. Economics*, (1).
- Indergaard, M. (2015). Detroit's Regional Question. *City & Community*, 14(2), 138-150.
- Industrial Policy Review Group (IPRG) (1992). A Time for change: industrial policy for the 1990s: report of the Industrial Policy Review Group. The Stationery Office
- Iversen, T., & Soskice, D. (2015). Democratic limits to redistribution: inclusionary versus exclusionary coalitions in the knowledge economy. *World Politics*, 67(02), 185-225.
- Jacob, M. C. (2014). *The first knowledge economy: human capital and the European economy, 1750–1850*. Cambridge University Press.
- Jalaei, S. A., & Samimi, S. (2014). The role of knowledge-based economics in improving competitive advantage with an entrepreneurial approach. *Kuwait Chapter of the Arabian Journal of Business and Management Review*, 3(12), 204-215.
- James, L., Guile, D., & Unwin, L. (2013). Learning and innovation in the knowledge-based economy: beyond clusters and qualifications. *Journal of Education and Work*, 26(3), 243-266.
- Jurigová, Z., & Tucková, Z. (2016). Sustainable tourism in a knowledge-based economy. Paper presented European Conference on Knowledge Management; Kidmore End: 1038-1046.
- Kanagatova, A., Nuketayeva, D., & Suleimenova, Z. (2014). Public challenges in creating an intellectual nation in Kazakhstan. Paper presented at the International Conference on Intellectual Capital and Knowledge Management and Organisational Learning; Kidmore End: 259-267
- Karna, A., Täube, F., & Sonderegger, P. (2013). Evolution of innovation networks across geographical and organisational boundaries: a study of R&D subsidiaries in the Bangalore IT cluster. *European Management Review*, 10(4), 211-226.
- Karwowski, W & Salvendy, G. (1994). Organization and management of advanced manufacturing, New York: John Wiley & Sons.
- Kaynak, S. & Yilmaz, M. (2016) Bilgi Ve İletişim Teknolojilerini Kullanma Düzeyi İle Firma Performansı Arasındaki İlişki: İmalat Sektöründe Bir Uygulama. *Dokuz Eylül University Journal of Graduate School of Social Sciences*, 18(4), 655-676.

- Keatinge, P. (1998). Ireland and European security: continuity and change. *Irish Studies in International Affairs*, 9, 31-37.
- Ken, S. (2013). History is a Key Decoder: Why China Aims at Re-emerging as a Global Leader of Innovation. *Law in Context*, 29(1), 117-132.
- Kennedy, K. (1982). The Design of a new Industrial Strategy. The Economic and Social Research Institute.
- Khadir-Poggi, Y., & Keating, M. (2014). An empirical study of knowledge management practices in small asset management firms based in Ireland. 2, 539-546.
- Khan, Z., Shenkar, O., & Lew, Y. K. (2015). Knowledge transfer from international joint ventures to local suppliers in a developing economy. *Journal of International Business Studies*, 46(6), 656-675.
- Klimova, N., Kozyrev, O., & Babkin, E. (2016). Introduction. In *Innovation in Clusters* (pp. 1-3). Springer International Publishing.
- Kuusisto, J. and M. Meyer (2003). "Insights into services and innovation in the knowledge intensive economy." *Technology Review* 134: 2003.
- Le Dinh, T., Rickenberg, T. A., Fill, H., & Breitner, M. H. (2015). Enterprise content management systems as a knowledge infrastructure: The knowledge-based content management framework. *International Journal of E-Collaboration*, 11(3), 49.
- Lee, J.J. (1990). Ireland 1912-1985: Politics and Society. Cambridge. UK: Cambridge University Press
- Leydesdorff, L. (2013). Triple Helix of university-industry-government relations. In *Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship* (pp. 1844-1851). Springer New York.
- Leydesdorff, L., Perevodchikov, E., & Uvarov, A. (2015). Measuring triple-helix synergy in the Russian innovation systems at regional, provincial, and national levels. *Journal of The Association for Information Science & Technology*, 66(6).
- Leydesdorff, L., & Strand, Ø. (2013). The Swedish system of innovation: Regional synergies in a knowledge-based economy. *Journal of the Association for Information Science and Technology*, 64(9), 1890-1902.
- Leydesdorff, L., & Zhou, P. (2014). Measuring the knowledge-based economy of China in terms of synergy among technological, organisational, and geographic attributes of firms. *Scientometrics*, 98(3), 1703-1719.

