SPATIAL CONCENTRATION IN THE IRISH PHARMACEUTICAL INDUSTRY: THE ROLE OF SPATIAL PLANNING AND AGGLOMERATION ECONOMIES

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ABSTRACT

This paper explores the idea that spatial planning-triggered satellite industrial platform-type concentrations may, over time, automatically gain the capacity to generate substantial agglomeration economies and ultimately transform into entities capable of stimulating self-perpetuating growth. Applying the lexicon of agglomeration theory, the idea is explored in the context of the spatial dynamics of the pharmaceutical industry in Ireland. Spatial concentration indices indicate a particularly high level of spatial concentration in one of the industry's sub-sectors, namely, drug substance production. Based on interview data and secondary sources, a detailed investigation of the spatial dynamics of the Irish concentrations suggests that, while some agglomeration advantages have emerged, they remain relatively limited and have played only a minor role in shaping local industrial concentration. They are mainly of the urbanisation type, relating particularly to the pooled market for workers. The evidence serves to show that the kind of spatial planning-triggered satellite industrial platforms in late-developing economies do not automatically start generating substantial agglomeration economies and crucial technological spillovers, not even after, as in the case of the Cork pharmaceuticals concentration, nearly 40 years of existence.

Key words: Agglomeration, cluster, spatial concentration, pharmaceutical, Ireland

INTRODUCTION

The tendency of economic activity in general, and industrial activity in particular, to concentrate in particular localities or regions has long attracted the attention of economists and geographers. The debate over the forms and determinants of such spatial concentration has recently been reignited (see McCann 1995; Martin 1999; Parr 2002; Phelps & Ozawa 2003; Phelps 2008).

The formation of industrial concentrations is normally characterised as a sequential process, consisting of an initial formation stage and a subsequent second stage of self-sustaining growth and development (Carlsson 2006). It is generally believed that agglomeration advantages, including technological spillovers, are an important driver of this second stage of industrial concentration. Moreover, this self-perpetuating expansion is often interpreted as an automatic process, in the sense that it requires limited government industrial policy intervention. However, some commentators point out that, in certain types of industrial concentrations, agglomeration advantages may

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play only a limited role in the industrial concentration process and that not all agglomeration factors are relevant in all concrete instances of concentration (see McCann 1995; Malmberg *et al.* 2000).

Governments have sought to build on this logic and have utilised spatial planning as a tool for creating this initial formation stage of industrial concentration with the view of triggering this automatic agglomeration process. One example of such spatial planning-driven industrial concentrations is the government-planned concentration that Markusen (1996) categorises as 'satellite industrial platforms'. The term 'satellite industrial platform' refers to congregations of unconnected branch facilities of externally based multiplant firms, often planned by national or regional governments as a way of stimulating regional development. Markusen (1996) and Park (1996) posit that such satellite platforms may over time gain the capacity to generate substantial agglomeration economies and ultimately transform into entities capable of self-perpetuating growth. However, they do not elaborate on the conditions that facilitate such a transition. Specifically, it is unclear whether such agglomeration and transition processes operate autonomously or whether a transition requires more comprehensive innovation and industrial policy intervention. This is one of the questions that our analysis seeks to address.

Applying the lexicon of agglomeration theory, this paper conceptualises the development over time of government-planned satellite platform concentrations and investigates one critical case. The proposition of this paper is that spatial planning-driven industrial concentrations, such as satellite industrial platforms, are, even over time, unlikely to automatically gain the capacity to generate substantial agglomeration economies and subsequently transform into entities capable of stimulating self-perpetuating growth. In such a scenario, rather than merely constituting the initial trigger for a concentration, it is government spatial planning and general location factors, and not agglomeration economies that remain the most important driver behind observed industrial concentrations. Particularly in late developing countries and regions, which are generally characterised by an underdeveloped innovation infrastructure and low levels of entrepreneurial activity, spatial planning policies alone are unlikely to instigate a transformation into self-perpetuating concentrations.

The proposition outlined above will be investigated via a study of the spatial dynamics of the pharmaceutical industry in Ireland. The Cork concentration was the earliest established satellite platform-type pharmaceutical manufacturing concentration worldwide, and is currently one of the two largest concentrations of its kind worldwide. It therefore usefully serves as a critical case for testing this paper's proposition regarding the role of agglomeration economies in the development of satellite platform concentrations.

The paper begins with a conceptualisation of agglomeration economies and the development of government-planned concentration over time using the lexicon of agglomeration theory. This is followed by an outline of the development of the pharmaceutical industry in Ireland. The next section is methodological, focusing, firstly, on data issues encountered in the research and, second, on the spatial concentration measures utilised in the analysis. The paper then proceeds with a description of the spatial distribution of the industry. It will be shown that the overall level of spatial concentration of the industry is entirely due to the spatial concentration of one of the sub-sectors – the manufacture of drug substances. The paper continues with a more detailed investigation of the spatial dynamics of the drug substance subsector, identifying the initial causes of spatial concentration and the subsequent role of agglomeration economies. The paper concludes with a discussion of key findings and offers policy relevant insights into the requirements for instigating the transformation of satellite platforms into self-perpetuating clusters.

GOVERNMENT-TRIGGERED CONCENTRATION AND AGGLOMERATION

The period since the mid-1980s has been characterised by a renewed interest in spatial concentration and agglomeration involving an increasingly diverse range of theoretical perspectives (Benneworth & Henry 2004). The variety of approaches considered has instigated

an intense debate regarding the forms and determinants of spatial concentration and the operative processes involved (see McCann 1995; Martin 1999; Parr 2002; Phelps & Ozawa 2003; Brown & Rigby 2010; Boschma & Fornahl 2011). Two important foci of this debate have related to: (1) the specific agglomeration factors that are responsible for particular observed concentrations; and (2) the extent to which agglomeration economies are responsible for observed spatial concentrations of industrial activity.

A discussion of the first of these foci benefits from an overview of the range of possible agglomeration advantages. Marshall's original contributions are still useful for grouping the agglomeration advantages identified in recent literature. His observations on the subject of agglomeration (Marshall 1898, 1919, 1930) tend to be summarised into a triad of external economies – a pooled market for workers with specialised skills, a growing number of increasingly specialised input suppliers and technological spillovers.

The local pool of labour can provide an efficiency gain for both workers and firms by maximising job-matching opportunities and thus reducing search costs (Simpson 1992; Gordon & McCann 2000), while the associated accumulation of human capital can enhance both labour skills (Arrow 1962) and firm productivity (Romer 1987; Scott 1988). The argument regarding input relations is also based on neoclassical concepts such as cost minimisation, economies of scale, and the Smithian division of labour. A localised industry can support more suppliers, which increases the level of specialisation and efficiency of the supply base, which, in turn, presents an efficiency gain for the customers (Harrison 1992). The actual driver for geographical proximity between firms is the desire to reduce the costs of transactions across space (Krugman 1991).

The third advantage that is commonly distilled from Marshall's work, technological spillovers, introduces a more dynamic perspective. It involves knowledge externalities which result from the concentration of (both vertically and horizontally) related firms, facilitating processes of learning and innovation in the locality (Malmberg & Maskell 1997, 2002). Technological spillovers are believed to be intensified by informal rules, conventions and other 'untraded interdependencies' (Storper 1995). They are partially independent of the degree of intentional interaction, that is, they occur irrespective of the fact that companies intentionally interact (e.g. in the context of commercial and collaborative relations). Knowledge tends to become embedded in the local milieu (Malmberg 1996). Unintentional interaction (Oerlemans & Meeus 2005), as distinct from intentional exchange, involves the acts of observation and comparison by firms (Malmberg & Maskell 2002).

