LUND UNIVERSITY
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A Decomposition of Ireland's Manufacturing Industry: Technological Change, Productivity Improvement and associated Regional Patterns (1991 – 2007)

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Abstract:

This thesis presents a decomposition of Ireland's manufacturing industry with respect to technological change, addressing productivity improvement and how these changes affect the regional system during transformation. This work is primarily based on the technology shift thesis, encompassing improvements in productivity arising from technological advancement and their associated divergence/convergence traits. Also of considerable importance, especially in Ireland's case is technology transfer through Foreign Direct Investment. Therefore, this consideration and its implications for technological and productivity change are addressed in depth.

This research found that structural change has and is occurring in Ireland's manufacturing industry, with higher technology industries coming to comprise greater proportions of the overall productivity over time. Divergence and convergence trends are also evident, with some regions at first seeing increases in productivity before others. FDI was found to play a very important role in Ireland's manufacturing productivity improvement, although the level of embeddedness, particularly in relation to some industry groups, could be questioned.

Key words: Technology Shift, Productivity, Industrial Development, Foreign Direct Investment, Technology Transfer, Ireland

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Section 1: Introduction

The geographical patterns associated with the technology shift thesis encompass inherent trends of divergence during transformation and convergence during rationalisation. These patterns arise from changes in technology and productivity, which affect elements of industry and the regional system at different stages and to varying extents (Schön, 2007; 2009; Lundquist *et al*., 2007; 2009 and Lundquist and Olander, 2010). The technology shift thesis will be discussed further in Section 2.

The purpose of this research is to consider the geographical component of the technology shift thesis for Ireland's manufacturing industrial development during the period 1991 – 2007, using a method closely related to that of Lundquist *et al*. (2007). The authors, with the backdrop of the technology shift thesis, indicate that there is a cyclical diffusion of technology effects taking place through Sweden's regions. This diffusion affects the regional hierarchy in a top-down manner in a divergence-convergence fashion, with an inherent time lag (Lundquist and Olander, 2010). They follow the current technology shift's "first investment cycle" through decomposing Swedish aggregated growth, with a focus on the manufacturing industry.

Drawing on this work, this thesis endeavours to bridge the gap in the literature regarding the regional patterns associated with the technology shift and productivity change over time in Ireland. This gap applies in particular to the manufacturing industry which is a key component of the technology shift (Lundquist *et al*., 2007). Therefore, the following research question is presented:

"*What are the technological and regional patterns associated with the changes in productivity in the manufacturing industry in Ireland during the period 1991 – 2007*?"

In order to answer this research question, a longitudinal decomposition and analysis of the manufacturing industry has been carried out. This involved decomposing industrial change through categorising manufacturing industries of similar technological characteristics and following their productivity change over time and across regions in Ireland. In this way, it was possible to see whether observable changes are comparable to those associated with the development of Sweden's manufacturing industry across its regional system. However, it is

important to bear in mind that Ireland has experienced "catch-up growth" (Ahearne, 2006; Begley *et al*., 2005; Barry, 2000; Lin *et al*., 2010, see further Sections 2 and 3) as the technology shift appears to have taken hold in Ireland at a later stage than it did in Sweden.

The technology shift thesis inherently focuses on endogenous development as this is the main consideration for the processes of creative destruction and transformation (see further Schön 2007; 2009, and Section 2). However, due to the open nature of Ireland's economy and the substantial level of Foreign Direct Investment (FDI) hosted by the country, it is impossible to consider a process of endogenous-led development in isolation. FDI is a great concern when it comes to Irish industrial development, as, since the late 1950s, Ireland has pursued an exogenous-oriented industrial policy. This has meant that FDI has come to be considered the "*bedrock of Irish industrial policy*" (Ó'Riain, 2004). Ó'Riain (2004) highlights that many have argued in favour of foreign firms, crediting them with contributing a large amount to productivity improvement in Irish industry.

Considering the overriding importance of FDI for Ireland, the focus of this thesis subsequently moved to the exogenous component of Ireland's industrial development, emphasising the theory of technology transfer through FDI (see further Florida, 1996; Buckley and Ruane, 2006; and Section 2). This involved analysing and comparing the levels of productivity arising from both the foreign-owned and indigenous elements of the manufacturing industry over the time period in question. In this way, the technology groups and/or regions with strong elements of FDI productivity were identifiable.

The "embeddedness" of foreign firms and/or multi-national corporations (MNCs) is also an important consideration for indigenous development. Embeddedness is loosely considered by many to be the integration of foreign firms into the indigenous structure, incorporating elements such as the transfer of knowledge, technology and best practice. Thus, the *relationship* between FDI and indigenous productivity was analysed as part of this research. The results from this analysis suggest the extent to which the foreign component of industry is embedded in Ireland's indigenous industrial structure at a national level, within technology groups and across regions.

The outcome of this research brings with it many benefits. Ó'Riain (2004) points out how industrial development was crucial to the growth of the Irish economy in the 1990s, during

which time the economy "*changed drastically*". O'Sullivan (2010), on the other hand, highlights how concerns have been raised over the sustainability of the *magnitude* and *speed* of the growth in Ireland's industrial development since the late 1980s. Decomposing this change at an industry and regional level gives a greater understanding as to *how* this change took place and what patterns were associated with it. The patterns of diffusion are particularly important. In that respect, the geographic component of this research gives a great insight into intra- and inter-regional trends which are key considerations for state agencies involved in industrial development. A longitudinal analysis such as this thus allows policymakers to consider future trends and plan and tailor policy accordingly.

Bearing in mind that Lundquist *et al.*'s (2007; 2008) research is relatively innovative and has only been carried out for Sweden to date; building on this research is of great importance at this time, and proportionately, adds a substantial amount to this body of knowledge. If the trends arising from this research are similar to those of Sweden, support will be added to the theory. If they are different, it will important to consider *why* they are different.

The theoretical framework underlying this research is discussed in Section 2. This is followed by a more in-depth discussion of the existing literature surrounding this research, and similar previous studies that have been carried out in Section 3. Section 4 outlines the hypotheses under consideration in this research, gives a description of the data that were employed and the methods used to answer the research question and address the hypotheses. Section 5 presents the results obtained from this research and gives an analysis and discussion of these results. Section 6 outlines the conclusions, policy implications and recommendations that arise as a result of this research.

Section 2: Theoretical Framework

2.1 Introduction

There are four aspects to the theoretical framework underpinning this thesis, each of which will be discussed in detail below. The first is the "technology shift thesis" which is associated with Schumpeter's consideration of creative destruction (Schumpeter 1942, cited in Bosma *et al*., 2011). This theory is endogenous in nature.

Secondly, the geographical patterns associated with the technology shift thesis are considered. This builds on Schön's (2007) work, pointing out the divergence/convergence patterns related to the transformation/rationalisation investment periods of the technology shift. Lundquist *et al*. (2007; 2008) and Lundquist and Olander (2010) outline their application of this theory to the regional patterns of Sweden's industrial transformation from the late 1970s to 2004. This work is of utmost importance to the research in question.

Thirdly, unlike Sweden, with its transformation occurring over the theorised c.25 years (Schön, 2007; 2009), it would appear that Ireland's transformation was much more rapid as it experienced "catch-up" growth. This consideration is part of the technology shift thesis, in that, at first only some regions are affected by the new technology, with standardisation and diffusion resulting in a more broad range of regions/countries included in the process towards the end (Schön 2007). These trends and associated time lags are also discussed in Abramovitz's (1986) "catch-up" thesis. The 1980s was a period of decline for Ireland, interrupting or perhaps, delaying Ireland's industrial transformation, while Sweden's began in the late 1970s. However, at the beginning of the 1990s, Ireland's per capita gross domestic product (GDP) was 60 per cent that of the European Union (EU) average, rising rapidly to over 100 per cent by the end of the decade (Ahearne, 2006). This characteristic of rapid and converging growth is associated with a "catch-up" process (Abramovitz, 1986). Therefore, as part of the theoretical framework for this thesis, it is considered that the bulk Ireland's transformation was much more rapid than that of Sweden.

As a fourth and arguably, most important point, in the case of Ireland – as will be discussed in more detail in Section 3 – much of its industrial transformation was "facilitated" by exogenous-led development in the form of FDI. This is as opposed to the endogenous growth

component of the technology shift thesis. However, this exogenous development can be considered to facilitate endogenous development, subject to conditions such as competition, embeddedness, etc. This point is brought to the fore by Florida (1996) in his analysis of the transformation of the Mid-West region in the United States (US), where he cites FDI as a considerable facilitator of innovation for the region. This point is further emphasised by Buckley and Ruane (2006), stating that "*technology transfer* [in the form of FDI] *can trigger and speed up economic development*" for the host country.

2.2 The Technology Shift Thesis

The technology shift thesis – which is much associated with Schumpeter's considerations – is inherently linked to the processes of structural change brought about by creative destruction. Schumpeter (1942, p.83, cited in Bosma *et al*., 2011) describes creative destruction as a "*process of industrial mutation [...] that incessantly revolutionises the economic structure from within, incessantly destroying the old one, incessantly creating a new one*". This process invades the entire industrial structure, with technological and organisational change facilitating both the creation of new industries, and the transformation of existing ones (Eriksson and Lindh, 2000). Creative destruction can be further described to work in waves – or "gales" according to Schumpeter – of innovative activity hitting the economy at different points in time (Hospers, 2005). Fujita (2008) also emphasises the destructive nature of the creation, that is, how new firms adapting to new knowledge can lead to the fall of existing firms. On the other hand, Abernathy and Clark (1985) stress the *multi-faceted* nature of innovation, with some innovations disrupting, destroying and making obsolete the incumbent, while others refine and improve them.

Many acknowledge the General Purpose Technology (GPT) as the key to technological change (see further Bresnahan and Trajtenberg, 1995). A GPT pervades all parts of industry and society; its pervasiveness highlighted in the way it eventually finds applications that were not even imagined from the outset (Dahmén, 1983). Eriksson and Lindh (2000) point out how technological development can be, in part, induced by the discrete replacement of obsolete technologies, owing primarily to the constant innovation of components for the new GPT. The authors do stress however, that all "old" components are not made redundant with the arrival of the new GPT. This is in tandem with Abernathy and Clark's (1985) point above.

The diffusion of these "disruptive" and "pervasive" technologies spells important consequences for the industrial structure and for economic growth (Dewick *et al.*, 2006). Kingston (2006) agrees, stating that theories of endogenous development have to bear with the "complex interactions" between innovation and the institutions governing and/or facilitating their development and diffusion. Mateos-Planas (2004) builds on this consideration, warning that, if the processes of innovation and obsolescence coincide, policies that meddle with the obsolescence can result in implications for economic growth. He cites subsidies and selective taxes in industry as possible means of interfering with these processes.

The GPT and associated technological innovation has huge strength in pushing industrial development, resulting in productivity growth (Abernathy and Clark, 1985). Fujita (2008) credits productivity as being "*the engine of economic growth*", with technology allowing firms to produce new products or improve the efficiency of the production of existing products. Bosma *et al*. (2011), coming from a similar point of view, argue that productivity growth is most probably a better measure of competitiveness than employment growth. The authors cite Porter (1990; 1998) and Krugman (1990) in their positions in favour of using productivity as a competitiveness indicator.

The development block concept, as part of "Schumpeterian Dynamics" is widely considered the foundation of industrial dynamics (Dahmén, 1988). This development block traces the role of the GPT over time and the changes it makes, both directly and indirectly, to the wider industrial and economic structure. Enflo *et al*. (2008) point out the central consideration of the development block concept; that there is an innovation (or possibly more than one) around which complementarities develop. The authors go on to describe this as "*a struggle between new and old combinations or blocks in the economy – a struggle that intensifies in periods of creative destruction*". (Enflo *et al*., 2008)

The technology shift with its associated GPT and development block encompasses three distinct stages. The first stage is transformation, during which industrial structures change, industries see the reallocation of resources between them and this reallocation is supported by "*the diffusion of basic innovations within industry*" (Schön, 2009). Structural change is usually back-loaded to the end of the transformation, during which is the strongest period of "creative destruction". From that point onwards, a new growth structure is set out. The second stage is rationalisation, whereby resources are concentrated in the most productive

areas within branches, and measures are taken to enhance production efficiency (Schön, 2009). The third stage is structural crisis, where institutions can no longer cope, change ensues, and the cycle starts afresh.

Naturally, these considerations have geographical implications. These implications are of greatest concern to the research in question and will be discussed further in the following section.

2.3 The Geographical Patterns of Industrial Change

Schön (2007) points out the divergence brought about by the transformation stage. Transformation initially lends itself to agglomeration economies, which, as expected, result in a divergence between regions. Different regions and countries react to periods of transformation in different ways. There are leading countries and regions due to circumstances and due to the geographic confinement of complementarities and externalities. Diffusion is also selective in nature, favouring the conditions of some regions and countries over others. This inevitably leads to the divergence of growth rates (Schön, 2007). With time and adaptation to new complementarities, the diffusion of development blocks becomes more widespread (see further Schön, 2007 for a description and analysis of transformation, divergence and diffusion). This gives rise to geographical changes both within and between countries, and with regard to the latter, in part, explains Ireland's lag behind Sweden and subsequent catch-up growth. This is discussed in more detail in the next section. With regard to the former, Lundquist *et al.*'s work (2007; 2008) applies these considerations to Sweden's transformation.

Lundquist *et al*. (2007) analyse Sweden's "*changing geographies of production and industrial renewal*" during the period 1978 – 2004. The authors trace the manufacturing industry's regional footprints during the transformation period by decomposing aggregated growth. Lundquist and Olander (2010, citing Lundquist and Olander, 2009; Lundquist *et al*., 2008; and Svensson-Henning, 2009) highlight how the growth cycle is inherently geographic in nature. Different stages of the technology shift (transformation, rationalisation and structural crisis) begin in some regions before moving to others in an intrinsic pattern over time. This is due to the GPT's influence on different elements of the economy during different stages of transformation and its changing affinity to varying regional economies.

Lundquist *et al*. (2007; 2008), drawing on the technology shift thesis, indicate that there is a cyclical diffusion of technology effects taking place through Sweden's regions. This means that the processes of transformation (c.25 years) – rationalisation (c.10 – 15 years) – structural crisis (and their associated effects on industrial productivity) took place in a divergence-convergence fashion, with an inherent time lag (Lundquist and Olander, 2010). This is in keeping with the theoretical considerations highlighted by Schön (2007; 2009) as discussed above.

Lundquist *et al*. (2007) pointedly note the "cumulative" consideration for the larger regions. New technologies take hold experimentally in the primate city (Stockholm) as industries seek to reap the benefits of economies of scale/agglomeration economies. The authors find that the manufacturing of new products and their ensuing development occurs "*carefully and experimentally*" in large regional markets to begin with. This is due to the ripeness of the "*receiver and development competence*" in these regions. When production is standardised and transaction costs begin to decline, activities diffuse to smaller regions, respectively, in a top-down fashion. Overall, different industry types each experience a different type of concentration/diffusion pattern and associated trajectory (Lundquist *et al*., 2007; 2008). This is due to the pervasive nature of the GPT and the gales of creative destruction (as discussed above) penetrating different elements of the economy and regional system at different points in time.

Primarily, the process of transformation (technology-induced restructuring) holds with it regional divergence with inherent "*time-lags and spatial asymmetries*" in relation to regional economic growth, job creation and income development (Lundquist *et al*., 2008). This supports the cyclical diffusion theory and is in line with Schön's (2007) analysis, outlined above.

As outlined in Section 1, these spatial considerations are central to this research, as a very similar research design is applied to the case of Ireland's recent industrial development for this study (see further Section 4).

2.4 Catching Up

Ireland's industrial productivity began to grow at outstanding rates from the early 1990s. Many theorise that this growth, resulting in the convergence with the average EU growth rates (Ahearne, 2006), has been a "catch-up" process. This point is inherent in the technology shift's standardisation and diffusion patterns, with technological change and productivity improvement taking hold in some countries at first and then spreading to others. Catch-up is quite central to this analysis as it means that the transformation that Sweden (and probably many other developed countries within the EU) experienced would have spanned 25 years (from the late 1970s), whereas Ireland's transformation period is more likely to have seen a compressed, quicker and much more dramatic change.

Central to the catch-up concept is the hypothesis that productivity growth rates have a tendency to vary inversely with productivity levels (Abramovitz, 1986). Thus, a "backward" position in terms of productivity means "*a potential for rapid advance*" or "catch-up". The greater the technological and productivity gap between the most and least advanced, the greater the potential for the "follower" or least advanced (Abramovitz, 1986). As the follower's productivity level converges with that of the "leader" or most advanced, the weaker its potential for productivity growth becomes. This catch-up process is widely considered to be at play (or to have been at play) in Ireland over the course of the past two decades, and is therefore a central concern for this research.