- Lianhe, G., & Qian, D. (2014). Local financial innovation, industrial cluster financial generation and fiscal-taxation support. *Journal of Social Sciences*, 2014-02
- Lolich, L., & Lynch, K. (2016). The affective imaginary: students as affective consumers of risk. *Higher Education Research & Development*, 35(1), 17-30.
- Love, G. (2011). Ireland: a strong knowledge economy. *Nature*, 477(7366), 538.
- Low, S., Tee, L., Kew, S., & Ghazali, N. A. (2015). The link between financial development and knowledge-based economy - evidence from emerging markets. *Journal of Economic Cooperation & Development*, 36(1), 51-82, 84, 86-91.
- Lyons, R., & Alshibani, S. (2015). Entrepreneurship education: A tale of two countries. Paper presented at the 1-9.
- Mac Sharry, R., White, P., O'Malley, J (2000). *The Making of the Celtic Tiger: The Inside Story of Ireland's Boom Economy*. Mercier Press
- Madanipour, A. (2011). *Knowledge economy and the city: Spaces of knowledge*. Regional Studies Association. London, UK: Routledge Publishing.
- Madrak-Grochowska, M. (2013). Competitiveness of knowledge-based economies: Suggestion for measuring. *Ekonomia I Prawo (Economics and Law)*, 12(3), 357-370.
- Madrak-Grochowska, M. (2015). The knowledge-based economy as a stage in the development of the economy. *Oeconomia Copernicana*, 6(2), 7-21.
- Madrak-Grochowska, M. (2016). The information infrastructure of knowledge-based economies in the years 1995-2010. *Ekonomia i Prawo, (Economics and Law)*, 15(4), 503-513.
- Martín-de Castro, G. (2015). Knowledge management and innovation in knowledge-based and high-tech industrial markets: The role of openness and absorptive capacity. *Industrial Marketing Management*, 47, 143-146.
- Matevosyan, N. R. (2015). Ethical vignettes and knowledge economy: Priorities and sequelae in reproductive health. *Journal of the Knowledge Economy*, 6(4), 704-716.
- McLoughlin, R.J. (1972). *Administration Journal*, Spring 1972, Vol. 20, No.1. Institute of Public Administration of Ireland.
- Meenan, J.F. (1972). *The Irish Economy since 1922*. Liverpool University Press, 142.

- Melnikas, B. (2012). Intellectual economics and creation of a knowledge-based society and knowledge economy: New challenges in the context of global transformations. *Intelektine Ekonomika*, 6(1).
- Melnikas, B. (2013). Intellectual society, knowledge economy and cohesion processes in the European union: New challenges and priorities. *Intelektine Ekonomika*, 7(1).
- Miller, K., Moffett, S., McAdam, R., & Brennan, M. (2013). Intellectual capital: A valuable resource for university technology commercialisation? Paper presented at the 429-437.
- Morel, N. (2015). Servants for the knowledge-based economy? The political economy of domestic services in Europe. *Social Politics: International Studies in Gender, State & Society*, 22(2), 170-192.
- Moshkov, A. A., Zherebov, E. D., & Zdol'nikova, S. V. (2016). Methods and approaches of forming the state industrial policy. *St. Petersburg State Polytechnical University Journal. Economics*, (1).
- Mrinalini, N., Nath, P., & Sandhya, G. D. (2013). Foreign direct investment in R&D in India. *Current Science*, 767-773.
- Mungaray-Moctezuma, A., Perez-Nuñez, S. M., & Lopez-Leyva, S. (2015). Knowledge-based economy in Argentina, costa Rica and Mexico: A comparative analysis from the bio-economy perspective. *Management Dynamics in the Knowledge Economy*, 3(2), 213-236.
- Muthusamy, S., & Dass, P. (2014). Toward a smarter enterprise. *Competitiveness Review*, 24(3), 211-239.
- Naghavi, M., & Walsh, D. (2011). Research funding: Learn from Ireland's knowledge economy. *Nature*, 476(7361), 399.
- National Economic and Social Council (NESC) (1982). A Review of Industrial Policy. Summary of a report prepared by the Telesis Consulting Group. No. 64, February 1982
- Nauwelaers, C., Maguire, K., & Marsan, G. A. (2013). The case of Ireland-Northern Ireland (United Kingdom) - regions and innovation: Collaborating across borders. Paris: Organisation for Economic Cooperation and Development (OECD).
- Neef, D (1999). A little knowledge is a dangerous thing: Understanding our global knowledge economy. Woburn, MA: Butterworth-Heinemann.