Hoover (1937) further refined the theory of agglomeration economies by dividing such economies into two distinct types: localisation and urbanisation economies. Localisation economies, as identified by Marshall (1898), are advantages that firms in a single industry gain from being located in the same location while urbanisation economies are advantages gained by all firms, regardless of sector, from being located together. Recently, Asheim *et al.* (2011) has coined the concept of 'related variety', which in a sense links localisation and urbanisation economies. Here the advantages that firms in an industry gain from being located in the same location also benefit firms in a set of related industries (as opposed to firms in a single industry or all firms in the region).

Contributors to the debate suggest that not all agglomeration economies are operational in all concrete situations of concentration. This point is of particular relevance to concentrations of foreign branch plants in late developing countries (McCann & Mudambi 2004; Phelps 2008). Given the fact that in many concentrations most firms are observed to have few local backward linkages, cost-reduction in inter-firm transactions is no longer regarded as being helpful in explaining concentration (Phelps 1991; McCann 1995). Partly as a result of this, the focus of analysis has shifted to technological spillovers and related social, cultural and institutional issues (Martin 1999; Malmberg & Maskell 2002). The problem is that such technological spillovers are difficult to identify and measure. In the absence of cost-reduction factors, spatial concentrations are often assumed to be shaped by local spillovers, the existence of which has not been established

(McCann 1995; Malmberg & Maskell 2002; Orsenigo 2006).

The second, related, debate concerns the extent to which agglomeration economies are responsible for the genesis and sustainable growth of observed spatial concentrations. A commonly accepted view is that agglomeration economies are a pervasive force, reinforcing concentration (Orsenigo 2006; Menzel *et al.* 2010). Echoing Marshall's distinction between causes and advantages of localisation (Marshall 1898), the rationale of some approaches to understanding cluster formation is that the emergence of a cluster can be traced to a historical accident, leading to an initial concentration of firms. Once a certain threshold has been reached, agglomeration economies in the form of regional labour-market pooling, specialised suppliers and knowledge spillovers will occur (Menzel *et al.* 2010). In this tradition, after the initial inception of the industrial concentration, its further expansion is presented as a more or less automatic process that does not require comprehensive industrial policy intervention. By this we mean policies directly addressing areas such as regional innovation capacity and entrepreneurial activity, as opposed to the more basic spatial planning interventions.

Important causes for initial concentration today are related to government industrial spatial planning and related infrastructural spending by state and local government authorities/agencies. Some of this is mediated through government's role in the supply-side of the market for industrial sites, which partly determines the pattern of industrial location (Van der Krabben & Boekema 1994; Louw *et al.* 2004). This role can take the form of promoting the development of well-serviced industrial sites at certain locations (e.g. through financial/fiscal incentives or the direct provision of well-serviced industrial sites) and/or that of blocking industrial activities from other locations (physical planning and environmental regulations). Such developments are particularly likely to occur in sectors that are characterised by large-scale manufacturing plants requiring large and well-serviced industrial sites.

One example of such spatial planning driven industrial concentrations are the satellite industrial platforms identified by Markusen (1996). Here, the initial concentration of the branch operations of multiplant firms is stimulated by the cheap provision of industrial sites and infrastructure, as a way of promoting regional development. Markusen suggests that these districts are not static but may, over time, transform into other types of districts, including Marshallian-type districts. Park (1996) discusses a transition from a satellite industrial district into an 'advanced satellite' industrial district and, potentially, to a 'pioneering high-technology' industrial district. To the extent that these transitions are deemed likely, they are strongly linked to the role of agglomeration economies. For example Markusen (1996, p. 305) suggests that 'over time, districts built around platforms may begin to host growth of suppliers, oriented towards platform tenants, and they may enjoy some increase in local entrepreneurship because the platform enhances the pool of skilled personnel' (see also Park 1996). However, little attention has been paid to the conditions that facilitate such a transition. This raises the question of whether such agglomeration and transition processes operate autonomously or whether a transition requires more comprehensive innovation and industrial policy intervention.

It has been pointed out that in many cases of concentration, agglomeration economies may only play a limited role in driving the concentration process (see McCann 1995; Malmberg *et al.* 2000). An analysis of agglomeration processes must take account of the fact that there are probably not many industrial concentrations where agglomeration economies are totally absent (Parr 2002). Notably, most industrial concentrations in the vicinity of urban areas are bound to benefit from at least some level of urbanisation economies in the form of educational institutions, labour market pooling and infrastructure. However, these may have little impact on the process of spatial concentration or only act as 'reinforcing agglomeration economies' (Parr 2002).

The proposition of this paper is that spatial planning-driven industrial concentrations, such as satellite industrial platforms, are, even over time, unlikely to automatically gain the capacity to generate substantial agglomeration economies and ultimately transform into enti-

ties capable of stimulating self-perpetuating growth of the type associated with 'advanced satellite' industrial districts or 'pioneering high-technology' industrial districts. In such a scenario, rather than merely constituting the initial trigger for a concentration, government spatial planning and general location factors, rather than agglomeration economies, remain the most important driver behind observed industrial concentrations. A certain level of agglomeration economies may spontaneously emerge over time, mainly of the urbanisation type, and largely attributable to the presence of a local pool of labour, but their role in shaping local/regional industrial concentration remain at a much lower order of magnitude than that of spatial planning-type government intervention.

Substantial agglomeration economies and crucial technological spillovers are particularly unlikely to be generated in the case of sectors that are characterised by vertically strongly integrated production systems and in the context of late developing countries, generally characterised by an underdeveloped research infrastructure and low levels of entrepreneurship.

The Irish pharmaceutical industry provides an ideal case in which to test the proposition outlined above. The industry in Ireland has been spatially concentrated since its inception, and the Cork concentration has been in existence for nearly 40 years. The concentration was the earliest established satellite platform-type drug substance manufacturing concentration worldwide. It is the largest concentration of its kind in Europe, and together with Puerto Rico is among the two largest of its kind globally (Vinnova 2008). The drug-substance sub-sector of the pharmaceutical industry is a prime example of a sector characterised by large-scale manufacturing plants, high infrastructural and utility requirements and increasingly strict environmental regulations. The following section explores the development of the Irish pharmaceutical industry in more detail.

THE PHARMACEUTICAL INDUSTRY IN IRELAND

The value chain of the pharmaceutical industry includes the following segments: discovery, product development; process R&D, manufacturing, sales and marketing and corporate functions. Process R&D is concerned with the development of efficient manufacturing processes at commercial scale. Manufacturing encompasses the production of drug substances, other (non-drug substance) intermediate inputs, finished drug products and finished diagnostic products. Drug substances (or active pharmaceutical ingredients) are the most important ingredients of a drug product, being responsible for its pharmacological effect (Van Egeraat 2010).

Until the 1960s there was virtually no pharmaceutical industry in Ireland (Galvin 1998). The increasing shift towards more outward-looking economic policies (focused strongly on the stimulation of exports through the attraction of inward investment) from the end of the 1950s led quickly to the first substantial investments by foreign companies, including a handful of pharmaceutical companies, in the 1960s. The pharmaceutical industry in Ireland really took off in the 1970s after the Industrial Development Authority (IDA), the state agency responsible for attracting inward investment identified the fine chemicals industry (including pharmaceuticals) as one of the target sectors (Childs 1996). Pharmaceutical manufacturing employment grew strongly, from just over 1,300 in 1972 to nearly 19,500 in 2003, by which time pharmaceuticals had become one of Ireland's leading industrial sectors.