2.5 Foreign Direct Investment Facilitating Transformation

Barry (2000) notes how the "rebound" of Ireland's indigenous industry was, to a certain extent, due to creative destruction. However, as outlined in Section 1, Ireland hosts a remarkable level of FDI, and as many authors have discussed, a large proportion of Ireland's productivity improvement is attributed to the foreign-owned sector, alluding to essentially, exogenous-led development (see further Section 3).

Florida (1996), like Lundquist *et al*. (2007; 2008) and Lundquist and Olander (2010) highlights the geographical component to the transformation forces associated with Schumpeter's process of "creative destruction". He wishes to question the consideration that these new forms of production organisation are exclusive to emerging regions, leaving the older manufacturing regions confined to their out-dated forms. He does this through analysing the "older region" of the Mid-West in the US.

FDI is an important means of transferring technology (Blomström *et al*., 1994; and Blomström and Kokko, 1996, cited in Buckley and Ruane, 2006). In this way, FDI can be the fastest way for many countries to access outside competence (Buckley and Ruane, 2006). Florida (1996) emphasises that the process of transformation – at least in the case of the Mid-West in the United States – is supported by a strong connection between globalisation (through FDI) and new production organisation. These new forms of production organisation, and their diffusion, allow for increases in productivity throughout the regional manufacturing base, with a virtuous cycle of imitation, adaptation and improvement ensuing (Florida, 1996). Florida (1996) finds that new forms of production organisation have been adopted and diffused at a considerable rate within the region. He emphasises that this shift was spurred on by globalisation; through new FDI transplants transferring new production organisation forms to the region's manufacturing industry and thus, contributing to the region's economic transformation (1996, citing Graham and Krugman, 1991).

Florida stresses how the region is about to make the move from a regional and domestic focus to a more global-oriented focus. He contends that the Mid-West is going through "*a deep and fundamental process of economic transformation, or regional creative destruction*" in this respect. This is a very important consideration for Ireland's productivity improvement and transformation (see further Section 3).

Lundquist *et al*. (2007) also refer to FDI exogenous factors in their study of Sweden. They point out how the exogenous consideration more-or-less follows the same diffusion pattern; through the regional hierarchy in a top-down manner. However, FDI and technology transfer considerations are of much greater importance to the case of Ireland. They will therefore be discussed in much greater detail in this study, see Section 3.

2.6 Summary

The discussion of the four considerations above underpins this research. A great deal of this discussion will be elaborated on in the following section. However, while much research regarding FDI has been carried out in the case of Ireland's industrial development, a large proportion of the other considerations – particularly the technology shift thesis and regional trends – remains largely untouched in previous studies. This research, mainly in Sections 5 and 6, gives a great insight into these areas, while maintaining due regard for the FDI component.

Section 3: Literature Review

3.1 Industrial Development in Ireland

3.1.1 Ireland's Recent Growth

Doyle (1997) explains that the term "structural change" means "*transformations in the composition of production, employment, demand and trade that occur as countries develop*". Doyle (1997, citing Jacobs, 1969; Porter, 1990; Romer, 1990; and Schumpeter, 1942), outlines the basis of the technology shift thesis in relation to this structural change, that is, technological change is a key consideration in explaining productivity increases. Doyle (1997) also points out that changes in the structure of production act as an important means of increasing average productivity levels. Ireland's recent past is associated with a considerable level of the changes and improvements in productivity that she describes.

Ó'Riain (2000) points out how some consider the "*mastery of localised flexible production and innovation*" to be the basis of Ireland's success in the 1990s, and how others stress more the export-based industrial policy. Ó'Riain also joins others in citing Krugman's (1998) point that Ireland's success was due in part to luck and in part to policies. Others agree, highlighting how Ireland's policies and strategies sought by industrial development agencies assisted greatly in Irish industrial progress (Ó'Riain, 2000; O'Sullivan, 2000; Collins and Grimes, 2008).

O'Sullivan (2000) recognises Ireland's low-cost production base as being a major reason for the attraction of FDI, leading to productivity improvement. She, as well as Barry (2000) and Ahearne (2006), points to the low corporate tax levels on offer to foreign enterprises in Ireland as a reason for attracting such a high level of FDI.

O'Sullivan (2000) also emphasises how, in tandem, there has been a renewal of indigenous industry in Ireland in the 1990s with absolute indigenous employment levels and relative indigenous export levels both increasing. She also deems "remarkable" the increase in the number of patents from indigenous companies since 1995. Clancy *et al*. (2000) point out a policy shift during the 1980s, whereby the focus began to move towards the development of Irish indigenous industry, whilst still supporting the enticement of FDI.

Ó'Riain (2004) inadvertently highlights aspects of the technology shift taking place within Irish industry, focusing on the sectoral shift outlined by declines in older sectors, while the high-technology sector was growing at a rapid pace. He also emphasises how output per employee increased within and between sectors, resulting in an increased level of productivity overall.

However, Honahan and Walsh (2002) contend that no solitary "*ingredient*", but rather a combination of several measures, can explain Ireland's phenomenal economic and demographic growth in the 1990s; growth that was seen by no other EU country or metropolitan region during that period.

3.1.2 The Evolution of Ireland's Industrial Policy

Ireland's move towards an exogenous-led policy stemmed from the Whitaker Report (Whitaker 1958, cited in Collins and Grimes, 2008; Crotty, 2000). This meant that from the early 1960s, Ireland would pursue a policy of free trade and enticement of MNCs (Buckley and Ruane 2006) in order to spur on industrial development (Begley *et al*., 2001).

This change in policy came about due to the realisation that Irish industrialisation could not be fulfilled without outward-oriented policies as the Irish market was extremely limited (McHugh, 1985, cited in Doyle 1997). This policy has indeed evolved to a great extent since that point, especially towards the end of the 1980s and at the start of the 1990s, with authors such as Healy (1983) calling for changes to industrial policy from as early as 1983. Irish policy began to pursue a more balanced strategy since the initial development of the exogenous-led strategy. This involved expanding the export capacity of the indigenous sector and making conscious efforts to attract more high technology FDI (Lin *et al*., 2010).

Ireland came to be described as a "*flexible developmental state*", characterised by its ability to foster post-Fordist innovation and production networks, its potential for enticing international investment and its capacity to connect local and global technology networks in such a way so as to enhance development (Ó'Riain, 2000).

3.1.3 The Benefits of EU Membership

Ireland's membership of the EU is credited by many as being a major propellant of its industrial development (Crotty, 2000; Lin *et al*., 2010; Buckley and Ruane, 2006; Clancy *et*

al., 2001; Doyle, 1997; Honahan and Walsh, 2002; Barry 2000; Begley *et al*., 2005; Ahearne. 2006). This membership meant barrier-free entrance to the much larger EU market for MNCs (Begley *et al*., 2005; Clancy *et al*., 2001).

Ireland's initial entry to the European Economic Community (now the EU) in 1973 immediately increased its attractiveness to foreign-owned enterprises from outside the EU. In this way, Ireland reaped the benefits of the product life-cycle theory (Vernon, 1966, cited in Buckley and Ruane, 2006), as it became a low-cost manufacturing base inside the EU for mainly US companies (Buckley and Ruane, 2006).

Some authors have highlighted the importance of the considerable EU structural funding that was afforded to Ireland in 1988 (Honahan and Walsh, 2002; Barry, 2000). From the late 1980s onwards, Ireland began to experience considerable industrial development, with the period leading up to the 1992 Single European Market (SEM) commencement seeing substantial inward investment (Barry, 2000). Buckley and Ruane (2006) highlight how the SEM "*consolidated Ireland's role as a manufacturing base for high-tech, low-weight products within the EU*".

Membership of the EU has meant strong support both in terms of Structural Funds and Framework Programmes for the integration of Irish industrial and technology policy for the development of indigenous firms (Lin *et al*., 2010). Ireland's membership also facilitated its catch-up with other European counterparts through attracting MNCs, particularly from the US (Buckley and Ruane, 2006). Attracting such a considerable amount of FDI would have been close to impossible had Ireland not been a member of the EU (Barry, 2000).

3.1.4 Catching Up

As outlined in Section 2, Ireland's per capita GDP caught up to (and passed out) the EU average by the end of the 1990s (Ahearne, 2006). The growth of the second half of the decade was particularly remarkable after the depression that was experienced during the 1980s (Ahearne, 2006, citing Prescott and Kehoe, 2002). Ireland's outstanding growth was the subject of world attention during the latter part of the 1990s, as it caught up from a position much lower than its neighbours to being on par with them (Begley *et al*., 2005). Camacho *et al*. (2008) also point to this, stating how Ireland is one of the few countries

within their analysis that sees extreme gains during the "expansive" phase of economic development.

Barry (2000) argues that the economic growth Ireland enjoyed from the late 1980s could be described as a "*delayed catch-up*"; a reference to the previously mentioned Abramovitz's (1986) theory. It is widely considered that Ireland has, at this stage, caught up to the "leaders" in terms of productivity levels (Lin *et al*., 2010).

O'Leary (1999, citing Birnie and Hitchens, 1998) credits the "*dramatic improvement in manufacturing comparative productivity*" as the proximate cause of Ireland's catch-up to the UK in terms of GDP per capita during the period 1986 – 1995.

3.1.5 Spatial Elements of Ireland's Industrial Development

While it appears that relatively little work has been carried out on the intra and inter-regional patterns of Ireland's industrial development over time, there are some geographical studies which are useful to focus on. For example, Barrios *et al*. (2005) study the dynamics of geographic concentration of manufacturing firms in both Ireland and Portugal over a thirteen-year time-span. They find a high level of geographical mobility within the firms in both countries, despite agglomeration levels remaining stable at an aggregated level. They also find that Ireland experienced much greater changes in spatial concentration across industries, in comparison to Portugal.

Their findings show no clear pattern of spatial concentration within the high technology sector. The authors point to a process of technological progress, with new technologies rising from different regions with an overlap between old and new technologies. This is very similar to the considerations highlighted by Lundquist *et al*. (2007; 2008), Lundquist and Olander (2010) and Florida (1996) in their respective studies of Sweden and the Mid-West region of the US.

Barrios *et al*. (2005) point to the strong centrifugal forces at play in relation to high technology industries and how centripetal forces are often not strong enough to overcome the aforementioned dispersing force. This is most likely a diffusion process at work. The authors also highlight an unexpected finding; agglomerated industries show a higher level of

geographical mobility than non-agglomerated. They cite dramatic structural change as a potential explanation for this finding.

Clancy *et al*. (2001) focus on the function of industry clusters (Porter 1990) – and clustering through interactions – in sustaining the competitive advantage of Irish indigenous industry. The authors point out how the difficulty for Ireland is that it is a small country and as such, does not have the capacity to support the number of requisite firms for domestic rivalry; a crucial element of Porter's model. Clancy *et al*. (2001) find that the indigenous software industry (as part of a wider group of industries) displays many of the necessary characteristics of a cluster – although it contains a considerable proportion of FDI, contrary to Porter's model. These industries are located primarily in concentrations in Dublin (hosting two-thirds of the entirety), and smaller concentrations in Cork, Galway and Limerick. These two regions constitute the "Core" and "Semi-Core", respectively for the research in question.

Buckley and Ruane (2006) and Meyler and Strobl (2000) highlight the spatial element to Irish industrial policy (since the 1970s); how MNCs have been financially incentivised to locate in regions of high unemployment and depopulation. More recently (since the 1980s), this policy has moved towards building "*sectoral and spatial clusters*", with a focus on the high technology industries of electronics and chemicals/pharmaceuticals (Buckley and Ruane, 2006).

3.2 Foreign Direct Investment

3.2.1 An Introduction to Ireland's FDI

Ahearne's (2006) research indicates that, if FDI was the most important factor during Ireland's time of economic expansion, its contribution was in the form of increased productivity. Ahearne cites the OECD Handbook (2003), in pointing out how Ireland had the second least restrictions on FDI, next to the UK, compared to other OECD countries. As a result of Ireland's small and open economy, its development is inherently connected to global dynamics (Begley *et al*., 2005).

Begley *et al*. (2005) highlight the five phases of Ireland's relationship with FDI. The fourth phase (in line with the 1990s decade) is of greatest concern to this research as this phase saw the arrival of enterprises building on Ireland's manufacturing expertise (Begley *et al*., 2005).

The first four phases are associated with an evolutionary process, moving from lower towards higher value-added functions mostly within manufacturing. Since then, as will be discussed in the following sub-sections, the focus has moved away from manufacturing (Begley *et al*., 2005).

However, many authors advise that a person exercise caution when looking at Ireland's productivity gains (O'Leary, 1999; Honahan and Walsh, 2002; Ó'Riain, 2000; O'Sullivan, 2000; Crotty, 2000; Collins and Grimes, 2008; van Egeraat and Barry, 2009). This is due to the existence of, what the aforementioned authors refer to as "*transfer pricing*".

Transfer pricing is essentially where MNCs partake in "*creative accounting*", adjusting their income so that they can avail of the relatively lenient Irish taxation system (with associated corporate tax benefits) rather than subjecting their profits to less lenient tax systems elsewhere (Ó'Riain, 2000; Crotty, 2000). This transfer pricing can overstate or exaggerate improvement in productivity (O'Leary, 1999; O'Sullivan, 2000) and economic growth (Ó'Riain, 2000).

Many have expressed concern over the difference between Ireland's GDP and gross national product (GNP) that has emerged since the mid-1980s (O'Leary, 1999; Honahan and Walsh, 2002). O'Leary (1999) considers that this gap can be accounted for by profit outflows from MNCs. Therefore, the "productivity" that is consider to arise from MNCs could well be exaggerated in some of the national accounts (see further Central Statistics Office (CSO), *various years1*).

As a result of this, much of the value that appears to have been created in Ireland could, in fact, be attributed to places outside of Ireland (van Egeraat and Barry, 2009).

3.2.2 Outstanding Industries

Honahan and Walsh (2002) point out the worrying trend of very high productivity levels and growth rates in MNC-dominated industries in comparison to other industries within Ireland. They consider that this indicates the existence of an "entrepôt" economy in Ireland. These entrepôts are at play in the chemicals, software, computers and cola concentrate industrial sectors, and are encouraged by the tax benefits associated with foreign-owned firms in Ireland (Ó'Riain, 2004, citing Honahan *et al*., 1998).

The production of cola concentrate (carried out by a US company) dominates the food industry's productivity (O'Sullivan, 2000). This is further alluded to by Ó'Riain (2004), pointing out how the foreign "Food, Drink and Tobacco" sector comes across as the only true entrepôt sector. He reaches this conclusion due to the decreasing investment and employment, yet increasing output in the sector.

Van Egeraat and Barry (2009) point out how the pharmaceutical industry in Ireland experienced strong employment growth, even post-2002, as employment in other manufacturing industries decreased. This change has resulted in an increasingly important pharmaceutical industry in Ireland (see further van Egeraat and Barry, 2009).

Ó'Riain (2000) focuses on the Irish software industry. He points out how, of all the manufacturing industries, it saw the fastest growth in terms of employment during the 1990s. He also emphasises how there is an almost equal division of labour between Irish and foreign-owned firms within the industry. O'Sullivan (2000) also notes the considerable development of the indigenous software industry during the 1990s. Clancy *et al*. (2001) enhance this point, acknowledging the interaction between indigenous firms within the software sector. The authors cite competition as well as co-operation between indigenous firms as substantial factors in the improvement of overall competitiveness.

Ireland had become one of the main European centres for hardware production by the end of the 1990s, with exports from Ireland accounting for approximately 6 per cent of worldwide exports of electronics parts (Barry and van Egeraat, 2008). However, hardware production enterprises began to pull out of Ireland by the late 1990s, and were often replaced by related higher-technology sub-sectors (Barry and van Egeraat, 2008). Many of the firms that remained in Ireland moved their operations within Ireland to "*higher value-added non-manufacturing functions*" (Barry and van Egeraat, 2008) in accordance with the product life-cycle theory.

3.2.3 Embeddedness and Technology Transfer

Technology transfer is a hugely important aspect associated with FDI's embeddedness (Buckley and Ruane, 2006 citing Blomström *et al*., 1994; and Blomström and Kokko, 1996). Technology transfer is an important facilitator of producing goods associated with greater value-added, enhancing exports and increasing efficiency. Embeddedness would also mean

the transfer of skills, knowledge and experience to the local workforce through employing professionals and managers from the host country (Blomström *et al*., 1994, cited in Buckley and Ruane, 2006).

Florida (1996, pointing to Graham and Krugman, 1991) highlights how transplant companies and FDI are becoming important for economic growth and indeed, productivity improvement. In his analysis of the transformation of the Mid-West region in the US, Florida stresses how the relationship between globalisation (filtered through FDI) and new production organisation supports the economic transformation of the region. This is an important consideration for Ireland too, due to the high levels of FDI it hosts. Mirroring Florida's point, van Egeraat and Barry (2009) emphasise the strong link between globalisation and Ireland's regional development.

Ó'Riain (2004) refers to the huge change that occurred in Irish industry during the 1990s, emphasising the FDI entrepôt bubble that inflates this change. He stresses how foreign-owned industry is much less likely than indigenous to develop "*a local dynamic of industrial transformation*". Further to this, FDI is unlikely to prompt indigenous industry into upgrading without the help of a local coalition working towards that aim (Ó'Riain, 2004).