- OECD. Knowledge Economies: Trends and Features. (2013). Paris: Organisation for Economic Cooperation and Development (OECD).
- O'Gorman, C. (2015). The study of entrepreneurship in Ireland. *Irish Journal of Management*, 34(1), 7-21. doi:10.1515/ijm-2015-0003
- O'Shaughnessy, M., & O'Hara, P. (2016). Social enterprise in Ireland - why work integration social enterprises (WISEs) dominate the discourse. *Nonprofit Policy Forum*, 7(4), 461-485.
- Parker, R. (2007). Networked governance or just networks? Local governance of the knowledge economy in Limerick (Ireland) and Karlskrona (Sweden). *Political Studies*, 55(1), 113-132.
- Piekut, M. (2013). Comparison of R&D expenditures in selected countries. *Comparative Economic Research*, 16(3), 107-126.
- Popescu, G. H., Comănescu, M., & Sabie, O. M. (2016). The role of human capital in the knowledge-networked economy. *Psychosociological Issues in Human Resource Management*, 4(1), 168-174.
- Probert, J., Connell, D., & Mina, A. (2013). R&D service firms: The hidden engine of the high-tech economy? *Research Policy*, 42(6), 1274-1285.
- Qi, C., & Wei, L. (2014). Analysis on motivation and economic effect of establishing China (Shanghai) Pilot Free Trade Zone [J]. *Scientific Development*, 2.
- Riain, S. Ó. (2010). The Missing Customer and the Ever-Present Market: Software Developers and the Service Economy. *Work & Occupations*, 37(3), 320-348.
- Roper, S., Love, J. H., & Hígon, D. A. (2006). The determinants of export performance: Evidence for manufacturing plants in Ireland and Northern Ireland. *Scottish Journal of Political Economy*, 53(5), 586-615.
- Saldana, J. (2009). *The coding manual for qualitative researchers*. Los Angeles, CA: SAGE.
- Salem, M. I. (2014). The role of universities in building a knowledge-based economy in Saudi Arabia. *The International Business & Economics Research Journal (Online)*, 13(5), 1047-n/a.
- Samadi, S. (2016). A review of factors influencing the cost development of electricity generation technologies. *Energies (19961073)*, 9(11), 1-25.

- Satti Osman, M. N. (2014). Prospects for transition to a knowledge-based economy in the Arab region. *World Journal of Science, Technology and Sustainable Development*, 11(4), 256-270.
- Schumpeter, J. A. (1970). *Das Wesen des Geldes*. Vandenhoeck u. Ruprecht, 90.
- Sezonova, O. N., Galchenko, S. A., & Khodirevskaya, V. N. (2016). The efficiency of higher education institutions as a basis for forming competent personnel for region economy. *European Journal of Contemporary Education*, (4), 464-471.
- Shi, D., Li, X., & Wang, W. (2015). Influencing factors of knowledge dissemination in rural areas in china. *Nankai Business Review International*, 6(2), 128-155.
- Sinanovic, J., & Becirovic, S. (2016). The Determinants of Lifelong Learning. *European Researcher*, 103(2), 107-118.
- Sindakis, S., Depeige, A., & Anoyrkati, E. (2015). Customer-centered knowledge management: Challenges and implications for knowledge-based innovation in the public transport sector. *Journal of Knowledge Management*, 19(3), 559-578.
- Sledzik, K. (2013). Knowledge based economy in a neo-Schumpeterian point of view. *Equilibrium*, 8(4), 67-77.
- Spirkova, D., & Stehlikova, B. (2015). Employment analysis in technologically demanding branches in the EU countries at the level NUTS 2. Paper presented at the 305-313.
- Stewart, J. (2005). Capital in the new economy: A Schumpeterian perspective. *Entrepreneurship, the New Economy and Public Policy: Schumpeterian Perspectives*, 163.
- Stewart, J., & Tansley, C. (2002). *Training in the knowledge economy*. CIPD Publishing. X.
- Stough, R. R. (2015). Cluster life-cycles, entrepreneurship and regional economic development with a case study of the Korean shipbuilding cluster. In *Regional science matters* (pp. 223-254). Springer International Publishing.
- Suárez-Ortega, S. M., García-Cabrera, A. M., & Knight, G. A. (2016). Knowledge acquisition for SMEs first entering developing economies: Evidence from Senegal. *European Journal of Management and Business Economics*, 25(1), 22-35.
- Sum, N. L., & Jessop, B. (2013). Competitiveness, the knowledge-based economy and higher education. *Journal of the Knowledge Economy*, 4(1), 24-44.