The absolute growth figures mask qualitative changes in Ireland's role in the global production networks since about the mid-1980s, raising the level of value creation (Van Egeraat & Barry 2009). First, many production sites were given the responsibility of higher-skilled product launch activities. Second, some pharmaceutical plants in Ireland obtained wider product mandates to cover European and global markets.

In relation to R&D functions, since the mid-1980s pharmaceutical firms started to significantly internationalise their R&D activities. However, much of this internationalisation has been spatially highly selective, tending to concentrate in a small number 'innovation arenas' or 'megacentres' such as Boston and San Francisco (Zeller 2004). Ireland's role in the high value generating drug discovery and product development activities has remained very

Table 1. *Number of operations and employees in pharmaceutical industry, 2003.*

	Foreign		Indigenous		Total	
	Operations	Employees	Operations	Employees	Operations	Employees
Drug substance	30	6,379	1	26	31	6,405
Drug product	32	9,082	13	886	45	9,968
Both substance and product.	5	1,772	1	20	6	1,792
Other Intermediates	2	109	2	58	4	167
Diagnostics	5	732	4	411	9	1,143
Total	74	18,074	21	1401	95	19,475

Source: Based on Forfás Employment Survey.

limited (Van Egeraat & Barry 2009). Since the mid-1990s, Irish subsidiaries have begun to play an increasing role in the global process R&D function. In the period 2000–06, the number of people involved in process R&D almost doubled. However, even in this area, Ireland's involvement is concentrated in the (relatively) lower value generating down-stream phases of the cycle (Van Egeraat & Breathnach 2012).

Indigenous companies have played a relatively insignificant role in the sector's growth. In 2003, foreign companies accounted for 93 per cent of total pharmaceuticals employment and virtually all employment in the drug substance sub-sector. US companies represented the largest group by far, accounting for nearly half of all foreign companies, followed by companies from the UK (12%), France (9%), Germany (10%), Switzerland (6%) and Japan (6%). Indigenous operations remained relatively small with only seven indigenous companies employing more than 50 staff (see Table 1).

DATA AND METHODOLOGY

The analysis of spatial concentration and its drivers is based on both quantitative and qualitative research exercises. The quantitative exercise involved the computation of spatial concentration indicators for the pharmaceuticals industry from the annual Forfás Employment Survey of manufacturing operations in Ireland. The survey is conducted at operations level. An operation in the data set is generally a separately incorporated unit of a firm or corporation. The survey provides, for each year from 1972 onwards, data on the location, employment and activity of each manufacturing operation in Ireland. Activity is categorised in the survey returns using the 4-digit NACE classification.

The following activities were included in the analysis: drug substances (part of NACE 2441), drug products (NACE 2442), diagnostics (part of NACE 2466 and part of NACE 3310) and other intermediate chemicals (part of NACE 2441). A separate category was included for a small number of operations that produced both drug substances and drug products. The final data set includes a total of 122 pharmaceutical manufacturing operations, 95 of which were in operation in 2003 – the last year for which data are made available at the required level of aggregation (Table 1).

This dataset was used to compute measures of spatial concentration in the pharmaceutical industry and its various sub-sectors. The geographic unit of analysis used was the administrative county, giving a total of 26 observation units. The level of spatial concentration of an industry can be analysed very basically by inspecting the geographical distribution of employment across spatial units. The proportion of employment in the top region or top two regions can function as a simple measure of spatial concentration.

Many measures of geographical concentration aim to compare the geographic pattern of employment or plants for one sector with the pattern of an aggregate (for example, all industry). Such measures are often interpreted as an indication of the operation of localisation economies. This paper uses the index proposed

by Maurel and Sedillot (1999) (henceforth referred to as the MS index). The index, γ, controls for differences in industrial concentration (distribution of employment over the plants in an industry) and provides a measure of spatial concentration of an industry (suggestive of localisation economies) beyond what would be expected on the basis of industrial concentration. The formula for the MS index is:

$$\gamma = \frac{G - H}{1 - H}.$$

The first component, G, is a measure of raw geographic concentration, where:

$$G = \frac{\sum_{i=1}^{M} s_i^2 - \sum_{i=1}^{M} x_i^2}{1 - \sum_{i=1}^{M} x_i^2},$$

s_i is the proportion of sector employment located in geographic area i and x_i is the proportion of aggregate industrial employment in area i. M denotes the number of geographic areas.

The size distribution of plants is controlled via the Herfindahl index[1] of industrial concentration (measured as the distribution of employment across plants), where:

$$H = \sum_{j=1}^{N} z_j^2,$$

z_j is the share of plant j in total sector employment and N denotes the number of plants in the sector. Maurel and Sedillot (1999) adopt the following classification of concentration levels: a low degree of concentration ($\gamma < 0.02$); moderately concentrated ($0.02 < \gamma < 0.05$); very concentrated ($\gamma > 0.05$).

The qualitative research involved semi-structured, face-to-face, interviews with senior staff at twelve major pharmaceutical plants. As part of a larger research project, a total of 53 senior staff members were interviewed, including 12 general managers, 12 materials managers, 12 personnel managers and managers of R&D. Researcher-developed questions dealt with the decision-making involved in selecting the plants' locations, the relevance of various agglomeration factors in the decision-making process. All interviews were recorded and fully transcribed. All interviews were conducted at the companies' premises and typically lasted one hour.

In addition to the company interviews, the research included 12 interviews with current and retired staff at relevant institutions, notably the Industrial Development Agency (in the Dublin head office as well as the Cork regional office) and Cork County Council (within whose boundaries one of the main concentrations of pharmaceuticals plants is located). The qualitative micro-level data and contextual information derived from these interviews was used to make logical deductions regarding the relevance of the various agglomeration factors. The combination of multiple company interviews, interviews with agencies and the quantitative exercise provided complementary methodologies that allowed for cross-verification and triangulation. This combination of research methods was preferred over social network analysis which has recently grown in popularity. Apart from the fact that the required data is not available, social network analysis has serious limitations in relation to identifying actual knowledge spill-over in spatial concentrations (Van Egeraat & Curran 2013).

It is important to be cautious when it comes to drawing conclusions from corporate interviews. This applies in particular to data on technological spillovers. A number of strategies were applied to minimise the potential problems associated with corporate interviews (Schoenberger 1991). In relation to the structure of the interviews, the interviewer started with detailed questions on a topic to obtain detailed information, followed by more general discussions. The general discussion was used to probe the answers and assess the interviewees' knowledge of the topic. Multiple interviews were conducted in individual companies and institutions. Multiple interviews per company allowed for real-time company-internal verification of the results in two or three interviews, supporting the validity of the research data. Interviews in 12 companies, including the main multinational players, proved sufficient to probe the salience and role of individual agglomeration factors.