While Barry (2000) attributes a proportion of the rebound of the Irish indigenous industry to creative destruction, Collins and Grimes (2008) state how others credit Ireland's exogenous-led development model as being the "*cornerstone*" of the country's economic success. However, Collins and Grimes (2008) do emphasise that there are two sides to the story of foreign-owned firms in Ireland and their embeddedness (or lack thereof, as the case may be). The authors consider that many of the national statistics bring to the surface "*Ireland's dependence on importing technology*", which could be viewed as a negative aspect in terms of hosting high levels of FDI.

Barry (2000) emphasises the differences between the characteristics of indigenous and foreign-owned industries, the former paying much lower wages, oriented much less so towards exports, employing lower proportions of skilled labour, and being less R&D intensive than the latter. This highlights the wide ranging differences between the two.

On a similar vein of thought, Ó'Riain (1999, cited in Collins and Grimes, 2008) points to the "*two globalisations*" Ireland is experiencing, with the explosion of the foreign-owned sector, and the "*significant growth*" of the indigenous. There is, however, a wide gap between the former and the latter. Citing O'Hearn (2001, p.193), Ó'Riain (2004) points out how FDI will not contribute to the local economy's long-term development, but simply "*generates short-term growth spurts*". He highlights the weak presence of connections between MNCs and the local economy and the "*disarticulation of the local economy between an advanced, foreign-dominated sector and a backward indigenous sector*". Lin *et al*. (2010) add weight to this point, stressing how a dual economy has developed in Ireland; one of a "*technologically advanced, externally-owned sector based largely on R&D conducted elsewhere*" and the indigenous sector which is technologically inferior. O'Sullivan's (2000) point supports this consideration further, where she highlights how net output per person in US companies is much higher than that of Irish-owned companies.

Clancy *et al*. (2001) pointedly comment on the connections between indigenous and foreign-owned firms and the importance of these connections for the success of the local software industry. Despite this, there is a disappointingly low level of embeddedness by software subsidiaries (Clancy *et al*., 2001). In their analysis, the authors find that the sectors that turned out to be competitive were predominantly foreign-owned. In other words, it was difficult to find "convincing" examples of competitiveness in Irish indigenous sectors (Clancy *et al*., 2001).

Krugman (1997, cited in O'Sullivan, 2000) warns how Ireland's recorded productivity can be very misleading in that "*it may bear little or no relationship*" to the actual competencies that have been developed by the indigenous sector. O'Sullivan (2000) questions whether recent developments in indigenous industry in Ireland actually mean a transformation in its competitiveness. She is sceptical of whether Ireland has really escaped its previous trends associated with industrial production, or whether the apparent change is simply due to FDI. She questions whether FDI is really a foundation for long-term industrial development, and thus, the sustainability of Ireland's industrial growth could be at risk. Despite the massive changes to Ireland's industrial structure that MNCs have brought with them, Begley *et al*. (2005) are also concerned about the unsustainable conditions that this success entails. Ireland's current cost structure can no longer support low and medium technology manufacturing the way that it could before.

Ó'Riain (2000) highlights how embedding by MNCs is, to some extent, evident in Ireland. He cautions how this embeddedness is however, rather limited. There is also evidence of spin-off indigenous firms arising from MNCs, although again, to a very limited extent. He further voices his concern in his 2004 paper, pointing out how it is very uncommon for foreign-owned firms to become involved in any sizeable technology transfer, joint venture or licensing collaborations with indigenous companies. Investment relationships between the two are also few and far between (Ó'Riain, 2004).

Ó'Riain (2004) also stresses how authors such as Polanyi (1944) and Granovetter (1985) point out the importance of social embedding. Ó'Riain considers that without such social embedding, a "*neo-liberal political project*" such as chasing FDI without embeddedness, will hold with it the seeds of its own destruction.

Buckley and Ruane (2006), on the other hand, highlight the positive aspects of FDI. One of such aspects is the provision of a package of new managerial skills and technologies. In this way, they argue that FDI allows the host country to develop its comparative advantages in a more efficient manner. A second – and the most important – aspect is how FDI assists in enhancing production and export capacity. This is an aspect associated with the product life-cycle theory (Buckley and Ruane, 2006).

3.2.4 Moving Away from Manufacturing FDI

Ireland's cost-base became too expensive for manufacturing towards the end of the 1990s (Begley *et al.*, 2005; van Egeraat and Jacobson, 2004) and Ireland could no longer fulfil a role as the "*semi-periphery of Europe*" (van Egeraat and Jacobson, 2004). Competition from locations such as Eastern Europe (new EU member states) and Asia (Begley *et al.*, 2005; Collins and Grimes, 2008; van Egeraat and Jacobson, 2004) resulted in Ireland's focus moving from manufacturing towards services (Collins and Grimes, 2008). According to Collins and Grimes (2008), the reasons for this shift in focus were two-fold; manufacturing became unsustainable in terms of costs; and a move towards services meant an "*upgrade*" of skill and productivity for the workforce.

Barry and van Egeraat (2008) highlight how the electronics components sector was hit particularly badly as much of this production relocated to China and Eastern Europe. This

resulted in the loss of one-third of the jobs within the sector during the period 2000 – 2004. This loss was originally considered to be associated with the bursting of the dot-com bubble, but the decline in Ireland's global export share could suggest that Ireland's computer hardware sector was subject to shifting comparative advantage rather than a victim of the high-tech downturn (Barry and van Egeraat, 2008).

3.3 Summary

From the discussion above, it is clear that Ireland's industrial structure has undergone substantial change over the time period under consideration for this research (1991 – 2007). The industrial structure has seen change both within industries (the rise of the high technology sector) and between industries (the increased focus on the services' sector). These processes occurred due, in no small part, to the strong presence of FDI in Ireland. The following outlined methods and subsequent results give a much greater insight into the sub-processes at play within the manufacturing industry, across regions and over time in Ireland.

Section 4: Methods

4.1 Context

Finding a suitable method that could thoroughly highlight the principal concerns of the technology shift, technological change, productivity change, regional patterns and indeed technology transfer in Ireland's context was a primary consideration for this research. Further to this, developing a method and obtaining data capable of producing results that would be comparable to Lundquist *et al*.'s (2007) work for Sweden was also a concern.

Firstly, an appropriate time period in line with the bulk of Ireland's transformation was decided upon. O'Mahoney (2011) points out that during the period 1990 – 2007, economic growth in Ireland averaged 6.5 per cent per annum. Ó'Riain (2000) seconds this point, stating how economic growth rates in Ireland have seen a massive improvement since the 1980s, and were "*among the most rapid in the world during the 1990s*", with Ireland's industries experiencing a huge change in productivity during this time (Ó'Riain, 2004). These considerations, along with the "catch-up growth" points discussed in Sections 2 and 3, as well as the notable increase in volume output from production industries starting from the late 1980s (CSO, *various years2*, see Appendix A), indicate that a time period starting from the late 1980s – early 1990s for Ireland's transformation is most appropriate. Data in a consistent form (NACE Rev. 1.1) is only available from 1991 onwards and therefore, the time period starts from that year. Years beyond 2007 were excluded due to data availability issues. However, it is considered that 2008 onwards "buck the trend" so to speak, as the global crisis, property crash and banking crisis in Ireland ensued from that year.

Also, as outlined in Section 1, the manufacturing industry plays an important (arguably the most important) role in the process of transformation (Lundquist *et al*., 2007), therefore it was considered imperative to focus on this industry at first, rather than any other. The industrial scope of this study is confined to the manufacturing industry (Section D of NACE Rev. 1.1). According to the CSO (2012), "Industry" excluding "Agriculture" and "Construction" employed on average approximately 13.72 per cent of the workforce for the period 2005 – 2011 (CSO, 2012, *own calculations*). Therefore this industry is considerably important to the Irish economy, although perhaps now to a lesser extent than in the 1990s.

It was important to disaggregate the manufacturing industry in such a way so as to capture technological and productivity change, in keeping with the technology shift thesis. It was also

necessary to divide the regional system in a hierarchical manner so that the regional patterns could be deciphered. This would indicate whether a cyclical diffusion of technology effects was taking place in a divergence-convergence manner in Ireland in a similar fashion to that of Sweden.

FDI simply could not be ignored as part of this research as discussed in Sections 1, 2 and 3. Therefore aspects of its importance for productivity and embeddedness in Ireland's industrial structure were examined.

Results were compared to those of Lundquist *et al.* (2007; 2008) and Lundquist and Olander (2010) for Sweden's industrial development. Policy implications were then considered and discussed based on these results (see Section 6).

4.1.1 Hypotheses

In order to answer the research question posed in Section 1, the following hypotheses have been developed in line with both the technology shift thesis and the exogenous-led consideration, as discussed in Sections 2 and 3:

1. Increases in productivity occur in a top-down manner through the regional tier hierarchy with an inherent time-lag resulting in divergence-convergence patterns.
2. Structural change is evident with the *higher-technology* groups gaining a higher proportion of the aggregate productivity in manufacturing, again in a top-down manner through the regional tier hierarchy with an inherent time-lag.
3. FDI plays a major role in the increase of productivity and in industrial change.

In order to test these hypotheses, the following methods have been adopted. These methods have been split into four sub-sections; National Trends; Regional Tier Manufacturing Productivity Trends; Technology Group Productivity Trends; and FDI Manufacturing Productivity Trends and will be outlined below. Firstly, however, it is important to focus on the data employed.

4.2 Data

The principal data were derived from Section D (Manufacturing NACE Rev 1.1 15 – 37) of the Census of Industrial Local Units as part of the Census of Industrial Production (CIP) (CSO, *various years3*). This census encompasses all local units involved in industrial activity (manufacturing in this instance) which employ an average of three or more people during the

year in question. Each local unit is attributed to a specific location (county) within Ireland. For further information, please see the CIP MetaData (CSO, 2009).

For the purpose of this research and due to the data available, net output per person engaged was used as a proxy for "productivity". "Net output", as part of the CIP, is "gross output" minus "industrial input". Essentially, this constitutes "*the selling value of goods actually produced in the year*" (regardless of whether the goods are sold or not) **minus** "*the cost of materials, industrial services and fuel and power used in the year*" (CSO, 2009). O'Malley and Roper (2003) used gross output in their comparison of the Irish and Northern Irish manufacturing industries during the 1990s. However, net output is considered a more optimal representation of industrial progress as it accounts for input. Moreover, the productivity "per person engaged" gives more of an indication of productivity than the aggregate output. Through factoring in these considerations, costs are, in part, accounted for.

Thus, the variables of "net output" and "persons engaged" were obtained for the years 1991 – 2007 at the regional tier level and technology group level with which this research is concerned. Net output was then divided by persons engaged. As expected, due to the nature of this data source, values were initially obtained in current prices (without any regard for inflation). In order to carry out a longitudinal analysis, it was necessary to convert this data from current to constant prices. This was done using the "Industrial Production Index" (IPI) (CSO, *various years2*). This index measures "*trends in the volume of production of local units*" with three or more people engaged (MetaData from the IPI, CSO *various years4*). This index accounts for the "*quantitative volume of production*". The index is available for the years in question (1991 – 2007) with a base year of 2000 = 100.

Due to the nature of the index (all disaggregated values equal 100 per cent in 2000, regardless of actual volume), a breakdown at technology group level was impossible to decipher. As a result of this, the aggregate yearly volume index (accounting for NACE 10 – 41, which is outside the range of this research) at a national level was used to convert all prices. Therefore, values were changed over time, but cross-sectional values were not changed as it was assumed that all industries within all regional tiers experienced the same inflation effect during the same year. This was done in order to limit the margin of error. Please see Appendix B for a more extensive outline of this calculation.

In the case of this research, due to the nature of the data available, the proportion of manufacturing that is deemed "FDI" or "foreign-owned" was determined by the "*nationality of owners of 50 per cent or more of the share capital*" of the firms involved being a nationality other than Irish (CSO, 2009).

4.3 Classification of Industries and Regions

4.3.1 Industrial Classification

The classification of manufacturing industries was quite limited in terms of data confidentiality constraints arising from the CIP. Therefore, several combinations of industry classifications and regional classifications were tested before the data were obtained. Due to these confidentiality constraints, the methods employed by Lundquist *et al*. (2007; 2008) – the division of industries into "*theoretically stylised industry groups*", characterised as renewed, transformed, induced, contracting and obsolete – could not be employed. Their classification was carried out using time-series productivity as well as gross value-added data per industry, tracing the absolute and relative growth of industries over time and grouping them based on similarities in their growth and productivity trends. Therefore, an alternative means of classifying the industries prior to obtaining the data was necessary. Classifying industries into the four categories of Low, Low-Medium, Medium-High and High Technology was considered to encompass the element of technological difference. Using this classification would still indicate technological change through analysing how the composition changed over time, and it was possible to see how each group behaves differently as the process of transformation takes hold. Hence, EuroStat's "High-technology Classification of Manufacturing Industries" has been employed (EuroStat, 2005; see Table 4.1).

Table 4.1: Classification of Manufacturing Industries by Technology Level

Classification	Constituent Industries (NACE Rev 1.1 Classification)
Low Technology	Food, beverages and tobacco (15 and 16) Textile and Clothing (17, 18, 19) Wood, pulp, paper products, printing and publishing (20, 21, 22) Other manufacturing and recycling (36 and 37)
Low-Medium Technology	Coke, refined petroleum products and nuclear fuel (23) Rubber and plastic products (25) Non-metallic mineral products (26) Basic metals (27) Fabricated metal products (28) Shipbuilding (35.1) (35.11 and 35.12)
Medium-High Technology	Chemicals, excluding pharmaceuticals (24, *excluding* 24.4) Non-electrical machinery (29) Motor vehicles (34) Electrical machinery (31) Other transport equipment (35.2, 35.4 and 35.5) *[Aerospace (35.3)]
High Technology	Pharmaceuticals (24.4) Computers, office machinery (30) Electronics-communications (32) Scientific instruments (33)

Source: (Eurostat, 2005)

*Aerospace (35.3) is placed in the High Technology group by Eurostat, however this sector could not be disaggregated from 35.2, 35.4 and 35.5 when obtaining the data required for this research so it was placed in the Medium-High Technology group.

4.3.2 Regional Tier Classification

Lundquist *et al*. (2007) divided Sweden's regional system into the following tiers: "*1st tier (primate city), 2nd tier (other metropolitan areas), 3rd tier (large and mid-sized regions) and 4th tier (small regions)*". Ireland's regions have been categorised in a *similar* fashion for this research. Firstly, the Republic of Ireland's twenty-six counties were divided into tiered groups based on a defined typology. This typology is based on population levels, city status, commuter county status, core-periphery association and inherent characteristics according to the typology outlined in Appendix C. This was done so as to group counties of similar characteristics together in order to show which type of region leads, which type follows, which is left behind, etc. The populations were derived from the "County Population Time-series Dataset" for Ireland (CSO, *various years5*). This dataset comprises population census data from 1981, 1986, 1991, 1996, 2002, 2006 and 2011. In this way, the primary concern – each county's relative growth/decline in population was traced over time (see further Appendix C).