- Sundac, D., & Krmpotic, I. F. (2011). Knowledge economy factors and the development of knowledge-based economy. *Croatian Economic Survey*, 13(1), 105-141.
- Sutton, A., Bosky, A., & Muller, C. (2016). Manufacturing Gender Inequality in the New Economy. *American Sociological Review*, 81(4), 720-748.
- Svarc, J., & Dabic, M. (2017). Evolution of the knowledge economy: A historical perspective with an application to the case of Europe. *Journal of the Knowledge Economy*, 8(1), 159-176.
- Tahrima, S., & Jaegal, D. (2013). Applicability of knowledge-based innovation system in Bangladesh. *International Review of Public Administration*, 18(3), 185-208.
- Talal Abu-Ghazaleh Organization (TAG-Org) (2016): Talal Abu-Ghazaleh Knowledge Forum's Launch Aims at Transforming Jordan into a "knowledge-based Society" by 2040. (2016). *MENA Report*.
- Tiuca, T., Rusu, C., Noveanu, S., & Mândru, D. (2015). Study of a General KBE Model for Mechanical Systems Analysis. *Scientific Bulletin Series C: Fascicle Mechanics, Tribology, Machine Manufacturing Technology*, 2015(29), 86-89.
- Tkachenko, E., Rogova, E., & Bodrunov, S. (2016). Regional models of the management of knowledge economy development: The problem of measurement and assessment. Paper presented at the 881-889.
- Tomasello, M. V., Perra, N., Tessone, C. J., Karsai, M., & Schweitzer, F. (2014). The role of endogenous and exogenous mechanisms in the formation of R&D networks. *Scientific Reports*, 4.
- Turkcan, B. (2015). Knowledge Externalities in Turkish High-Technology Manufacturing Industries: Spatial Panel Data Analyses. *Journal of Yasar University*, 10(40), 6711-6729.
- Turner, T., & D'Art, D. (2008). Is there a new knowledge economy in Ireland? An analysis of recent occupational trends. *International Journal Of Manpower*, 29(8), 700-714.
- Varblane, U., Mets, T., & Andrijevska, J. (2010). Knowledge-based entrepreneurship in Estonia. *CASE Network Studies and Analyses*, 407(1), 3-45.
- Veugelers, R. (2011). Assessing the potential for knowledge-based development in the transition countries of central and Eastern Europe, the Caucasus and central Asia. *Society and Economy*, 33(3), 475-504.

- Vikramchaudhary. (2014, Dec 08). Innovation is at the heart of Ireland's knowledge economy: Patrick O'Riordan. *Financial Express*.
- Vojislav Iliæ, V. N. (2014). *Assessing countries' readiness for developing knowledge-based economy*. St. Louis: Federal Reserve Bank of St Louis.
- Vorobeva, N. A., Island, R., & Region, P. (2014). Cluster policy in regional development of Japan. *Life Science Journal*, 11(12s).
- Walsh, J. (2009). The politics of expansion: The transformation of educational policy in the Republic of Ireland, 1957-1972. *Manchester University Press*, 182-194.
- Walsh, J. (2014). A contemporary history of Irish higher education, 1980–2011. In *Higher education in Ireland: Policies, practice and possibilities*, 33-55. Springer Publishing.
- Walsh, J., & Loxley, A. (2015). The Hunt Report and higher education policy in the Republic of Ireland: 'an international solution to an Irish problem?' *Studies in Higher Education*, 40(6), 1128-1145.
- Wegrzyn, G. (2013). The service sector of a knowledge-based economy - a comparative study. *Oeconomia Copernicana*, (1), 53-64.
- Weiss, J. (2015). Industrial Policy in High-Income Economies. by International Centre for Trade and Sustainable Development (ICTSD)
- Whitaker, T. K. (1960). Economic Development, 1958-1985. *Ireland in Transition: Economic and Social Change Since*, 10-19.
- Wiele, T. v. d., J. v. Iwaarden, et al. (2010). "Six Sigma implementation in Ireland: the role of multinational firms." International Journal of Quality & Reliability Management **Vol. 27 No. 9, 2010**: pp. 1054-1066.
- Wobbe, W., Charles, T. (1994). Human roles in advanced manufacturing technology. In *Organization and Management of Advanced Manufacturing*. New York, NY: John Wiley and Sons
- Woodward, R., Yörük, D. E., Koc, P., & Pander, W. (2010). Knowledge-based entrepreneurship in Poland. *CASE Network Studies and Analyses*, 408(1), 3-65.
- Yavaş, H. K. (2014). Bilgi Ekonomisi ve Türkiye. *TISK Academy*, 9(18), 48-73.
- Yin, R.K. (2009). *Case study research: Design and Methods* (4th ed. Vol 5). California: Sage Publications.