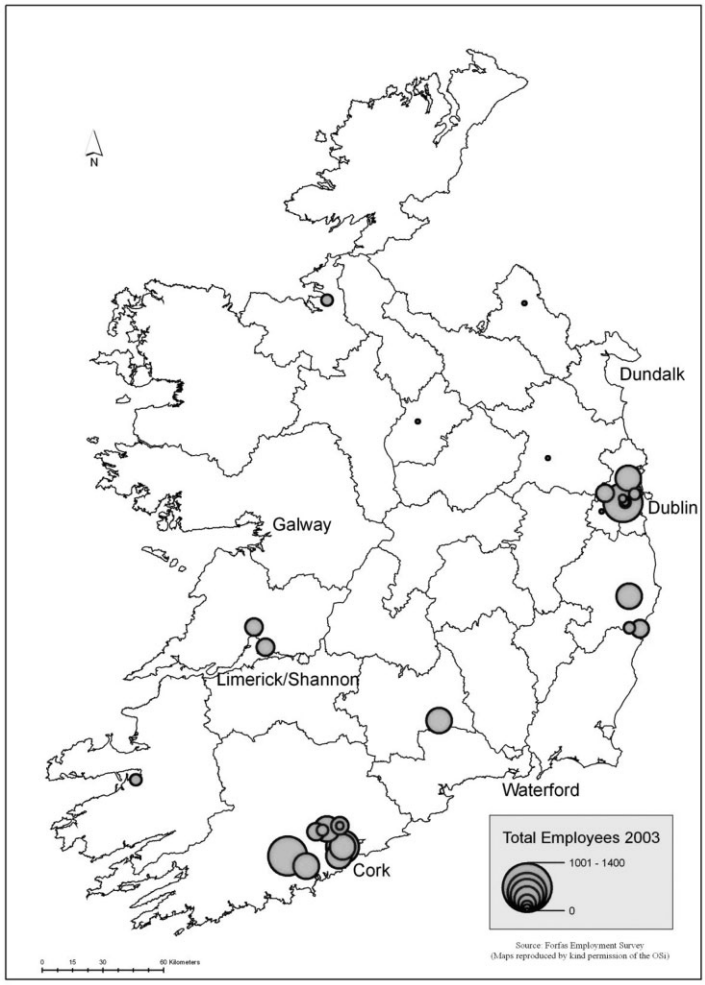

Figure 1. *Location of drug substance operations, 2003.*

THE SPATIAL DISTRIBUTION OF THE IRISH PHARMACEUTICAL INDUSTRY

Ireland is characterised by a very mono-centric urban system. Approximately one third of the state's population of 4.5 million people are concentrated in the Dublin Metropolitan Area. The urban centres in the second tier are far smaller than Dublin. Cork City is the second urban centre of the country with a population of 190,000, followed by Limerick/Shannon, Galway, Waterford and Dundalk (See Figure 1). These cities all have important and varied urban services functions for relatively large hinterlands.

Table 2 presents the spatial distribution of employment in the pharmaceutical industry in Ireland. The overall picture is one of modest concentration. There are two main concentrations, one in Cork county and one in Dublin county. In 2003 the two counties accounted for 45 per cent of all employment in the industry. Outside these two regions there are sizeable secondary concentrations in four other counties. Still, a significant number of operations, accounting for 22 per cent of employment, are scattered around the country outside these concentrations. The simple figures regarding the spatial distribution of pharmaceutical employment are reflected in the MS index, often used

Table 2. *Employment pharmaceutical sector by county (%), 2003.*

	All pharmaceutical operations[a]	Drug substance operations[b]	Drug product operations[b]
Cork	25	48	8
Dublin	20	26	16
Mayo	10	0	19
Waterford	9	0	17
Wicklow	7	8	5
Kildare	7	0	13
Tipperary	5	7	4
Clare	4	8	0
Roscommon	4	0	8
Other	9	3	10
Ireland	100	100	100

Notes: [a] Includes drug substance, drug products, non-substance intermediates and diagnostics operations. [b] Excluding employment in operations involved in both drug product and drug substance production.

Source: Forfás Employment Survey.

as an indication of the operation of localisation economies. The value of γ for the total pharmaceutical industry in 2003 was 0.03, on the low side in the 'moderately concentrated' category.

A more detailed examination of the industry reveals strongly contrasting spatial patterns for the two main sub-sectors. The drug substance or API sub-sector is characterised by a large grouping of operations in Cork, a secondary grouping in Dublin and a relatively small number of isolated operations outside these two counties (See also Figure 1). County Cork accounts for nearly half of total employment while Dublin accounts for another quarter. The MS index for the sub-sector in 2003 is 0.20, indicating a very high level of spatial concentration. In contrast, drug products operations are far less spatially concentrated. Six counties each account for between 8 and 19 per cent of the total and several other counties are active in this sub-sector. The MS index computed for the sub-sector in 2003 is –0.02, indicating a very low level of spatial concentration.

Figure 2 shows the trends, over time, for the MS index for all pharmaceutical employment and for employment in the drug substance and drug products sub-sectors. The drug substance sub-sector has been characterised by a high and rising MS index for most of the period since 1972. After a period characterised by a relatively low MS index during the 1970s, the sub-sector became 'very concentrated' ($\gamma > 0.05$) by 1980 and for the next two decades the index shows a rising trend, reaching the very high value of 0.25 in 2001. Since reaching this peak the value has dropped somewhat. In contrast, the drug products sub-sector has always been characterised by a low level of concentration. The MS index was very low during the early 1970s. From 1975 the index rose to a peak in 1984, but since then has shown a downward trend, falling below zero in 1992.

This paper focuses on spatial concentration and the role of agglomeration economies in this process. Since the drug products sub-sector is characterised by very low levels of spatial concentration, the remainder of this paper will focus on the drug substance subsector.

THE SPATIAL DYNAMICS OF THE DRUG SUBSTANCE SUB SECTOR: CAUSES OF CONCENTRATION AND THE ROLE OF AGGLOMERATION ECONOMIES

The high and rising level of spatial concentration in the drug substance sub-sector might suggest the operation of agglomeration economies, notably localisation economies. This section will investigate the spatial dynamics of the industry and the determinants for the high level of spatial concentration. The analysis identifies the causes for concentration (in Marshall's terms) and the role of agglomeration economies.

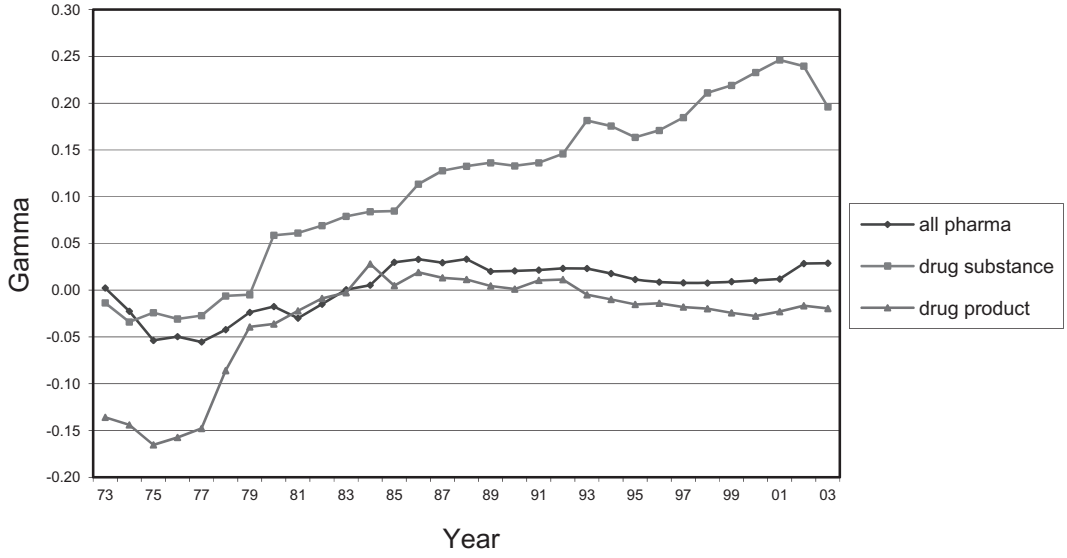

Figure 2. *MS-index pharmaceutical sub-sectors, 1973–2003.*

Table 3. *Location of new drug substance operations on new sites, 1961–2006.*

	Cork Harbour	Cork (other)	Dublin	Ireland (other)
1961–71	0	0	3	0
1972–86	8	2	1	5
1987–2002	2	0	7	3
2003–2006	2	0	1	1

Source: Forfás Employment Survey.