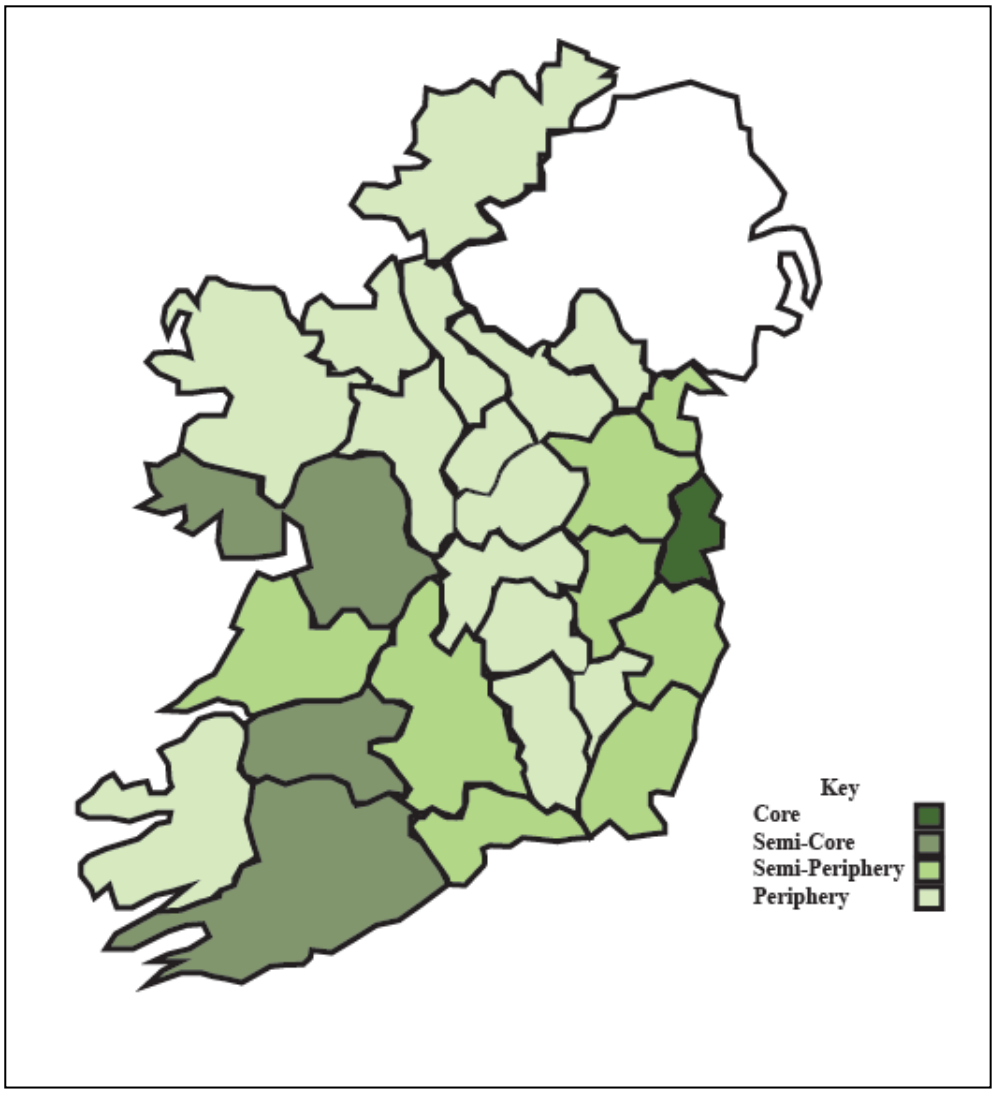
Table 4.2: Regional Tiers and Constituent Counties

Regional Tier	Description	Counties	Aggregate Population*	Average Population*
Core (1st Tier)	*Primate City*	Dublin	1,270,603	1,270,603
Semi-Core (2nd Tier)	*Medium-sized City-County*	Cork, Galway, Limerick	959,975	319,992
Semi-Periphery (3rd Tier)	*Outside City/Commuter Regions*	[Kildare]**, Meath, Louth, Wexford, Wicklow, Clare, Tipperary, Waterford	1,187,762	148,470
Periphery (4th Tier)	*Small Regions*	Donegal**, Kerry**, Mayo**, Kilkenny, Westmeath, Laois, Offaly, Cavan, Sligo, Roscommon, Monaghan, Carlow, Longford, Leitrim,	1,162,929	83,066

**Source*: Census 2011 (CSO, 2011), *own calculations*

**These counties have considerably higher populations than the other counties in the group but are more closely associated with the tier in which they have been placed. See further Appendix C.

Figure 4.1: Map of Regional Tiers' Constituent Counties



Despite these classifications, within the Low and Low-Medium Technology groups the data were not available for the Periphery in the years 2000, 2005 and 2007 and for the Semi-Core for the year 2005. These missing values were substituted with the value from the previous year, due to difficulties in extrapolation and/or interpolation for the Periphery as there were more than two missing data points. Further to this, a very small proportion of manufacturing firms could not be attributed to any group or regional tier and were thus excluded from this research.

4.4 The Research Model

4.4.1 National Trend Analysis

General trends related to sectoral change in the manufacturing employment structure were analysed, noting the growth/decline in employment within and between technology groups. Key statistics such as overall growth/decline of each technology group during the time period 1991 – 2007, growth rates between years and average growth rates for the entire period have been highlighted. This was done in order to gain an overall picture of the change in the composition of employment for the manufacturing industry for the time period under consideration. This was done using "persons engaged" per technology group.

National manufacturing productivity was traced over the seventeen-year period in order to gain a picture of what the national trend in relation to productivity has been over the time period. Both the data from the CIP (net output per person) and from the IPI (volume index) were used. From there, the decomposed (technology group and regional tier) trends could be deciphered.

The overall productivity at a technology group level over time was analysed to determine the relative positions of each group: which groups are growing, which are declining, etc.

The ratio of FDI productivity to indigenous productivity on a national level over time was analysed to gain a picture of the changing patterns of the contribution and/or dominance of FDI-associated productivity in the manufacturing industry (see Equation 1).

Equation 1: *Ratio = NFI/NII*

An OLS (Ordinary Least Squares) bivariate regression was carried out using the variables of net output per person engaged (productivity) associated with FDI (x variable) and net output per person engaged (productivity) associated with indigenous industry (y variable). This was done in order to gain a picture of the relationship between the two variables over time; whether there is a weak, moderate or strong connection between the two. This was carried out for the entire 17-year period (1991 – 2007). Please see Equation 2.

It is acknowledged that there would presumably be an underlying relationship between productivity arising from the foreign component and from the indigenous component, and that this would thus give a strong co-efficient of correlation and co-efficient of determination between the two. However, because all regional tiers and technology groups are within the same economy and subject to the same economic conditions, the analysis is considered relative, and thus, can still give a good picture of the strength of the relationship on a technology group level and at a regional tier level. However, it could be considered overly presumptuous to suggest that foreign productivity can serve as an explanatory variable for indigenous productivity. Nevertheless, it is considered that such regressions show the overall *relationship* between the two. This is based on Hayes' (2005, p.68) consideration of the "strength of association" between variables, represented by co-efficients of both correlation and determination. Clearly, there are many reasons why there may be varying degrees of association between foreign and indigenous industry, but the aim here is to suggest that a strong association, for example, would suggest a greater degree of embeddedness of foreign industry than a moderate or weak association. A threshold p-value of ≤ 0.05 for the t-statistic was assigned to all regressions.

Equation 2: $y = \alpha_{NFI} + \beta x_{NII} + \varepsilon$

"NFI" represents the total productivity arising from the foreign component of the manufacturing industry at a national level.

"NII" represents the total productivity arising from the indigenous component of the manufacturing industry at a national level.

The ratio of FDI productivity to indigenous productivity within technology groups over time was also analysed to gain a picture of the changing patterns of the contribution and/or dominance of FDI-associated productivity in the manufacturing industry in a decomposed fashion. A regression (as outlined above) was carried out for each technology group. This consideration is highly important in that it shows whether the strength of the relationship between foreign-owned and indigenous in sectors which are often considered "entrepôt" (please see Section 3).

Equation 3: $Ratio = FI_{TG}/II_{TG}$

Equation 4: $y = \alpha_{FITG} + \beta x_{IITG} + \varepsilon$

"FI_{TG}" and "FITG" represent the productivity arising from the foreign component of the manufacturing industry for each technology group.

"II_{TG}" and "IITG" represent the productivity arising from the indigenous component of the manufacturing industry for each technology group.

4.4.2 Regional Tier Trend Analysis

Firstly, each regional tier's overall productivity was analysed to determine inter-regional trends. Secondly, each regional tier's constituent technology groups' productivity was analysed to determine trends within regional and between regional tiers in terms of their composition of manufacturing productivity. The sigma convergence (co-efficient of variation, see Equation 6) between the regional tiers' levels of overall manufacturing productivity were measured to determine whether there is divergence or convergence occurring.

Equation 5: $CV_{TTG} = SD_{TTG} / \ddot{X}_{TTG}$

"TTG" represents the aggregate (total) productivity arising from all technology groups combined in each regional tier.

The sigma convergence between regional tiers of the productivity arising from the four technology groups was then assessed in order to show whether there is a trend of divergence or convergence over time at a technology group level between regional tiers. Moreover, this analysis shows which technology groups have the most and least levels of convergence (see Equation 6).

Equation 6: $CV_{RTTG} = SD_{RTTG} / \ddot{X}_{RTTG}$

"RTTG" represents the productivity arising from each of the four technology groups at a regional level. This calculation was obviously repeated for each of the four technology groups under consideration.

The ratio of FDI productivity to indigenous productivity within regional tiers over the time period was also analysed to gain a picture of the changing regional patterns of the

contribution and/or dominance of FDI-associated productivity in the manufacturing industry. A regression between foreign and indigenous productivity (as outlined in Section 4.4.1) was carried out for each regional tier.

Equation 7: $Ratio = FI_{RT}/II_{RT}$

Equation 8: $y = \alpha_{FIRT} + \beta x_{IIRT} + \varepsilon$

"FI_{RT}" and "FIRT" represent the productivity arising from the foreign component of the manufacturing industry for each regional tier.

"II_{RT}" and "IIRT" represent the productivity arising from the indigenous component of the manufacturing industry for each regional tier.

4.5 Limitations

The most important limitations of this research are as follow:

City-regions to not coincide with county boundaries (see further Davoudi, 2008). Some parts of counties may be considered "core" areas and some "peripheral", however the counties are categorised depending on their overall characteristics.

This research cannot be directly compared to Lundquist *et al*. (2007; 2008) due to the slight differences in data and methods.

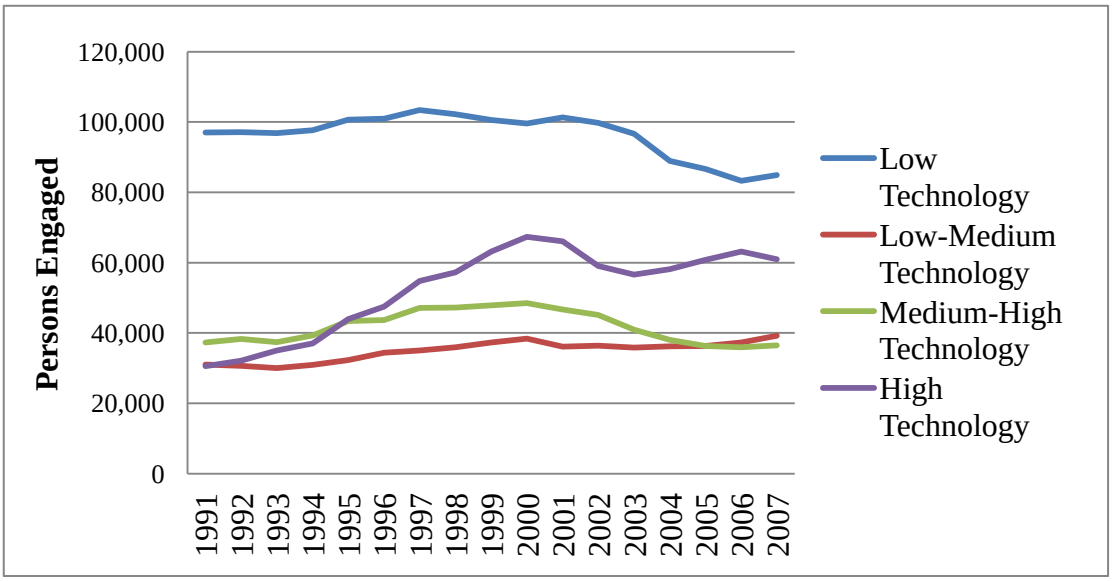
The data are rather coarse-grained. Therefore, one cannot really decipher whether one industry in particular is supporting the entire technology group or whether one county is supporting the entire regional tier, for example.

Net output per person engaged in manufacturing is used as a proxy for productivity. This measure does not encompass all forms of productivity but it was considered the best measure within the scope of limitations associated data availability.

Section 5: Results and Analysis

5.1 National Trend Analysis

Figure 5.1: Employment by Manufacturing Technology Group



Source: (CSO, *various years3, own calculations*)

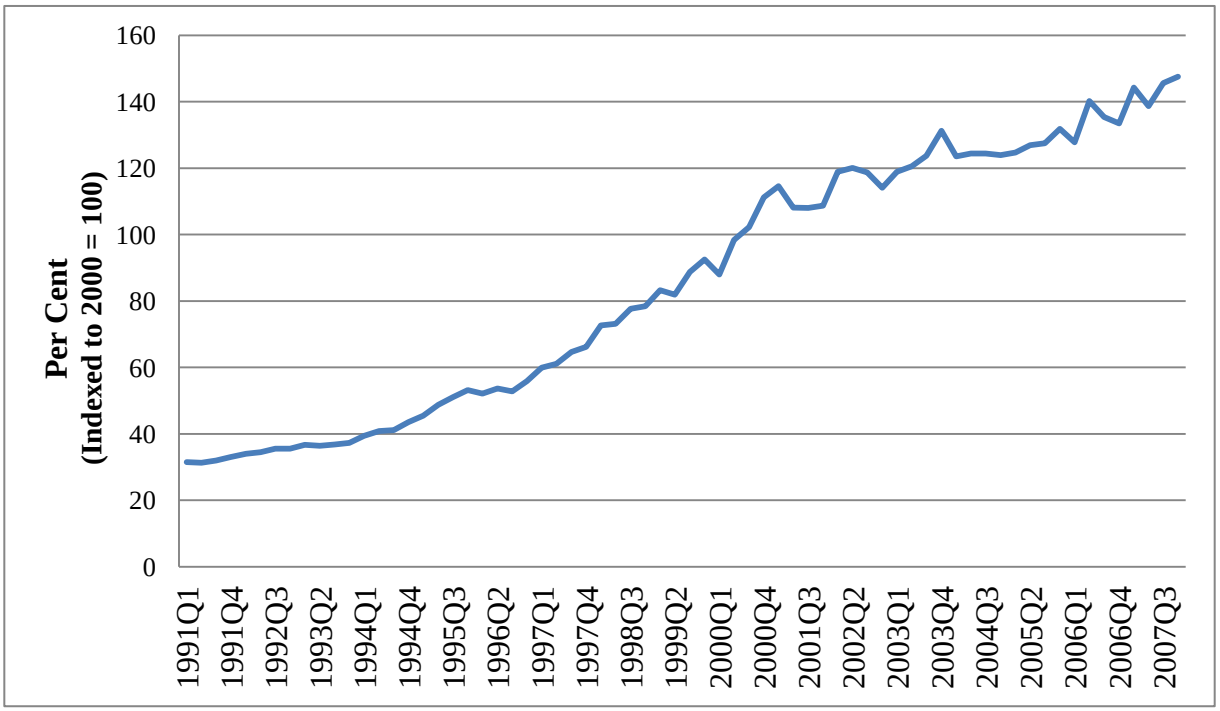
Before decomposing the productivity of the manufacturing industry at a regional level, it is first useful to focus on the national trends. Initially, it is important to consider and analyse the changing numbers of people working in each technology group over the time period (1991 – 2007). When looking at Figure 5.1 it is notable that the Low Technology group employs more people than any other technology group at approximately 100,000 employees for most of the time period. Its level of employment decreases from 2002 onwards, evening out at just less than 85,000 towards the end of the period. The High Technology group, employing just over 32,000 at the beginning of the period (1991), sees the highest growth in terms of employment until 2000, when it sees a slight dip, before levelling off at just over 60,000 in 2007 (almost double the number it employed in 1991, and 75 per cent of the employment of the Low Technology group). The Low-Medium Technology group shows stable, very slow, growth, whereas the Medium-High Technology group rises towards the middle and declines towards the end of the period.

These trends are, in part, consistent with the technology shift thesis, in that the High Technology group sees an absolute and relative increase in employment for the period, while

the Low Technology group sees an absolute and relative decline. The increasing presence of the High Technology group shows that a technology shift and a change in structure is taking place. The Low Technology group is, however, very dominant in terms of employment, which is, of course, an undesirable trend in terms of productivity growth. It seems that the Low-Medium and the Medium-High Technology groups do not really take part in the shift to the same extent as the other two groups, at least in terms of employment. Further analysis below will give a greater insight into what is happening in more detail.

Figure 5.2: National Volume Output Index of Production Industries

(NACE Rev. 1.1 10 - 41)

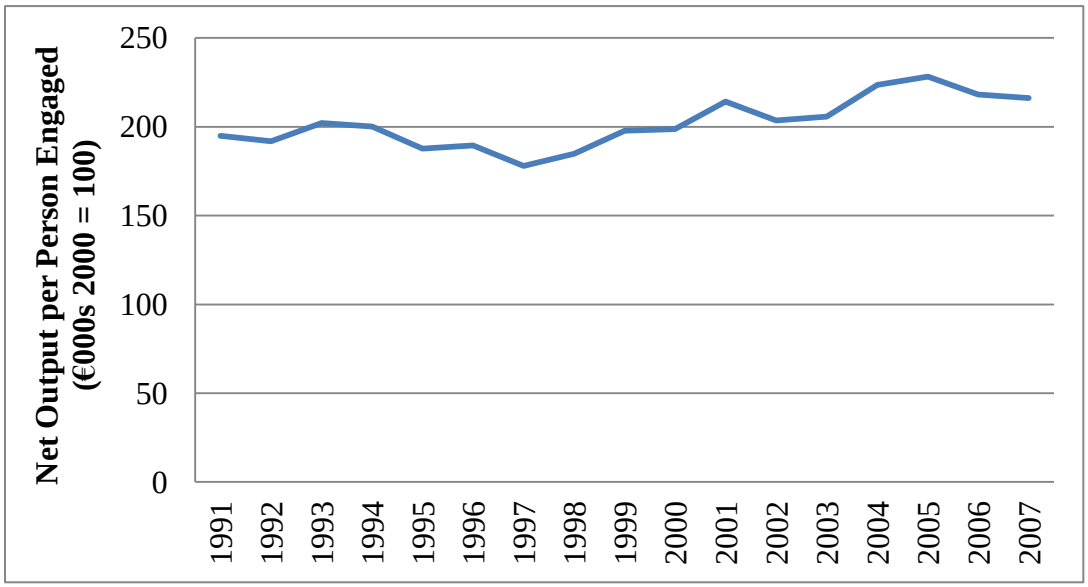


Source: CSO (*various years2*)

Although volume output data are not available exclusively for the technology groups with which this research is concerned (NACE Rev. 1.1 15 – 37), they are available for NACE 10 – 41, as in Figure 5.2. These data are still considered to give a good representation of manufacturing output for the groups under scrutiny here as these groups account for the majority of production. It is clear to see from Figure 5.2, that volume output has increased dramatically from approximately 30 per cent of the output of 2000 in 1991 to c.145 per cent by the end of the period in 2007.

Figure 5.3: National Level Manufacturing Productivity

(NACE Rev 1.1 15 - 37)



Source: (CSO, *various years3*, *own calculations*)

Zooming in on manufacturing productivity (Figure 5.3), a very different trend emerges to that of the employment and volume output trends. Net output per person (in euro corresponding to 2000 = 100) sees growth from just under €195,000 in 1991 until 1994 before declining until 1997, where its productivity begins to grow again. This growth continues towards the end of the period, finishing at €216,000 per person engaged in 2007. This trend (with a turning point in the late 1990s) suggests that there is a period of rationalisation beginning when the innovations become standardised, costs decrease and productivity increases (see Schön, 2007; 2009). The volume output also reflects this consideration, with the level of production output increasing much more rapidly than before towards the mid-1990s and beyond.

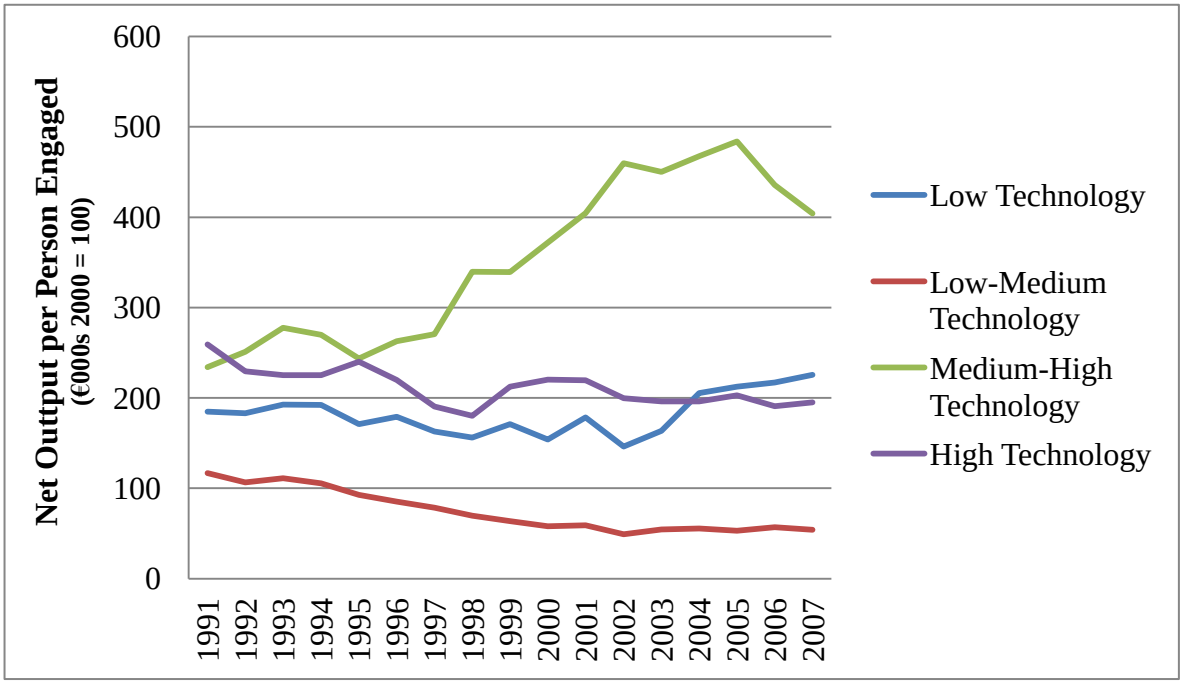
There are several possible explanations for the differences in the trends of Figure 5.2 (volume output) and Figure 5.3 (net output per person engaged). Primarily, the former sees much stronger growth than the latter. The first, and probably most likely reason, could be a decrease in prices (as mentioned above). The second could be that the manufacturing industry comes to employ more people with less output per person. The third could be that the composition of goods produced has changed to constitute an increased proportion of lower value-added, higher volume goods. The outcome could also, of course, be a combination of all three considerations. The decrease in prices, however, is considered the most likely as it is

in keeping with the technology shift thesis, in that costs begin to decrease at the start of rationalisation and the production is not as experimental as it was during transformation (see Lundquist and Olander, 2010).

The Swedish case showed that there was a lagged productivity development compared to employment and volume changes (Lundquist *et al*., 2007). The Irish case mirrors this, as it can be seen from Figure 5.1 that the increases in employment begin in c.1994-1995 for all technology groups (albeit at different slopes). Figure 5.2 shows that volume output begins to increase to a much greater extent also in c.1994-1995. However, 5.3 shows that productivity does not begin to increase to a much greater extent until after 2000.

The decomposition at technology group level below gives a greater insight into – and explanation for – these trends.

Figure 5.4: Productivity by Manufacturing Technology Group



Source: (CSO, *various years3, own calculations*)

Having analysed the overall national trends, it is now important to focus on the trends at play within and between the technology groups themselves for the time period (see Figure 5.4) to give an indication as to when, to what extent, and in which sectors the structural change occurred. The High Technology group starts off as the most productive of the four at the beginning of the period, before immediately being overtaken by the Medium-High

Technology group in 1991-1992. The Medium-High Technology group, in fact, sees much greater growth than any other group for the time period, with its position advancing from 1995 for a decade before beginning to decline sharply in 2005. The High Technology group sees nowhere near the same growth, and nowhere near the same levels of productivity as those arising from the Medium-High Technology group. See Appendix D for growth rates of technology groups.

The Medium-High Technology group appears to be the forerunner in terms of productivity improvement for the time period in question. In that way, it seems that this group is the leader in the technology shift. However, it must be questioned why the shift occurs primarily in the Medium-High Technology group and not in the High. Counter-intuitive to the technology shift thesis, the high point of productivity for the High Technology group is at the beginning of the period, with its productivity levels declining from that point onwards.

The Low Technology group sees a very similar trend to that of the High Technology group in terms of productivity development, but does not experience such strong levels of productivity until 2004, where the two groups intersect and the Low Technology group passes out the High. The revitalisation of the Low Technology group at the end of the period could, for a large part, be attributed to the "Food, Beverages and Tobacco" sector (NACE 15, 16) of the group, as a number authors note its dominance in terms of productivity (O'Sullivan, 2000; Honahan and Walsh, 2002; and Ó'Riain, 2004) as it has increasing output but decreasing numbers of employees (Ó'Riain, 2004). Furthermore, some of these authors have pointed out that the huge productivity arising from the cola concentrate production industry has an effect on the productivity statistics for the Food, Beverages and Tobacco sector, which will be discussed further below. This is however, simply speculation, as without disaggregated data, it is impossible to know for sure.

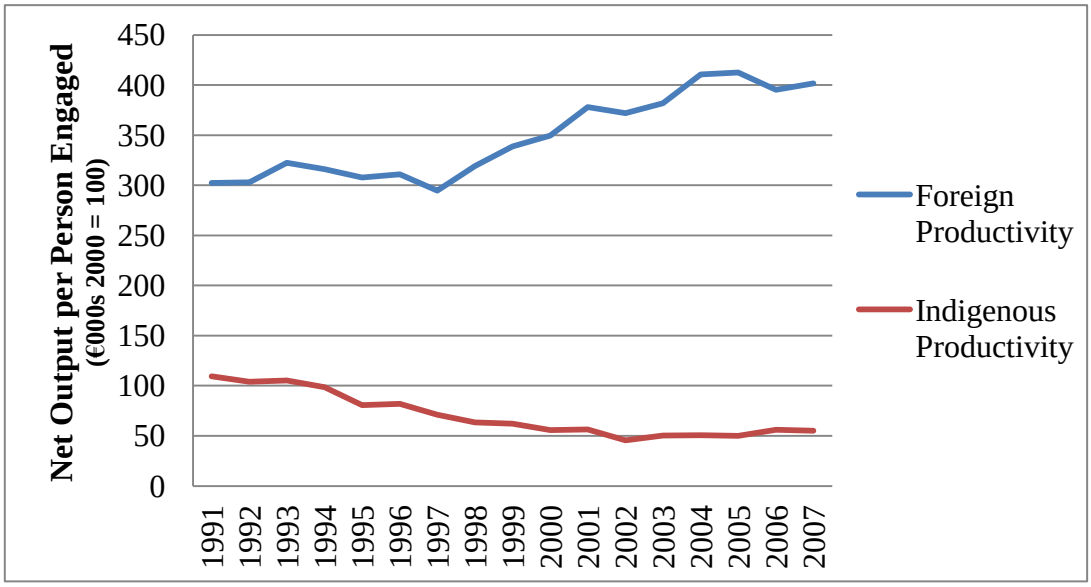
The Low-Medium Technology group sees the least growth over the time period, in fact, considerably less than the other three technology groups. Its growth rates decline substantially (relative to the other groups' rates) from 1993 – 2000, and from that point, its growth rates begin to level off (see Appendix D for growth rates). The results for the Low-Medium Technology group are very different to those of Sweden, where the induced industries (roughly similar to the Low-Medium Technology group) began as the smallest and weakest-growing until the mid-1980s. They then grew at a rapid rate for many years, until

they experienced weak growth again towards the end of the period (Lundquist *et al*., 2007). This is, of course, very different to Ireland's trend, where this group declined until 2002, before seeing next to no growth until 2007.

The above considerations, especially the lack of productivity development in the High Technology group could indicate that *process* innovation took hold in Ireland much more so than product innovation. This would result in increased productivity and lowered costs, but little or no development of new products, whereas in Sweden, the technology shift was much more associated with product innovation (see further Lundquist *et al*., 2007; 2008). Therefore, it could be theorised that Ireland did not create new products in the same way as in Sweden.

Zooming in on the composition of the productivity changes discussed previously, it is important to focus on the productivity that arises from the foreign element of the manufacturing industry compared to the productivity that arises from the indigenous element. This is due to the exogenous and FDI-focus associated with Irish industrial policy, as discussed in Sections 2 and 3.

Figure 5.5 National Level Foreign and Indigenous Manufacturing Productivity
(NACE Rev. 1.1 15 - 37)

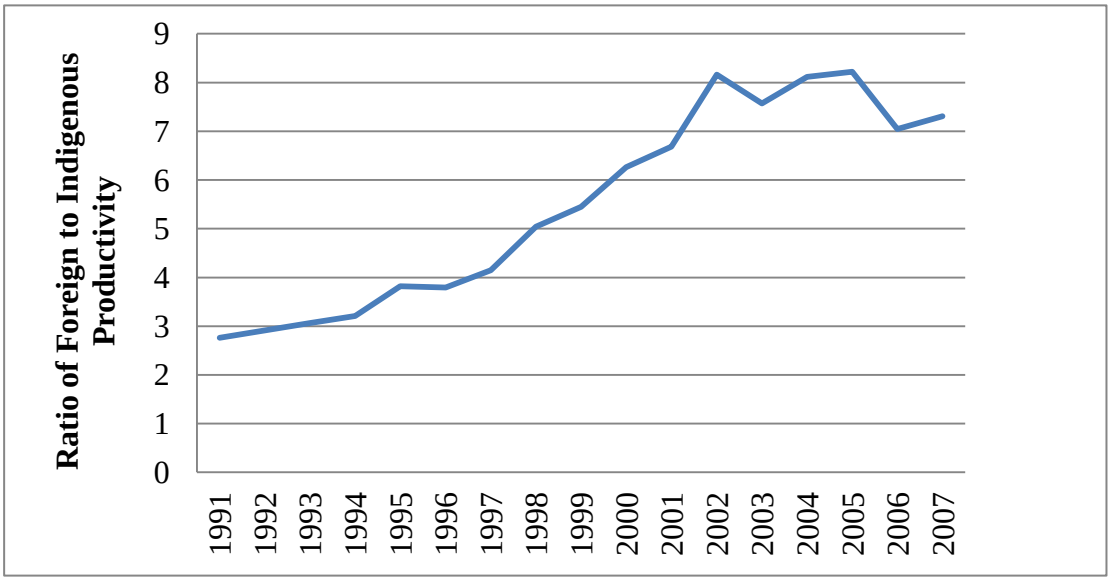


Source: (CSO, *various years3, own calculations*)

Focusing firstly on the national trends associated with FDI manufacturing productivity (Figures 5.5), it can be seen that, on average the productivity arising from foreign firms

increases over time, while the productivity arising from indigenous industry decreases. In absolute terms (Figure 5.5), the increase of the foreign element is much less dramatic than relative to the productivity arising from the indigenous sector (Figure 5.6) where there is an evident large increase in the proportion arising from foreign firms.

Figure 5.6: National Ratio of Foreign to Indigenous Productivity in Manufacturing
(NACE Rev. 1.1 15 - 37)

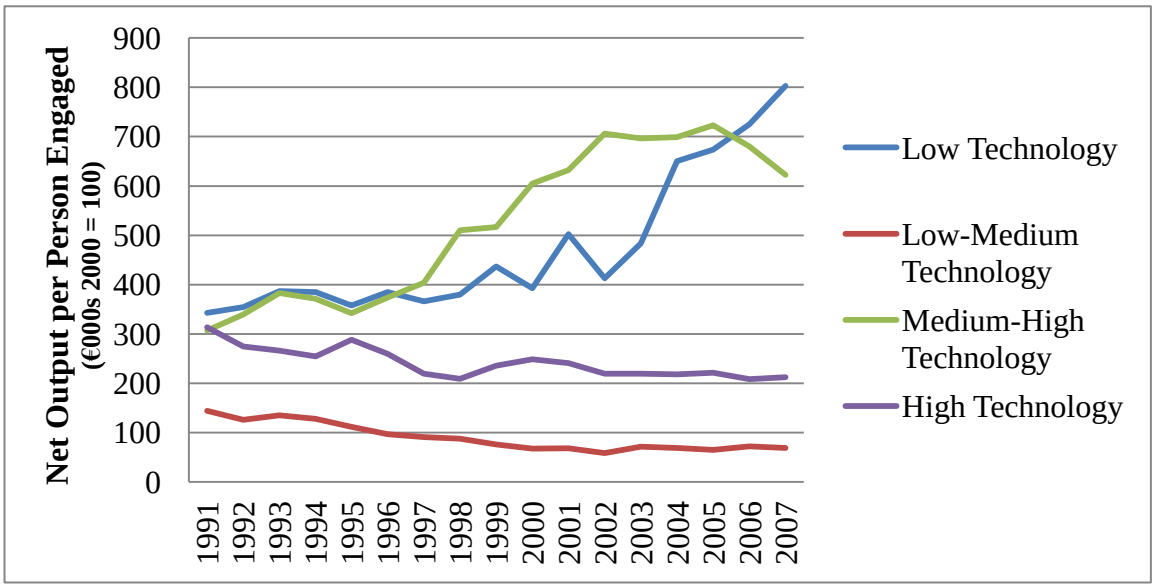


Source: (CSO, *various years3, own calculations*)

Focusing on Figure 5.6, the level of foreign productivity rises from just under three times that of indigenous productivity in 1991, peaking in 2002 at just over eight times that of indigenous, before declining to 7.3:1 in 2007. This highlights the enormous presence of foreign firms in the manufacturing industry in Ireland, and also, their substantial contribution to overall productivity.