Spatial dynamics and causes of initial concentration – Table 3 lists the new drug substance operations established on new sites in the period up to 1986. Three drug substance plants were established in the 1960s, all of them in the Dublin region. However, despite this head start, the period of rapid growth of drug substance manufacturing activity in Ireland in the 1970s largely bypassed Dublin. Until the mid-1970s, in terms of number of operations, the spatial pattern of the sub-sector was rather dispersed. Apart from Dublin and the area around Cork City, a number of companies had established plants on isolated sites in small rural towns on or near the banks of rivers that were used to discharge the wastewater. It was only in the second half of the 1970s that Cork really started to establish itself as the centre of drug substance production in Ireland. By the mid-1980s there were ten drug substance operations in County Cork. The data on new operations are reflected in Figure 3, which charts the changing distribution of employment. Cork's share of total drug substance employment rose from 36 per cent in 1972 to 47 per cent in 1986.

The main 'causes' (as defined by Marshall) for this spatial concentration in Cork are related to government intervention, notably environmental regulation, regional policy, and related investment in serviced industrial sites. In the early 1970s the IDA identified the pharmaceuticals industry as one of its target sectors. Pharmaceutical plants had specific locational requirements. Pharmaceutical production facilities – in particular large drug substance plants – required sites that were serviced, to a relatively high specification, with effluent disposal facilities, fresh water, and electricity. In general the fresh water requirements far outstripped the existing capacities available in most municipalities (Leonard 1988). In fact, one of the early movers, Pfizer in Cork Harbour, needed to drill a series of wells to augment the public water supply (Clarke *et al.* 2003).

As part of its strategy, the IDA invested in the necessary infrastructure, concentrating most of

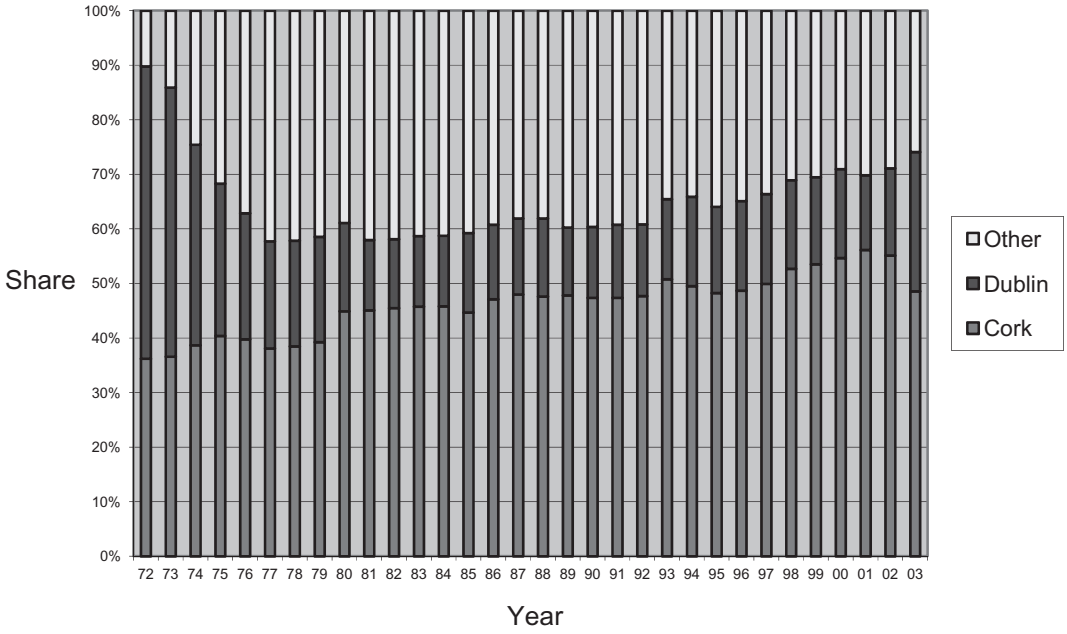

Figure 3. *Share of Cork and Dublin in drug substance employment, 1973–2003.*

its limited resources in Cork Harbour, adjacent to Cork City. In the second half of the 1970s, the IDA purchased large land banks in the harbour area, notably at Little Island and Ringaskiddy. It invested in the required drainage infrastructure, including a major marine outfall for discharge of effluent in Ringaskiddy. In addition, during the late 1970s/early 1980s, Cork County Council created the largest capacity of processed water in the country through the Harbour and City Water Supply Scheme. In later years, the Electricity Supply Board installed the required power supply (Childs 1996).

The rapid build-up of suitable physical infrastructure and the availability of sizeable industrial sites, often with outline planning permission already in place, made Cork Harbour a relatively attractive location (in the context of Ireland) for new drug substance projects (Gallagher 2003). In addition, having made substantial investments, the IDA was eager to sell the land in Cork Harbour. Whenever a company was interested in setting up a drug substance plant in Ireland, the IDA would strongly promote its sites in Cork Harbour. In the words of a former national IDA executive: 'Ringaskiddy became *the* site if you like. That is where we wanted people to go' (see also Breathnach 1982).

Thus, in the ten-year period between 1975 and 1986, six of the ten new drug substance operations on new sites in Ireland were established in Cork Harbour, and by the mid-1980s, the area had firmly established itself as the centre of the pharmaceutical industry in Ireland. Without the spatial planning driven actions, the spatial pattern of the industry would have developed quite differently.

The question remains, as to why the IDA concentrated so much of its limited resources in Cork Harbour? One of the main reasons was regional planning. During the 1960s and early 1970s, spatial and industrial policy became increasingly characterised by an attempt to encourage a shift of manufacturing employment out of Dublin, the traditional core area of the national economy. The Buchanan Report (Buchanan and Partners 1968) advocated a policy of concentrated deconcentration in a select number of growth centres, notably Cork and Limerick-Shannon.[2] The industrial policy was to be implemented by the IDA through its regional industrial plans.

Partly in response to this, in 1972 the Cork Harbour Commissioners, in close co-operation with the IDA and Cork planning authorities, proposed the Cork Harbour Development Plan, involving a major upgrading of the port, including the development of large industrial zones. Ringaskiddy was to be specifically developed for deep-water industries requiring large volumes of water and adequate facilities for large-scale effluent disposal (Brunt 1980).