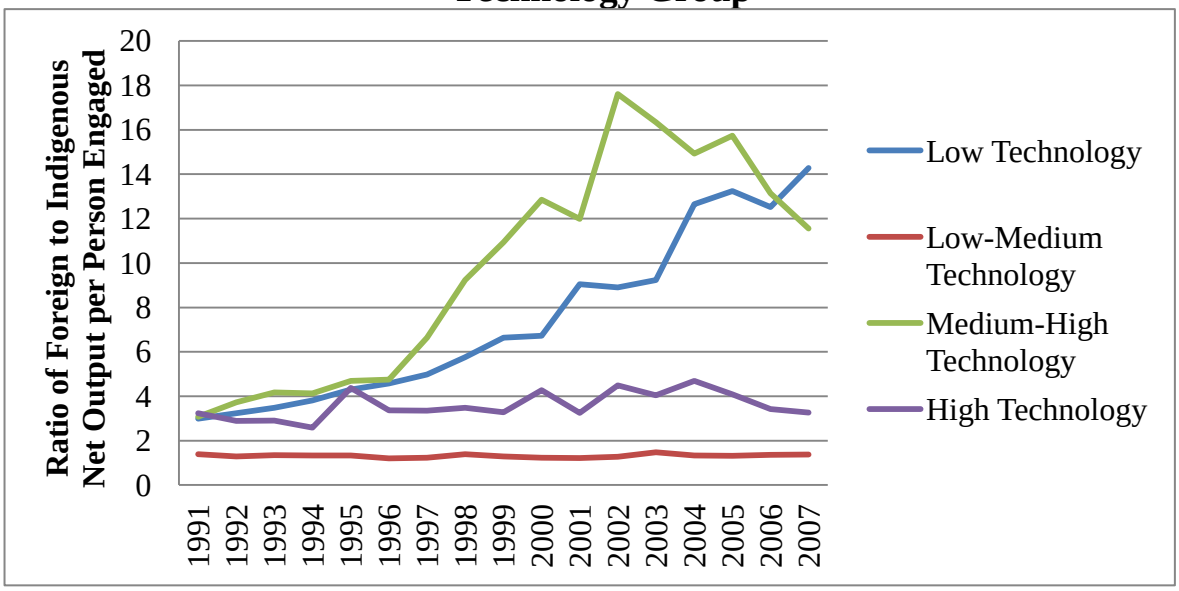
The "dual economy" referred to by Lin *et al*. (2010, discussed in Section 3) is quite evident here, with a strong increase in foreign productivity and a decline in indigenous productivity. This indicates that the foreign sector is highly productive while the indigenous is much less so. Decomposing these changes, firstly, by technology group and then by regional tier give a greater indication as to the sub-processes as play.

Figure 5.7: Foreign Productivity by Technology Group



Source: (CSO, *various years3, own calculations*)

Figure 5.8: National Level Ratio of Foreign to Indigenous Productivity by Technology Group



Source: (CSO, *various years3, own calculations*)

From Figures 5.7 and 5.8, we can see that the Medium-High Technology group hosts both the highest levels and highest proportions of FDI manufacturing productivity, falling into second position to the Low Technology group in terms of productivity levels at both the beginning and the end of the period. The Low-Medium Technology group experiences the least change in its proportion of FDI over the period. It also has much less presence of FDI than any of the other technology groups, despite aforementioned policy efforts.

Table 5.1: The National Level Relationship between Foreign and Indigenous Manufacturing 1991 - 2007

(NACE Rev. 1.1 15 – 37)

X Variable: Foreign Productivity	Y Variable: Indigenous Productivity	Regression number	Co-efficient of Determination R^2	P-value of t-statistic
Overall		1.	0.6000	(0.0005)
Low Technology		2.	0.3480	(0.01)
Low-Medium Technology		3.	0.9724	(0.0005)
Medium-High Technology		4.	0.7930	(0.0005)
High Technology		5.	0.5336	(0.0005)

Source: (CSO, *various years3, own calculations*)
Insignificant: ($p > 0.05$)
See further Appendix E.

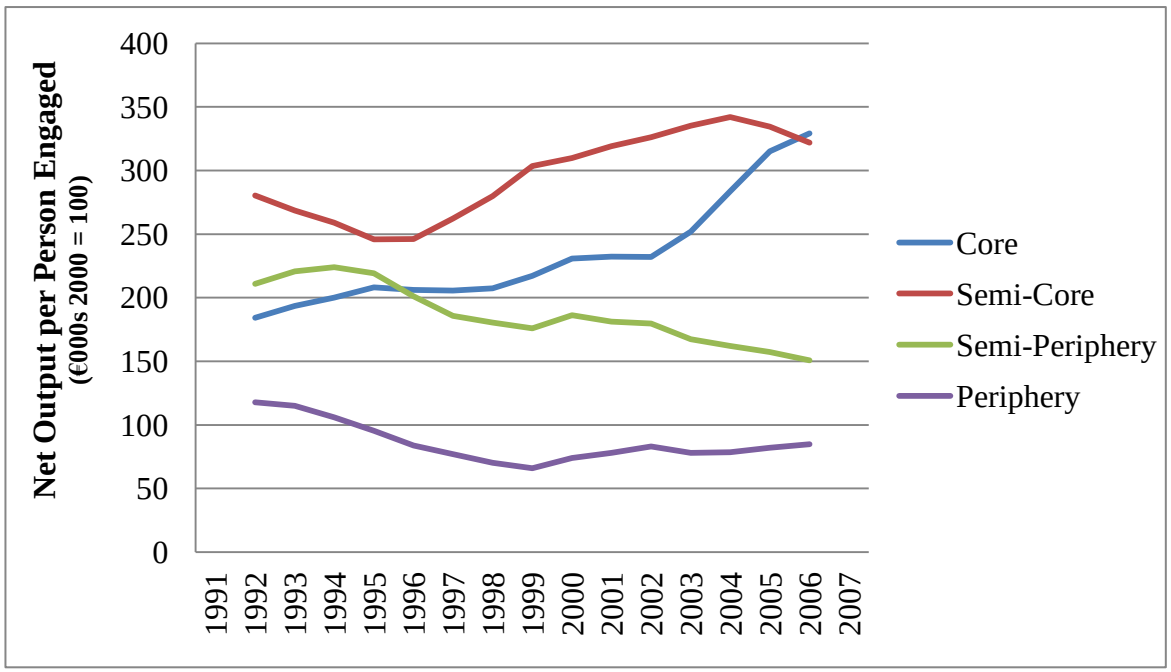
One of the results of greatest interest from the regressions carried out is the relatively moderate-strong association between the foreign and indigenous productivity components of the manufacturing industry at a national level for the period as a whole (1991 – 2007).

Interestingly, there is a weak-moderate association between foreign and indigenous productivity in the Low and High Technology groups, and the contrasting strong relationship between the variables within the other two groups. Looking back to Section 3 (Literature Review), some authors (Honahan and Walsh, 2002; Ó'Riain, 2004) pointed to the existence of entrepôt industries especially within both the High and Low Technology groups. Therefore, the embeddedness of the foreign enterprises within these groups could be further questioned, given the results of these regressions. These results add further weight to the consideration that perhaps the foreign component is not so related to the indigenous within these groups. This gives rise to the following questions: if indigenous productivity growth is not strongly linked to that of the foreign component, what is the differentiating factor?; why is there a differentiating factor in the first place?; and how could both components begin to converge in terms of productivity, if possible?

5.2 Regional Level Trend Analysis

Figure 5.9: Manufacturing Productivity by Regional Tier

(NACE Rev. 1.1 15 – 37) (3-Year Moving Average)



Source: (CSO, *various years3*, *own calculations*)

From looking at Figure 5.9, at the beginning of the period, the Core's levels of productivity are behind both the Semi-Core (to a large extent) and the Semi-Periphery (to a much lesser extent). From about 1995 onwards, the Core's productivity increases to above that of the Semi-Periphery. The Core begins to grow considerably from c.2002 onwards. At the very end of the period, the Core appears to begin to push ahead of the Semi-Core in terms of productivity.

There are several possible reasons for the Core's seemingly weak position in terms of manufacturing productivity, relative to that of the Semi-Core for the majority of the time period. One of such reasons could be the prominence of the services sector in the Core (especially financial services, see further Begley *et al.*, 2005), with the Semi-Core focusing much more on manufacturing. A second reason could be that elements associated with manufacturing productivity have already disseminated to the Semi-Core by the start of the

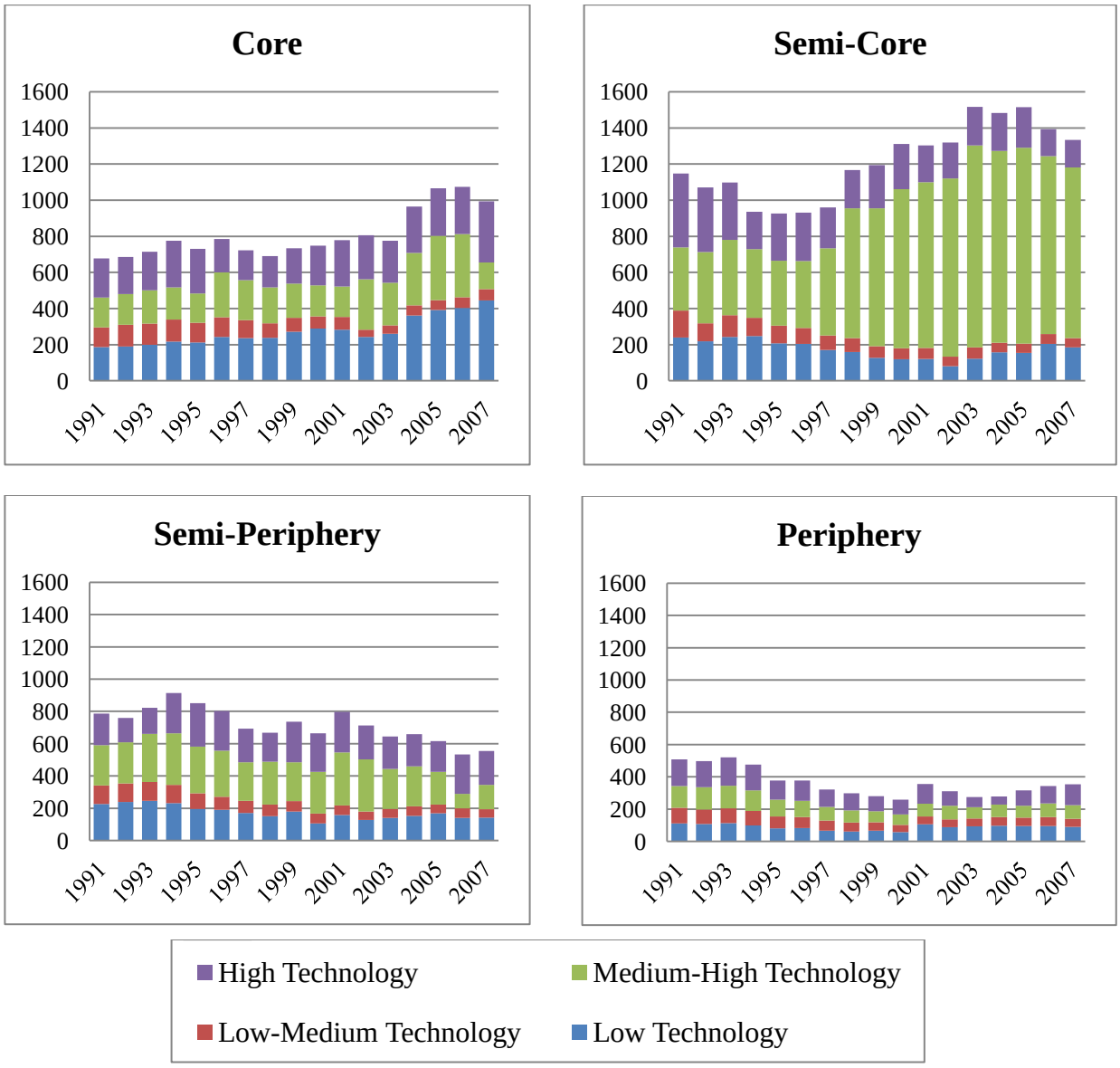
period, due to decreasing transaction costs and strained resources in the Core (see further Lundquist and Olander, 2010).

Unlike the Core and Semi-Core, the Semi-Periphery experiences a decline in productivity for the entire time period. The Periphery regional tier experiences much lower levels of productivity than the other regional tiers. This variation in growth forces for the different regional tiers is compliant with Lundquist *et al*.'s (2007) application of the technology shift thesis to Sweden's regional development, as it highlights the different roles regions play at different stages of the transformation process.

A potential reason for the Semi-Periphery's decline could be that the elements associated with increased productivity have not (yet) diffused to this regional tier, and it is therefore "missing out" on the productivity increases that the other regional tiers are experiencing. This trend, however, conflicts with the results of Lundquist *et al*. (2007). In the case of Sweden, they found that the top-tier regions (the equivalent of the Core and Semi-Core) had the highest labour productivity at the beginning of the time period, whereas after 2000, they had switched roles with the lower tier regions. This "switch" has not (yet) happened for Ireland's regional system.

It could be theorised that there is either a counter-force at play with regard to diffusion within the manufacturing industry in Ireland, or perhaps the exogenous processes associated with FDI are disrupting the national path. One of such processes at play could be the product life-cycle theory as mentioned in Section 3 (see further Buckley and Ruane, 2006; van Egeraat and Jacobson, 2004; Barry and van Egeraat, 2008). This theory puts forward a process whereby (most probably FDI in this case) manufacturing takes place in one economy with an initially low cost base, and when its costs begin to increase, the manufacturing moves to a host country with a lower cost base. As discussed in Section 3, Buckley and Ruane (2006) consider that this is a relevant theory for Ireland's manufacturing industry. Having to some extent, deciphered the trends occurring on a regional level, the following more detailed decomposition gives a clearer picture as to the intra-regional trends taking place within the manufacturing industry (Figure 5.10 below).

Figure 5.10: Changing Patterns of Manufacturing Technology Group Productivity within Regional Tiers (Net Output per Person Engaged)



Source: (CSO, *various years3, own calculations*)

From Figure 5.10, it is clear that the productivity of the Low Technology group increases dramatically for the Core over the course of the time period, in both absolute and relative terms. The strong presence of the Low Technology group in the Core is an interesting trend, one that cannot be fully understood without disaggregated data. As outlined above, the cola concentrate producing industry is extremely productive and is considered to add greatly to the productivity of the Low Technology group. This industry is primarily located in Dublin (the Core). Therefore, it could be considered that perhaps the large productivity increases

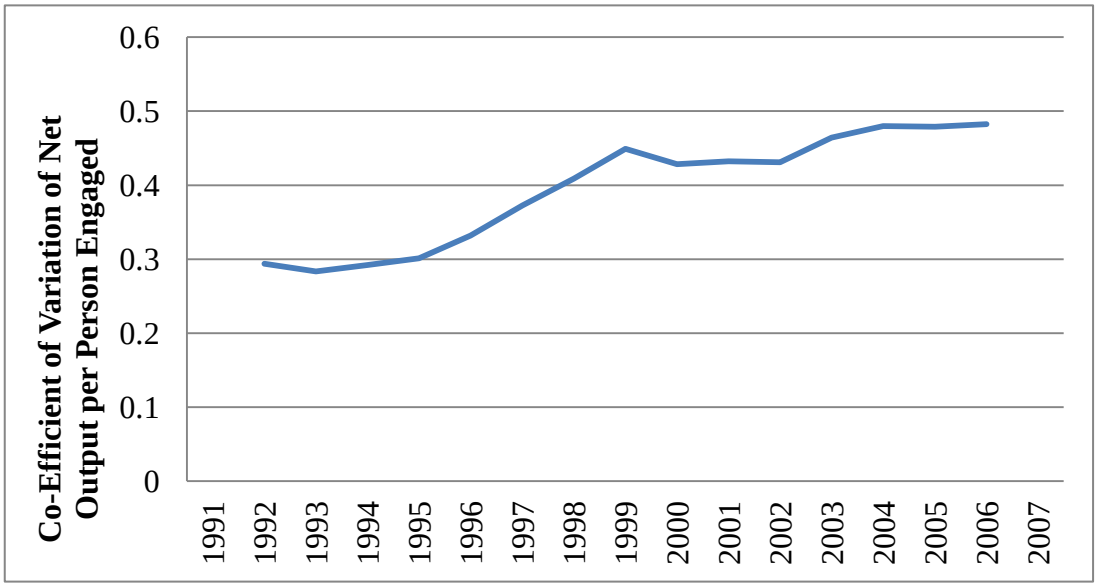
attributed to the Core from the Low Technology group are associated with the cola production industry. This, of course, is just speculation.

Interestingly, both the Semi-Core and Semi-Periphery experience higher productivity within the Low Technology group at the beginning of the period, with its levels of productivity falling from the early 1990s onwards, before increasing much less dramatically than it does for the Core from the early 2000s. This trend is also considered in Lundquist *et al*. (2007), where they describe how "*the production of obsolete industries* [roughly the same as the Low Technology group] *could be expected to diffuse to smaller regions through the technology shift, but will later concentrate towards the top of the hierarchy*".

It is clear to see that, the Semi-Core regional tier experiences the highest levels of productivity. The presence of the Medium-High Technology group increases considerably for the Semi-Core, reaching its peak in 2003, accounting for, by far, the greatest proportion of productivity in the regional tier. This trend in the Semi-Core is of great interest as it is the strongest regional tier in terms of absolute productivity, and in terms of technology groups mix (much of its productivity arises from a higher technology group). It could be questioned whether the Semi-Core has always led the transformation process in this way, or whether its "success" in terms of productivity has already diffused from the Core since the 1970s and 1980s, with the Core moving towards services due to strains on the resource side, as discussed by Lundquist *et al*. (2007).

The Semi-Periphery experiences the least change over the time period compared to the other regional tiers. Notably, its High Technology proportion does not decline to the same extent as that of the Core and Semi-Core. It, in fact, shows a strong proportionate increase in 2006. Although the Semi-Periphery does not catch up to either of the higher regional tiers in terms of productivity, this strong presence of the High Technology group could be as a result of diffusion from the transformation process. Much of the Semi-Periphery comprises large populations outside of cities (such as Kildare, Meath, etc.; counties that are considered to experience agglomeration economies). This strong presence of the High Technology group could be as a result of decreased costs in these commuter belt locations, relative to the Core and Semi-Core (which encompass cities). This outside-of-city High Technology trend could also be as a result of diffusion, with these regions developing the "*receiver and development competence*" (Lundquist *et al*., 2007).

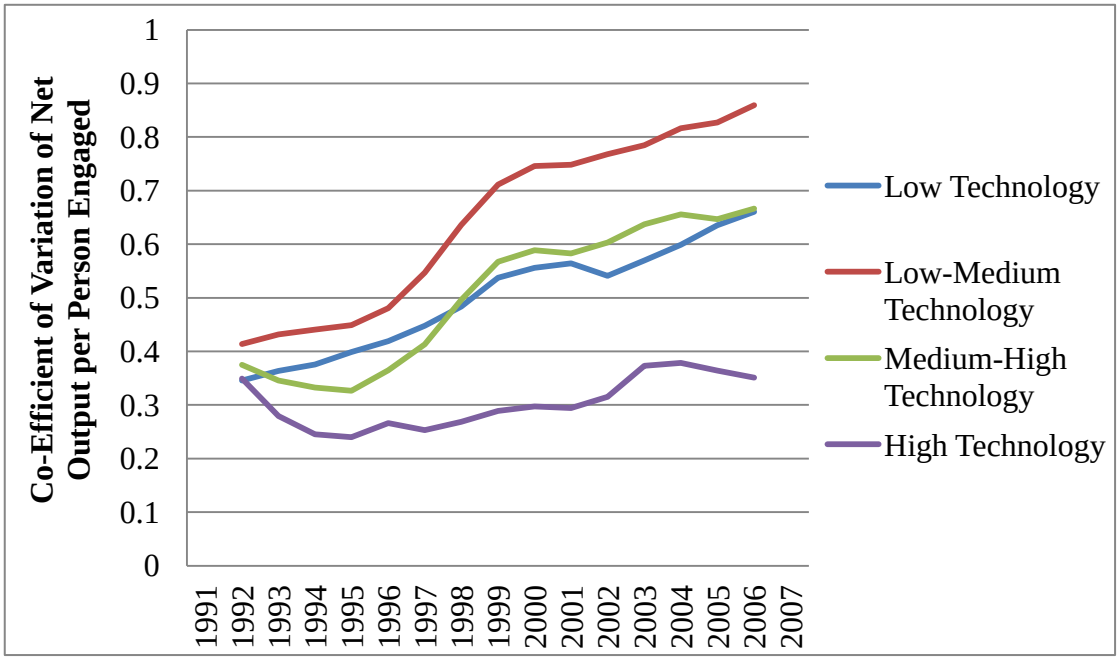
Figure 5.11: Sigma Convergence of Manufacturing Productivity between Regional Tiers
(NACE Rev 1.1 15 - 37)
(3-Year Moving Average)



Source: (CSO, *various years3, own calculations*)

From Figure 5.11 above, we can see that, overall, the regional tiers diverge over time in terms of productivity. The co-efficient of variation increases from 1991, before peaking in 1999 and declining for a short period until 2002 before increasing again. This initial process of increasing divergence between regions is a characteristic of the transformation stage of the technology shift owing to agglomeration economies in larger regions and a feedback loop of cumulative causation (Schön, 2007, see further Section 2.3). This trend was also noted by Lundquist *et al*. (2007; 2008) in their study of Sweden. They do, however, point out that the rationalisation stage then brings with it a process of increasing convergence for the regional system (Lundquist and Olander, 2010). Towards the end of the period, divergence ceases to increase for Ireland's regional system, and then begins to level out. This could be a first sign of the beginning of entering the rationalisation period. This coincides with the national trends in prices and volume output, as discussed at the beginning of this Section. Although, however, this trend of standardisation between regional tiers is lagged almost ten years behind volume output and about five years behind productivity. This is, however, expected as geographical implications of productivity change tend to manifest themselves at a later stage.

Figure 5.12: Sigma Convergence of Productivity between Regional Tiers by Technology Group
(3-Year Moving Average)



Source: (CSO, *various years3, own calculations*)

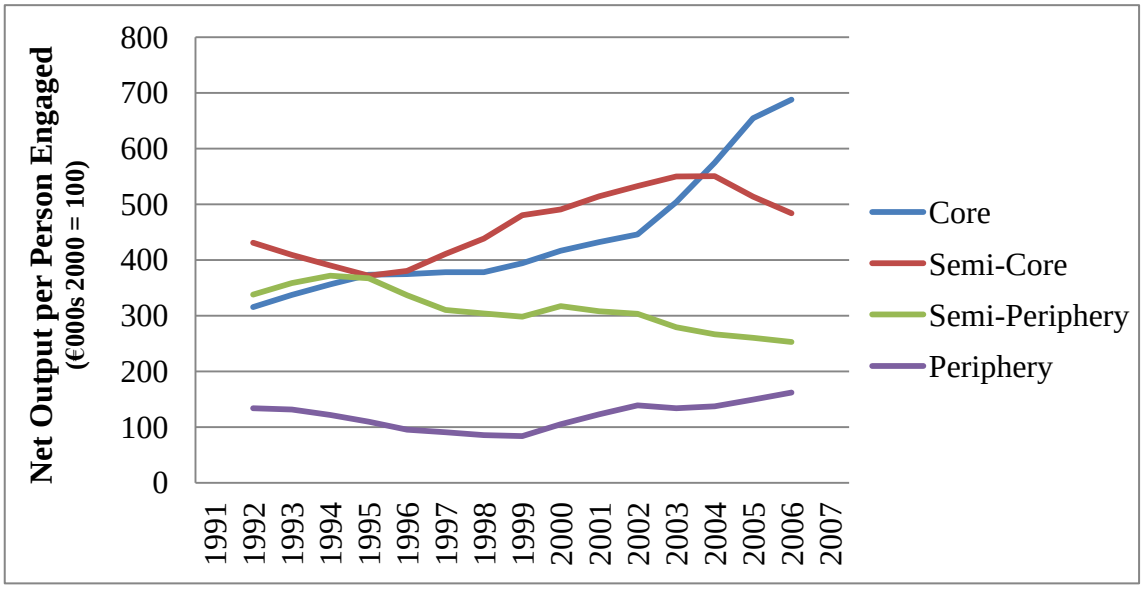
From Figure 5.12, it is evident that, over the entire time period, there is no convergence between the regional tiers in terms of their productivity arising from each of the technology groups. All technology groups (except for the High Technology group) end with a much higher co-efficient of variation than they had at the beginning of the period. The Low-Medium Technology group starts with the highest level of dispersion, which steadily increases over time between the regional tiers. The Medium-High Technology group also sees a steady increase from 1996 onwards (this trend is also reflected in the massive growth of the Medium-High Technology group in the Semi-Core above, and will be noticeable again in the ratio of foreign to indigenous productivity).

The Low Technology group experiences a fluctuating dispersion, with a convergence towards approximately 2002, and increasing divergence from 2002 onwards, most probably reflected in the high growth the Core experiences from that point onwards. It appears as though regional tiers begin to converge towards the end of the period when it comes to the High Technology group.

These trends of divergence, as discussed above, are a strong element of the transformation process. The decreasing/increasing divergence trends within technology groups suggests that both time lags and "*systemic spatial asymmetries between industries and regions*" (Lundquist

and Olander, 2010) are at play in Ireland's regional system. These trends also suggest that regional tiers are diversifying in terms of their profiles of manufacturing activity. The trends also suggest that productivity arising from different technology groups could be becoming increasingly concentrated in specific tiers. This trend of increasing divergence between regions over time is also pointed out as part of the process of transformation in Sweden, with regional disparities having increased by the end of the study period compared to the start (Lundquist and Olander, 2010).

Figure 5.13: Foreign Manufacturing Productivity by Regional Tier
(NACE Rev. 1.1 15 - 37) (3-Year Moving Average)

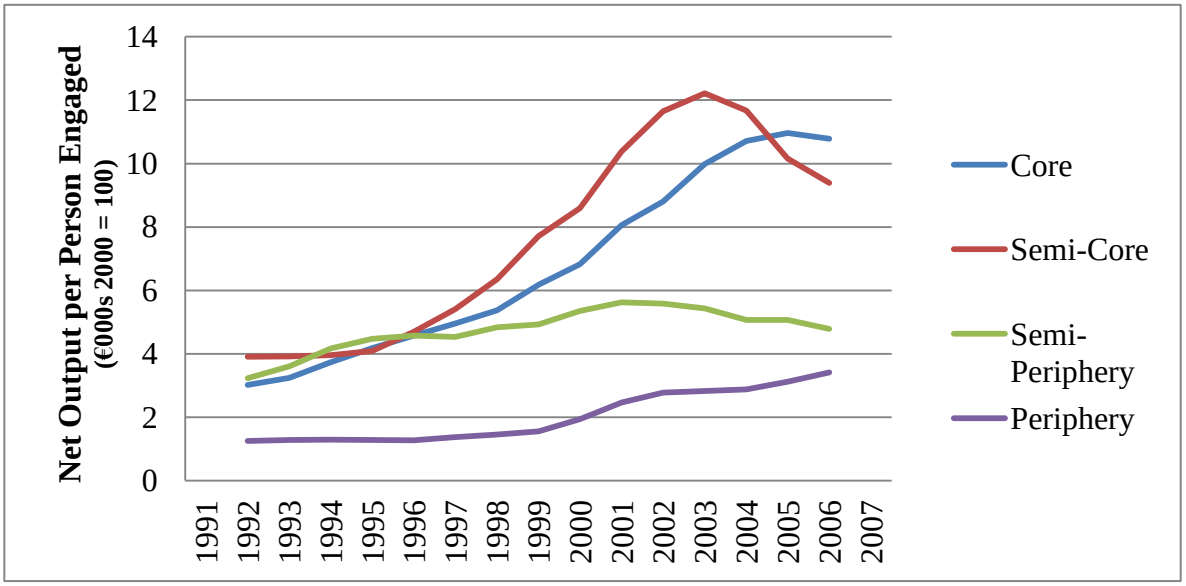


Source: (CSO, *various years3, own calculations*)

The Semi-Core clearly hosts the highest levels of foreign productivity for almost the entire period. This trend is interesting as the Semi-Core is also the most productive regional tier (in absolute terms) for the entire period.

The Periphery hosts nowhere near the same proportion of foreign productivity as the higher tiers, contrary to some of the policies pursued by IDA Ireland (1972 – 1996), in an attempt to direct MNCs into many peripheral regions so as to enhance job creation (Meyler and Strobl, 2000, see further Appendix C).

Figure 5.14: Ratio of Foreign to Indigenous Manufacturing Productivity within Regional Tiers
(NACE Rev. 1.1 15 - 37)
(3-Year Moving Average)



Source: (CSO, *various years3, own calculations*)

The ratio of foreign to indigenous productivity at a regional level again shows the huge importance of the foreign element of manufacturing productivity (see Figure 5.14). The shape of the Semi-Core's ratio curve also follows the growth in productivity within the Semi-Core's Medium-High technology group and also the trend of the national foreign to indigenous manufacturing productivity ratio. This indicates that the Semi-Core has a great influence on the national productivity, its Medium-High Technology sector playing a huge role, and that this sector is predominantly foreign-owned.

The Core's ratio trend mimics this but at a slightly lower level, and with a time lag. The Semi-Periphery begins with a similar presence of FDI to that of the Core and Semi-Core, but this presence does not increase to the same extent as the two higher tiers.

Table 5.2: The Regional Level Relationship between Foreign and Indigenous Manufacturing Productivity

(NACE Rev. 1.1 15 – 37)

X Variable: Foreign Productivity	Y Variable: Indigenous Productivity	Regression number	Co-efficient of Determination (R^2)	P-value of t-statistic
Core		6.	0.3092	(0.01)
Semi-Core		7.	0.5434	(0.0005)
Semi-Periphery		8.	0.4161	(0.0025)
Periphery		9.	0.006	(insignificant)

Source: (CSO, *various years3, own calculations*)
Insignificant: ($p > 0.05$)
See further Appendix E.

The Semi-Core has the strongest relationship between foreign and indigenous manufacturing productivity for the period. This suggests that the industrial structure within this regional tier supports the greatest connection between foreign and indigenous productivity arising from the manufacturing industry for the entire period. It could also indicate that the indigenous industry hosted by the Semi-Core is more prone to higher levels of productivity. These factors would serve as very plausible reasons for the regional tier's success in terms of productivity development. However, the relationship could be the other way around; its productivity levels could serve as a reason for its increased level of FDI involvement and productivity. The relationships of the foreign and indigenous sectors in the Core and Semi-Periphery are not too far behind that of the Semi-Core.

5.3 Summary

With respect to the hypotheses outlined in Section 4, it is firstly clear that increases in productivity did not occur in a top-down manner through the regional hierarchy, as the Core appears to have been bypassed in terms of manufacturing productivity improvement, and to an extent, technological change. Secondly, structural change is evident, however the High Technology group does not play such a strong role in this, as originally hypothesised. The third hypothesis could be considered largely true in that FDI does play a major role in industrial change (particularly in the Core) and in productivity improvement.

Section 6: Conclusions

Ireland experiences some similar trends to those of Sweden as discussed in Section 5. However, it is clear that exogenous processes must be given much more consideration. The results suggest that there is not just one theory, but rather elements of several theories at play in Ireland's transformation. For example, cyclical diffusion does not occur to the same extent as it does in Sweden, suggesting that there are some disrupting forces at play, such as those suggested by the "product life-cycle theory". This could be an explanation for the increasingly weak position of the High Technology group over time.

It is clear to see that different regional tiers have very different roles to play in the technology shift, as do the technology groups under consideration. There are a few further outstanding differences between the cases of Ireland and Sweden. For example, in Ireland's case the Semi-Core appears to lead the change, that is, if technological change and productivity improvement have not already disseminated from the Core by the beginning of the time period under consideration. Also, the Medium-High Technology instead of the High Technology group has a predominant position in terms of productivity improvement. This is again out of sync with the technology shift thesis. This suggests that the development of new products is not taking place, but rather that process innovation is underway. This is fitting with what some authors have emphasised regarding Ireland's innovation system, see for example, Lin *et al*. (2010).

The foreign element of the manufacturing industry is extremely important for Ireland although embeddedness, or lack thereof, within specific technology groups in particular could be considered a cause for concern (as outlined in Section 3). The indication that embeddedness is evident in some industries and regional tiers to greater extents than in others is also an important consideration. Therefore, policy could focus more on embeddedness and the overall integration including technology transfer, co-operation and collaboration within the industrial structure. Furthermore, perhaps more of a focus should turn to the indigenous elements of the manufacturing industry (see further Lin *et al*., 2010).

Another policy implication is that the manufacturing industry should not be overlooked in favour of services. This could be an issue considering Ireland's overwhelming dependence on FDI, its increasing cost base and the outward movement of FDI manufacturing in recent

years. Transformation will return and will firstly take hold in the manufacturing industry before the services.

Further research could focus on the effect (instead of just the relationship) of FDI on indigenous productivity, and would perhaps include a time lag. If the data were available, a more detailed analysis of different industries and regions at a disaggregated level would be beneficial. Furthermore, research of the entire economy, and not just manufacturing industry, would be useful in deciphering wider trends associated with the technology shift.