Another reason for concentrating limited resources in Cork Harbour is related to environmental regulations and public concerns, although Cork Harbour would not have been the only possible location on the basis of this factor. Although the standards were still relatively relaxed, by the end of the 1960s, local governments were starting to drive quite tough bargains with pharmaceutical plants about the level of chemical effluent the companies were allowed to discharge in natural water bodies (Leonard 1988). For drug substance plants located on the banks of inland rivers with limited assimilative capacity,[3] this created a need for intensive on-site treatment of wastewater. This reduced the relative attractiveness of such sites, especially in small urban centres with limited municipal sewage treatment capacity. On the other hand, it increased the suitability of locations near tidal rivers, estuaries or the sea. Large assimilative capacity was one of the most important location factors for the first two pharmaceutical companies which located in Cork Harbour in the early 1970s (Pfizer and Penn Chemicals). In fact, it is argued that Pfizer would probably not have invested in Cork Harbour at all if it had not been allowed to discharge untreated wastewater in the Harbour (Leonard 1988).

In addition, concern among the general public as well as local and central government about the potential pollution caused by pharmaceutical and other chemical plants rose very quickly during the 1970s (Leonard 1988). This was partly driven by severe odour problems caused by some of the first established drug substance plants. In response, between 1970 and 1978, the IDA started to carefully select sites that would minimise the environmental impact of new pharmaceutical projects. With respect to wastewater discharge, in principle there were many suitable locations in Ireland that offered sufficient assimilative capacity. However, intensifying public concern and stricter planning regulations made the establishment of isolated large-scale chemical synthesis plants in rural settings increasingly difficult. In 1978, Eli Lilly was the last company to get planning permission for such a development and, given the strong scrutiny by both general public and planning bodies, was fortunate to get it (Leonard 1988). Instead, the aim was to guide plants that produced large amounts of effluent into two areas, partly selected because of their great assimilative capacity, namely, Cork Harbour and the Shannon Estuary near Limerick (Leonard 1988). Initially, in the mid-1970s, two new drug substance plants located in the Shannon area. However, with the establishment of new, well-serviced, industrial estates in Cork Harbour in the second half of the decade, this area became the prime location for new drug substance plants.

After the mid-1980s, the geography of the drug substance sub-sector changed significantly. The main change has been the rising significance of Dublin as a location for drug substance plants. This change is best captured by the location pattern of new drug substance sites established between 1987 and 2006 (Table 3). With eight new drug substance sites, Dublin accounted for half of such sites in Ireland. Although Cork Harbour continued to receive new plants on new sites, it was less successful, particularly in the 15-year period from 1987–2003, when it accounted for only two of the 13 new plants established on new sites in Ireland.

These developments are not fully reflected in the data for investment and employment for the drug substances sub-sector. This is because many existing companies made significant repeat investments in Ireland, generally expanding on existing sites throughout the country. As regards the distribution of employment, it is only in the early 2000s that we see a significant decrease in Cork's share (from 56 per cent in 2001 to 49 per cent in 2003) and an increase in Dublin's share (from 14 per cent in 2002 to 26 per cent in 2003). The reduction in Cork's share is reflected in a reduction of the MS index (see Figure 2), indicating a lower level of spatial concentration in the sub-sector. However, the share of the top two counties (Cork and Dublin) actually rose from 61 per

cent in 1986 to 74 per cent in 2003 (see Figure 3).

The rise of Dublin's share of total drug substances employment in Ireland was, once again, strongly influenced by government intervention, notably changing regional planning policies and the related location of new well-serviced industrial sites. The 1970s policy of industrial dispersal and encouragement of a shift of manufacturing employment away from Dublin was progressively relaxed in the 1980s (White 2000). This was partly a response to the fact that, during the 1970s and 1980s, the East Region (containing Dublin) experienced serious industrial decline and its share of manufacturing employment shrank significantly (Drudy 1991). Thus, during the 1980s and 1990s local authorities, in conjunction with the IDA, developed a number of well-serviced industrial estates in County Dublin.

The attraction of such readily-available, large, well-serviced industrial sites has increased in the period since the mid-1980s. Increasingly stringent regulations and controls are shortening the effective period of patent protection in the pharmaceutical industry (Van Egeraat & Breathnach 2012), making the time it takes to establish a new manufacturing plant of strategic importance. In addition, the fermentation processes used in the expanding biopharmaceutical sub-sector have very high utility requirements, particularly power and wastewater disposal facilities. A good example of infrastructure influencing plant location involves the Wyeth Biopharmaceuticals plant in Dublin. Initially, the company considered locating this large biopharmaceutical facility near its existing drug products plant in Newbridge, a mid-size town some 50km southwest of Dublin. However, the campus was eventually located in Dublin because adequate wastewater treatment services were not immediately available in Newbridge (Byrne 2000).

Thus, since 1987 a new concentration of drug substance plants emerged in Dublin while the existing concentration in Cork expanded in absolute terms, particularly since 2003.

The role of agglomeration economies – Let us now consider to what extent the concentration of drug substance plants in Cork, and later in Dublin, was driven by the operation of agglomeration economies, and especially localisation economies, that is, a growing number of increasingly specialised input suppliers, technological spillovers and a pooled market for workers with specialised skills.

As regards specialised input suppliers, if this were an important factor in the concentration of drug substance plants in Cork, one would expect a co-location of buyers and suppliers. Drug substance plants use a range of material inputs, but the corporate interviews show that virtually none of the raw materials used by the drug substance plants are manufactured in Dublin or Cork – or Ireland for that matter (see also Van Egeraat and Barry 2009). Similarly, none of the interviewed drug substance plants sell their output to drug product plants in Ireland. In addition, drug products plants are strongly under-represented in Cork.

The growth of the pharmaceutical industry did help to attract a number of process engineering and construction management companies to both cities in the 1980s and 1990s (see also Kearny 2003). Most interviewees in Cork and Dublin perceived this concentration of engineering companies at their doorstep as beneficial. However, most of these companies service a range of other sectors, including other chemical sectors and food processing. Therefore, to the extent that the concentration of engineering companies does present an advantage, it is largely an urbanisation economy. This could point to a process of agglomeration involving 'related variety' (Asheim *et al.* 2011) where, via engineering services, knowledge of the pharmaceutical sector could have been transferred to other parts of the regional economy.

However, it is unlikely that it was a particularly important factor in companies' decisions to locate in Cork or Dublin since pharmaceutical plants in more isolated areas do not experience notable disadvantage due to distance from the offices of these service firms. Engineering companies tend to provide efficient services nationwide. As an interviewee at a more isolated plant stated: 'We have no issue with engineering companies. They are always very quick'. In a sense, the advantages operate on the Irish national scale, rather than the local scale.

As regards technological spillovers, like most plants operating in Ireland during the 1970s and 1980s, the drug substance plants in Cork had a strong branch-plant character, with limited functionality other than bulk manufacturing. Technology was generally directly transferred from the strategic plants in the home countries. Headquarter and product/process development functions were absent. This makes it unlikely that there were any technological externalities embedded in the local milieu, facilitating processes of learning and innovation. In spite of noticeable upgrading since the mid-1980s, the industry has remained truncated with virtually no R&D or headquarter functions. It was only at the late-1990s that a number of companies started to add late-stage process development functions to their Irish operations, while upstream process development and discovery functions remain largely absent.

The interviews provided very little evidence of genuine technological spillovers operating via untraded interdependencies and unintentional information exchange and facilitating innovation within the local industry. There is a degree of contact between local companies and local institutions concerning local infrastructure and production climate in general, notably in Cork. However, according to the interviewees this contact does not act as a medium for technological spillovers facilitating innovation within the local industry. Even intentional interaction regarding technology is limited, dyadic and often not locally/regionally bounded. In spite of focused nature of the interviews, we found very little evidence of technological interaction between pharma companies in Ireland, not to mention between companies in individual clusters. Collaborative research projects between companies and local universities have been rare, although there have been a handful of examples since the 2000s. Even then, some of these projects involve universities and companies located in different regions. Even a company with a substantial process R&D unit in Cork stated: 'We have no research collaborations'. A regional IDA representative considered the extent of local technological spillovers within the largest spatial concentration of plants in Ireland (in Cork) in the following way:

> Certainly, from a spatial point of view, it [the drug substance sector in Cork] is a cluster. But if you look at the broader definition of a cluster, as defined in terms of the interaction between the companies, with the broader environment, a greater level of interaction with the community . . . I think there is a long way to go yet before you can describe it as a full cluster.

Finally, the initial concentration in Cork was not driven by a market for workers with specialised skills. Most of the pharmaceutical workers in the 1970s and early 1980s were operatives, with relatively limited skill-levels and generally no third-level education.

> Most of the pharmaceutical workers at the time would have been operators. They would not have been, as they are now, graduates. It was leaving certificate level and less than that at the time (Interview IDA representative Region Cork).

Plants employed a limited amount of engineers and chemists, but these needed to be qualified as opposed to specialised. Cork did provide a number of more general labour-related advantages. It had an industrial history and a number of companies employed engineering skills, notably the Ford Motor factory. In addition, Cork had a well-developed third-level education infrastructure, including a school of chemistry. University College Cork produced mainly lower level, general, degrees and diplomas, with only one Masters and one PhD degree in chemistry awarded in 1975 (Higher Education Authority). Finally, as the second city in Ireland, Cork provided a large pool of general labour, much of which was unemployed after significant job losses in the early 1980s (Brunt 2005). These were undoubtedly important attractions for drug substance plants, as they were for a range of other industries. However, along with Cork City's well-developed urban services, these were mostly urbanisation, rather than localisation, economies.

It is difficult to determine the precise strength of these urbanisation economies during this period. However, whatever their size, these urbanisation economies cannot, on their own, serve as an explanation for the location and concentration of drug substance

plants in Cork, since similar economies were available in a range of other urban centres. 'Drug substance plants were able to locate at other locations without problem' (Interview national IDA executive).

Since the mid-1980s, the skill-levels in the drug-substance plants have risen sharply, partly due to the introduction of more sophisticated process technologies. Another reason lies in the expansion or establishment of new functions, notably quality control/assurance and the above-mentioned process research and development, particularly since the end of the 1990s (van Egeraat 2010). Apart from a general rise in skill levels, a substantial share of the required skills is also increasingly specialised. Interviewees invariably stated that the supply of suitably qualified labour has become an important location factor. To an extent, the existing concentration of drug substance plants in Cork and Dublin was perceived as an advantage in this respect, but nearly all interviewees related the supply of qualified labour more generally to the location of third level institutions and the quality of life in the major urban centres of Ireland. In relation to the third level institutions, one IDA executive remarked:

> All the colleges and universities in the country are supplying the people who work in the area. So the pharma sector is a national industry, particularly for the third-level institutions. It does not matter which university, your skill is to the same level.

Asked which role the local technical skills base had played in its decision to locate in Cork Harbour, the manager of a plant established since 1987 replied:

> For [our company] it was important that we had a university at our doorstep, good technical colleges for want of another word, for the supply of qualified staff . . . So long as they have a Regional Technical College it is okay. It does not have to be in Cork.

We do not have time series data which would allow us to analyse changes in the relevant importance of University College Cork (UCC) in the pharmaceutical-related sciences. What we can say is that Cork's graduate output in these sciences has substantially increased since the 1970s (Higher Education Authority[4]). UCC went from producing only a handful of biology/biochemistry, chemistry and combined life-science Masters (9) and PhD (2) degree graduates in 1974/75 to a far more substantial output in 2005/06 (41 Masters and 46 PhDs). However, UCC is not the sole (and not even the largest) producer of pharmaceutical-related post-graduates in Ireland. For example, the output of these post-graduate qualifications in the Great Dublin area (79 Masters and 143 PhDs) well surpasses that of UCC.

The interviews also show that most companies now have some interaction with local third-level institutions regarding course content. This interaction has had a positive influence on the numbers and specific skills of local graduates. For example, the course content of a recently established BPharm/BSc Pharm degree in UCC was to some extent influenced by the specific needs of the pharmaceutical industry and facilitated by discussions with staff of local pharmaceutical companies (Barron 2007). That said, the companies have had contact with non-local universities and some of the companies are represented in national-level forums, influencing the skill levels in Ireland as a whole.

As regards quality of life, interviewees noted that qualified and specialised labour is very mobile and most companies recruit on a national and international basis. The targeted highly qualified people tend to have relatively high expectations regarding availability of services, which often translates in a preference for a location in or near the major population centres (see also Malecki 1979).

> From the staff point of view, there is a trend that the higher educated people have higher expectations regarding services. That quality of service is only found in the major population centres. So Dublin, Cork, Waterford, Galway, Limerick are the primary locations (Interview manager drug substance plant).

For both reasons companies prefer locations in or near these centres. At least two plants that were located further away from the main urban centres in Ireland have experienced greater difficulties attracting qualified staff and one general manager stated that he would not locate in a similar area again for this reason. 'It has been difficult to attract people that want to

live here. At times we would have a position open for six months, or even a year' (Interview personnel manager drug substance plant). A number of interviewees believed that the attractiveness of Dublin is since the 2000s being offset by the rising house prices and cost of living in that city. It was believed that this was starting to have a deterring effect on investments in Dublin and may be one of the reasons behind the recent resurgence of investment in Cork harbour.

Thus, without completely dismissing the recent emergence of limited localisation economies, to the extent that drug substance plants were attracted to Dublin and Cork because of the location of third-level institutions and the quality of life that the two cities offered as major population centres, the market for qualified and specialised workers should again be interpreted mainly as an urbanisation economy. Again, these kinds of urbanisation economies were available in other urban centres as well. In this respect, other suitable urban centres mentioned during the interviews included Galway, Limerick, and Waterford. Thus, although both factors probably confer advantages on Dublin and Cork, it is questionable whether they represent an important part of the explanation for the concentration of the sub-sector in these particular cities.

As regards the future, interviewees at seven drug substance plants were asked to identify the three most important locational considerations if they currently had to decide on a location within Ireland. Two factors stood out in the replies. All interviewees regarded the availability of skills as an important factor. This factor was generally mentioned in conjunction with the proximity to a third-level institute. Five interviewees also mentioned the importance of well-serviced sites and utilities. This factor was less important for the two other plants because of their relatively small scale of operations. Given the fact that there are several urban centres that can satisfy the skills requirement, the factor that is likely to most strongly influence the location of drug substance plants, and their possible concentration in certain areas, therefore, is the availability of well-serviced sites. A former IDA executive expressed this as follows: 'They [the drug substance plants] look at Ireland for the tax, and they look for the availability of a site that would suit them, and then they check to see what the skills are like'. In support of this contention, a senior manager of a recently-established large-scale drug substance plant remarked:

> I would say the infrastructural issues are most important because, you know, we have a big facility . . . If you can't support the facility you have a major problem. Obviously the skills base then would be a significant additional factor . . . With the caveat that you could meet these requirements, mainly the infrastructural ones . . . there is no reason why you could not locate in some of these other centres [other than Dublin and Cork]. But again, with the caveat of meeting all of the infrastructural requirements, mainly utilities.