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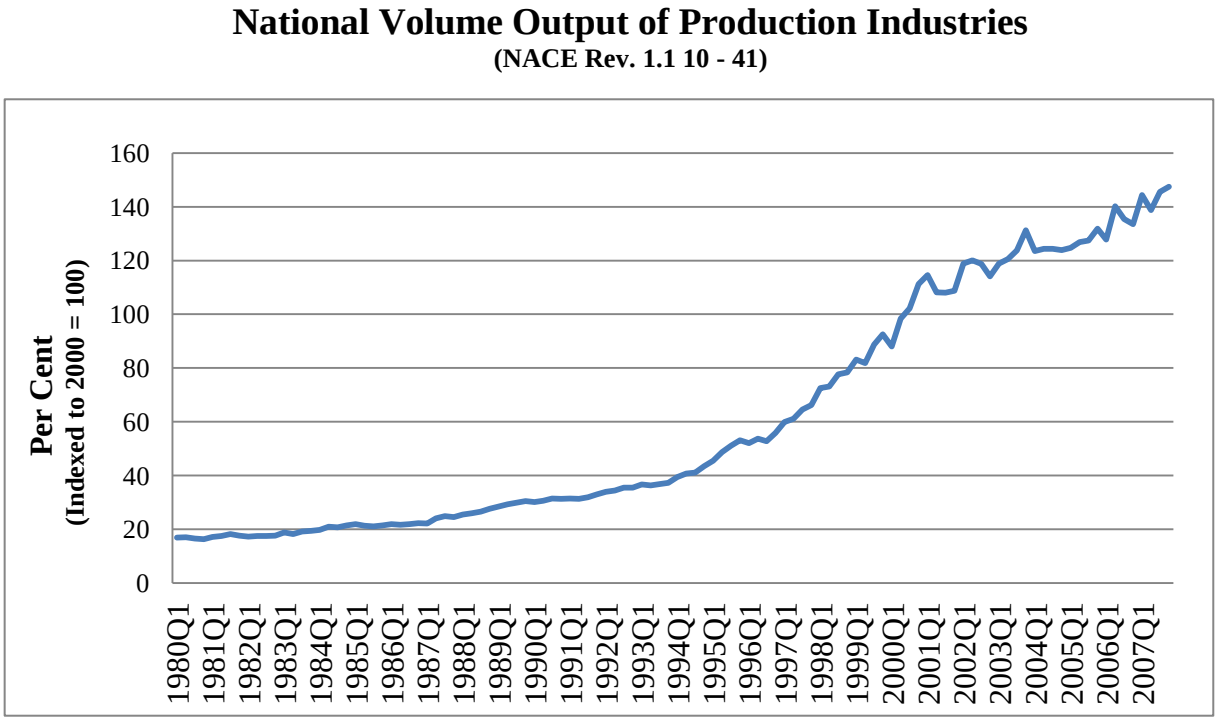
Appendices

Appendix A: The Notable Increase in Volume Output from the late 1980s



Source: (CSO, *various years2*)

Appendix B: Conversion from Current to Constant Prices

As discussed in Section 4 (Methods), prices were converted from current to constant using the Industrial Production Index which indexes the volume output of production. This calculation was quite simple as the index was already developed. The equation below summarises the calculation, where Y is the real or constant price (accounting for inflation), "W" is the nominal or current price (not accounting for inflation), X is the index and this is then multiplied by 100.

$$Y = W/X * 100$$

The table below outlines an example of such a calculation:

Example of a Calculation of Conversion from Current to Constant Prices

	Current Price	**Index (2000 = 100%)**	**Current Price / Index**	**Result * 100**	**Constant Price**
Calculation Example	€98	127%	98/127 = 0.7717	0.7717*100	€77.17

Appendix C: Regional Tier Typology

Regional Tier Typology Indicators

	1. Population Size*	2. City Status	3. Commuter Counties	4. Core/ Periphery/ Economic Trends
Core	1,270,603	1 primate	0	Excellent
Semi-Core	959,975	3 medium-sized	0	Very good
Semi-Periphery	1,187,762	1 small city	c.6	Varying - Good
Periphery	1,162,929	0	c.3 – 4	Varying – Fair

**Source*: (CSO, 2011)

Counties were grouped into regional tiers based on the above four (qualitative) indicators. However, the first and foremost consideration was to arrange the counties in such a way so as to avoid confidentiality breaches (as discussed in Section 4). Also, for the purposes of consistency, counties were also grouped so that all four tiers contained relatively even population sizes.

The first indicator was population. Unfortunately, time and data restrictions could not allow for density data (persons per kilometre squared per county) to be used, which would have been a "fairer" representation. As a substitute, county populations were used. Each county's population was traced over time (using the census data as outlined below). Some counties did not "suit" the tier they would automatically be placed in based on population (mainly due to their large areas) so they were placed in alternative tiers.

The second indicator was city status. Dublin (or often the Greater Dublin Area) is referred to by many as Ireland's "dominant core" (Clinch and O'Neill, 2009). Therefore, this county alone was placed in the first tier. The next three largest cities (Cork, Galway and Limerick) Along with Waterford, these cities are often referred to as "The Atlantic Gateway" (see, for example, Atlantic Gateways Initiative, 2006). Cork, Galway and Limerick were thus, placed

in the "Semi-Core". Waterford is a much smaller city and is not on par with the previous three so it was placed in the "Semi-Periphery" tier.

The third indicator (commuter-county status) is loosely based on a considerable proportion of the population commuting from that county to another for work. The commuting trait is mainly considered to be associated with the Semi-Periphery but it also obviously in-part applies to the Periphery (to a notable extent) and the Semi-Core and Core (to lesser extents).

It is considered that to base a large emphasis on core-periphery association grounded in a detailed economic analysis would be somewhat self-fulfilling for this research; therefore the indicator of "general economic trends" was used. This indicator is deliberately very vague and the situation varies to quite an extent between counties within the tiers. However the "Periphery" is of greatest concern. The counties of Donegal, Kerry, Mayo, Cavan, Sligo, Roscommon, Monaghan, Longford, Leitrim were designated as areas in need of job creation from 1972 to 1996 (Meyler and Strobl, 2000). These counties were "*typically the least wealthy, least populated, least industrialised and most peripheral regions of Ireland*" (Meyler and Strobl, 2000). The above-mentioned counties were therefore included in the "Periphery" for this research. This job creation policy also included Galway, and West Cork, however these counties include cities of considerable sizes so were excluded from the "Periphery" for this research. The counties of Kilkenny, Westmeath, Laois, Offaly and Carlow were also included in the Periphery for this analysis.

Regional Tiers, Their Constituent Counties and Populations

1st Tier/Core Counties	**Population**	**2nd Tier/ Semi-Core Counties**	**Population**	**3rd Tier/Semi-Periphery Counties**	**Population**	**4th Tier/ Periphery Counties**	**Population**
Dublin	1270603	Cork	518128	Kildare	209955	Donegal	160927
		Galway	250541	Meath	184034	Kerry	145048
		Limerick	191306	Louth	122808	Mayo	130552
				Wexford	145273	Kilkenny	95360
				Wicklow	136448	Westmeath	85961
				Tipperary	158652	Laois	80458
				Clare	116885	Offaly	76806
				Waterford	113707	Cavan	72874
						Sligo	65270
						Roscommon	63898
						Monaghan	60495
						Carlow	54532
						Longford	38970
						Leitrim	31778
Total	**1270603**		**959975**		**1187762**		**1162929**

Source: (CSO, 2011)

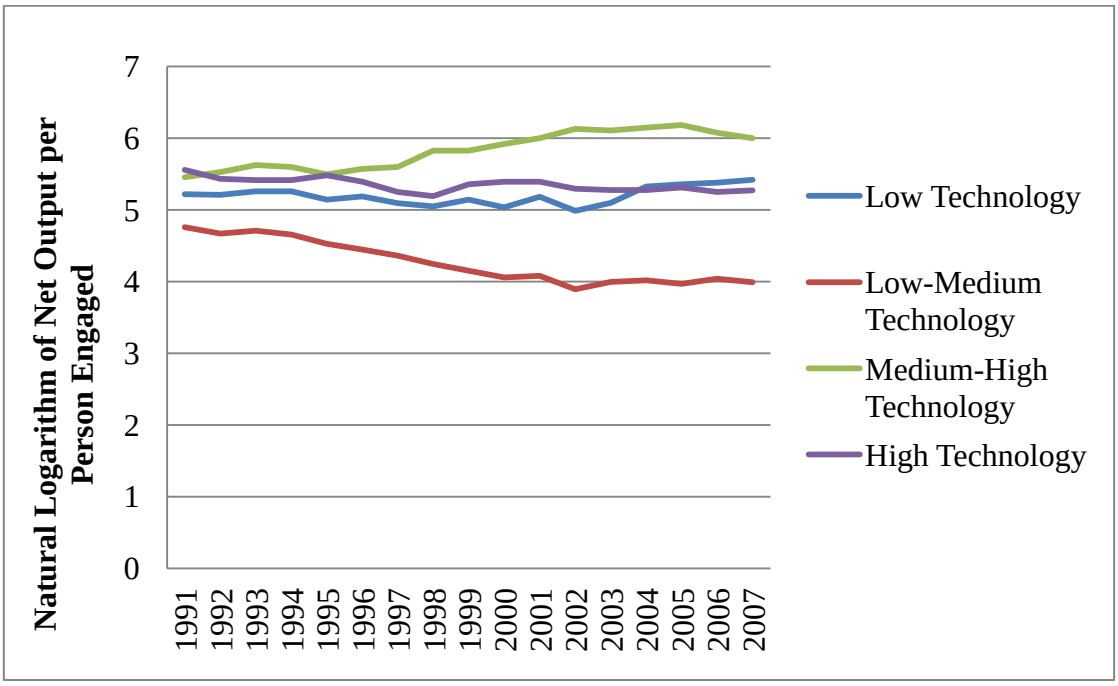
Changing Ranks/Sizes of County Populations 1986 – 2011

Census Year	Order of Counties (Largest to Smallest in terms of Population)
2011	Dublin, Cork, Galway, Kildare, Limerick, Meath, Donegal*, Tipperary, Wexford*, Kerry, Wicklow, Mayo, Louth, Clare, Waterford, Kilkenny, Westmeath, Laois*, Offaly, Cavan, Sligo, Roscommon, Monaghan, Carlow, Longford, Leitrim
2006	Dublin, Cork, Galway, Kildare*, Limerick, Meath*, Tipperary, Donegal, Kerry, Wexford*, Wicklow*, Mayo, Louth*, Clare, Waterford, Kilkenny, Westmeath, Offaly, Laois, Cavan*, Sligo, Roscommon, Monaghan, Carlow, Longford, Leitrim
2002	Dublin, Cork, Galway, Limerick, Kildare, Tipperary, Donegal, Meath*, Kerry, Mayo, Wexford, Wicklow, Clare*, Louth*, Waterford, Kilkenny, Westmeath, Offaly, Laois*, Sligo, Cavan, Roscommon, Monaghan, Carlow, Longford, Leitrim
1996	Dublin, Cork, Galway, Limerick, Kildare*, Tipperary, Donegal, Kerry, Mayo, Meath, Wexford, Wicklow, Waterford, Clare, Louth, Kilkenny, Westmeath, Offaly, Sligo, Laois*, Cavan, Roscommon, Monaghan, Carlow, Longford, Leitrim
1991	Dublin, Cork, Galway, Limerick, Tipperary, Donegal, Kildare*, Kerry, Mayo, Meath, Wexford, Wicklow, Waterford*, Clare*, Louth, Kilkenny, Westmeath, Offaly, Sligo, Cavan*, Laois*, Roscommon, Monaghan, Carlow, Longford, Leitrim
1986	Dublin, Cork, Galway, Limerick, Tipperary, Donegal, Kerry, Kildare*, Mayo, Meath*, Wexford, Wicklow*, Louth*, Clare*, Waterford, Kilkenny, Westmeath, Offaly, Sligo, Roscommon, Cavan, Laois*, Monaghan, Carlow, Longford, Leitrim
1981	Dublin, Cork, Galway, Limerick, Tipperary, Donegal, Kerry, Mayo, Kildare, Wexford, Meath, Waterford, Louth, Clare, Wicklow, Kilkenny, Westmeath, Offaly Sligo, Roscommon, Cavan, Monaghan, Laois, Carlow, Longford, Leitrim

Sources: (CSO, *various years5*) (for census years 1981 – 2006) and (CSO, 2011) (for census year 2011), *own calculations*

*County whose population has increased to the extent that its position/rank has changed by one or more places since the previous census.

Appendix D: Productivity Growth Levels by Technology Group



Source: (CSO, *various years3, own calculations*)

Appendix E: Regressions

A threshold significance level of 95% (≤ 0.05) was used i.e. any result corresponding to outside of the range of 0 – 0.05 for the respective number of observations was considered "insignificant". Regressions with insignificant results were not included in the Appendix. For the significance levels of each regression, please see Tables 5.1 and 5.2.

The following descriptions (weak/moderate/strong) were attached to the corresponding values of the co-efficient of determination (R^2). These descriptions are based on Hayes' discussion (2005, p.68):

Weak: $R^2 = 0.00 – 0.39$*

Moderate: $R^2 = 0.40 – 0.69$*

Strong: $R^2 = 0.70 – 1.00$*

(*with due consideration for adjusted R^2)

Regression 1: Total FDI Productivity/Total Indigenous Productivity 1991 - 2007

Regression Statistics	
Multiple R	0.7746174
R Square	0.6000321
Adjusted R Square	0.5733676
Standard Error	14.314157
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4610.7564	4610.7564	22.50301	0.0002612
Residual	15	3073.4265	204.8951		
Total	16	7684.1829			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	210.79352	29.804661	7.0725018	3.794E-06
X Variable 1	-0.403534	0.0850668	-4.743734	0.0002612

Regression 2: Low Technology FDI Productivity/Low Technology Indigenous Productivity 1991 - 2007

Regression Statistics	
Multiple R	0.5899299
R Square	0.3480173
Adjusted R Square	0.3045518
Standard Error	19.533113
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3054.9142	3054.9142	8.006747	0.0126783
Residual	15	5723.1374	381.54249		
Total	16	8778.0516			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	117.41079	16.448775	7.1379661	3.404E-06
X Variable 1	-0.094278	0.0333183	-2.82962	0.0126783

Regression 3: Low-Medium Technology FDI Productivity/Low-Medium Technology Indigenous Productivity 1991 - 2007

Regression Statistics	
Multiple R	0.9860954
R Square	0.9723841
Adjusted R Square	0.9705431
Standard Error	3.5351676
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	6600.7017	6600.7017	528.16557	4.176E-13
Residual	15	187.46115	12.49741		
Total	16	6788.1628			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	3.0804175	2.9784769	1.0342258	0.3174178
X Variable 1	0.7237744	0.0314933	22.981853	4.176E-13

Regression 4: Medium-High Technology FDI Productivity/Medium-High Technology Indigenous Productivity 1991 - 2007

Regression Statistics	
Multiple R	0.8905207
R Square	0.7930271
Adjusted R Square	0.7792289
Standard Error	9.4237233
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5104.0018	5104.0018	57.473251	1.659E-06
Residual	15	1332.0984	88.806561		
Total	16	6436.1002			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	123.63996	8.3363746	14.831382	2.277E-10
X Variable 1	-0.115938	0.015293	-7.581111	1.659E-06

Regression 5: High Technology FDI Productivity/High Technology Indigenous Productivity 1991 - 2007

Regression Statistics	
Multiple R	0.730443
R Square	0.533547
Adjusted R Square	0.5024502
Standard Error	11.922451
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2438.8616	2438.8616	17.157583	0.0008688
Residual	15	2132.1724	142.14483		
Total	16	4571.0341			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-27.79751	23.709039	-1.172443	0.2593036
X Variable 1	0.4030255	0.0972981	4.1421712	0.0008688

Regression 6: Core FDI Productivity/Core Indigenous Productivity 1991 – 2007

Regression Statistics	
Multiple R	0.556095
R Square	0.3092416
Adjusted R Square	0.2631911
Standard Error	17.376637
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2027.6572	2027.6572	6.7152637	0.0204466
Residual	15	4529.2126	301.94751		
Total	16	6556.8698			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	111.31145	15.043775	7.3991702	2.222E-06
X Variable 1	-0.08331	0.0321487	-2.591383	0.0204466

Regression 7: Semi-Core FDI Productivity/Semi-Core Indigenous Productivity 1991 - 2007

Regression Statistics	
Multiple R	0.7371197
R Square	0.5433455
Adjusted R Square	0.5129018
Standard Error	17.413697
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5412.046	5412.046	17.847587	0.0007354
Residual	15	4548.5526	303.23684		
Total	16	9960.5986			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	203.65506	31.599941	6.4447924	1.104E-05
X Variable 1	-0.287074	0.0679523	-4.22464	0.0007354

Regression 8: Semi-Periphery FDI Productivity/Semi-Periphery Indigenous Productivity 1991 - 2007

Regression Statistics	
Multiple R	0.6449425
R Square	0.4159509
Adjusted R Square	0.3770142
Standard Error	16.408391
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	2876.1787	2876.1787	10.68277	0.0051836
Residual	15	4038.5292	269.23528		
Total	16	6914.7079			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	-24.40966	29.09395	-0.838994	0.4146437
X Variable 1	0.3054578	0.0934564	3.2684508	0.0051836

Regression 9: Periphery FDI Productivity/Periphery Indigenous Productivity 1991 - 2007

Regression Statistics	
Multiple R	0.0775569
R Square	0.0060151
Adjusted R Square	-0.060251
Standard Error	24.023708
Observations	17

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	52.388007	52.388007	0.090772	0.7673343
Residual	15	8657.078	577.13853		
Total	16	8709.466			

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	74.744092	26.306449	2.8412839	0.0123829
X Variable 1	-0.062505	0.2074612	-0.301284	0.7673343