Regional planning policies and the concomitant investment in industrial sites and infrastructure are therefore likely to play an important role in the future spatial distribution of the sub-sector. In this respect the National Spatial Strategy (NSS) 2002–20 (Government of Ireland 2002) will play an important role. It aims to achieve a greater balance of socio-economic growth between regions, partly through the concentration of development in nine national 'gateway' centres of critical mass.

The IDA has embraced the NSS (see Dorgan 2004) and supports it via its FDI promotion strategy, including the distribution of 'strategic sites' (see also O'Kane 2005). This is a specific category of IDA sites developed to support large and medium-scale manufacturing activities with large utility requirements, especially pharmaceutical plants. Apart from Ringaskiddy (in Cork Harbour) and Dublin, the newer strategic sites are all located in the vicinity of coastal 'gateways': Galway, Dundalk, Limerick/Shannon and Waterford (See Figure 1). The completion of the strategic site in Waterford was promptly followed by Servier's decision in 2006 to establish a large scale bulk active ingredients plant on the site. These developments are likely to lead to a reduction of the high levels of spatial concentration on a national scale.

Environmental and regional planning policy and the related spatially selective provision of infrastructure clearly have been, and continue to

be, the most important influence on the spatial configuration of the Irish pharmaceutical industry, including on the continued growth of the Cork and Dublin concentrations. Although some localisation economies have emerged, these remain relatively limited and their role in shaping industrial concentrations remains at a much lower order of magnitude. The important role of environmental and regional planning policy reflects, of course, the specific characteristics of the drug-substance sub-sector, characterised by large-scale plants with high infrastructure and utility requirements. As illustrated in this paper, the lower utility requirement and relatively limited environmental impact of the drug products sub-sector has led to a dispersed spatial pattern. The consequences of these findings for the debate concerning the potential transformation of satellite industrial platform-type concentrations to self-perpetuating concentrations, will be discussed in the conclusion.

CONCLUSION

This paper has explored the idea that spatial planning-driven satellite industrial platform concentrations may, over time, automatically gain the capacity to generate substantial agglomeration economies and ultimately transform into entities capable of stimulating self-perpetuating growth associated with advanced satellite industrial districts or pioneering high technology districts. This idea has been explored in the context of the spatial dynamics of the pharmaceutical industry in Ireland, notably the drug substance sub-sector.

The drug substance sub-sector in Ireland has been spatially concentrated since the 1970s, when Cork Harbour established itself as by far the single most important centre of drug substance manufacturing in Ireland. The period since the mid-1980s has been characterised by a relative shift to Dublin, although the drug substance sub-sector in Cork has continued to expand.

We have shown how the high level of concentration of the drug substance sub-sector in the two particular urban centres has largely been driven by regional spatial planning policy and the related spatially selective provision of well-serviced industrial sites and infrastructure. The Cork concentration, even after forty years of existence, has not generated substantial agglomeration economies and has not transformed into an entity capable of stimulating self-perpetuating growth of the type associated with advanced satellite, or pioneering high technology, industrial districts. Spatial planning-type government intervention, rather than agglomeration economies, remains the most important driver for growth.

This is not to say that companies in the two locations do not benefit from agglomeration economies at all. Certain types of agglomeration economies have spontaneously arisen, particularly since the mid-1980s. However, their role in shaping local industrial concentration remains at a much lower order of magnitude than that of government spatial planning and related environmental legislation. They are mainly of the urbanisation type, relating particularly to the pooled market for workers and, to a lesser extent, input suppliers (engineering services). Limited localisation economies have recently been developing in the form of the supply of specialised qualified labour. The research found no evidence of genuine technological spillovers. Although urbanisation economies have been a factor in the concentration of the industry near the two urban centres, the fact that these economies have also been available in several other urban centres means that they cannot serve as an explanation for the particular concentration of the drug substance plants in Cork and Dublin.

The limited role of localisation economies is partly underlined by the development of the second concentration of drug substance plants in Dublin since the mid-1980s. Under a changed spatial planning regime, the provision of suitable sites and utilities in Dublin instigated a substantial shift in the location of new drug substance plants. Further support for the relatively limited influence of localisation economies is found in recent investments on IDA strategic sites near urban centres other than Dublin and Cork, again driven by spatial planning considerations.

The findings of this case study of the Irish pharmaceutical industry cannot simply be generalised to all other cases of spatial planning driven industrial platforms. Developments may depend on the specific knowledge base

involved (Asheim *et al.* 2011). The pharmaceutical industry has distinct functional requirements along the value chain, with a relatively high level of analytical knowledge. Industrial development might be different in contexts where synthetic (Moodysson *et al.* 2008) or symbolic knowledge bases dominate (Van Egeraat *et al.*, 2013). Spatial planning driven platforms based on foreign direct investment are not confined to industries characterised by analytical knowledge based industries.

But the findings do reiterate the need to differentiate between different types of industrial concentrations. The evidence presented in this paper does not challenge the large body of work that demonstrates the salience of localisation economies, notably technological spillovers, in the process of spatial concentration in general. Existing studies of the global 'megacentres' of the pharmaceutical industry in core economies such as the USA and the United Kingdom show that localisation economies, notably technological spillovers, have played an important role in the process of spatial concentration (e.g. Schreuder 1998; Boasson and MacPherson 2001; Cooke 2003). However, the case of the Irish pharmaceutical industry serves to show that the kind of spatial planning-driven satellite industrial platforms in the context of late-developing countries do not automatically start generating substantial localisation economies and crucial technological spillovers, not even in the largest concentration worldwide after nearly 40 years of existence. In the context of underdeveloped research infrastructures and low levels of entrepreneurship, a transformation into self-perpetuating industrial concentrations will require more than spatial planning policy.

Such a transformation, notably the development of technological spillovers, requires the truncated branch plants to become involved in more substantial innovate activities, as well as the development of an indigenous segment with sufficient absorptive capacity. This will require a more comprehensive innovation and industrial policy that supports investment in R&D, development of the science-base and the functioning of innovation system, and is generally more sensitive to the role of institutions and the path dependent nature of spatial concentration and innovation processes (Menzel *et al.* 2010). Such policies would better position Ireland to take full advantage of the current strategy of pharmaceutical companies to internationalise their core R&D functions and, at the same time, would support the development of an indigenous segment.

Transforming the pharmaceutical concentrations in Ireland into self-perpetuating pharmaceutical innovation arenas will require a greater focus on the development of indigenous innovation capacity, both in the form of university departments and research institutes. This includes policies supporting entrepreneurship, spin-off formation and the availability of venture capital (Carlsson 2006; Orsenigo 2006). The Strategy for Science Technology and Innovation (DETE 2006) and the more recent 'Smart Economy' document launched by the Irish Government (Government of Ireland 2008) include many elements that will support such a development over time.

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Notes

1. The Herfindahl index is a measure of industry concentration, generally used as an indicator of competition among firms. It is defined as the sum of the squares of the market shares of each individual firm. It can range from 0 (a very large amount of small firms) to 1 (a single firm).
2. Subsequent official policy statements emphasised a greater dispersal of development throughout the country (Drudy 1991) but Cork remained a focus for industrial development.
3. Assimilative capacity is the capacity of a natural body of water to receive wastewaters or toxic materials without deleterious effects.
4. www.hea.ie. Data for UCC 1974/75 were specially compiled by the HEA from archive material. The Greater Dublin universities category comprises of Trinity College Dublin, University College Dublin, Dublin City University, and National University of Ireland Maynooth.

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