MAPPING THE POTENTIAL FOR ALL-ISLAND SECTORAL ECOSYSTEMS

A SUMMARY REPORT

SEPTEMBER 2015

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Contents

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Foreword

The potential benefits to arise from economic agglomeration, industrial districts or cluster development are widely researched and evidenced. In 2007 the OECD noted how 'the cluster concept spread rapidly through policy circles in the 1990s ... and at both the national and regional levels the key concepts that underlie the cluster approach continue to be at the centre of policy formulation'.[1]

From a practical policy point of view the concept has influenced various initiatives from locational choices of inward investment to the development of business networks. In both Northern Ireland and the Republic of Ireland the development of clusters has had a considerable influence on policy. For example, in Ireland, Enterprise Ireland's Pilot Clustering Programme has been in operation since 2012 and builds on earlier interventions designed to develop research and innovation networks, partnerships and flows of knowledge between businesses and other ecosystem actors. One of these, Science Foundation Ireland's Strategic Research Clusters (run since 2006), specifically supports partnerships between higher education institutions (HEIs) and between HEIs and businesses.

In Northern Ireland, the clustering approach has underpinned Invest Northern Ireland's Collaborative Business Networks programme, begun in 2009/10, which has seen the development of more than 30 networks. Furthermore funding from the EU cross-border INTERREG programmes has supported several cross-border business networks and clustering initiatives.

Such initiatives have forged better connections between businesses and between businesses and other actors in the ecosystem, such as trade associations, business development agencies, financial services organisations and HEIs. Success stories include for example, the Global Wind Alliance and Digital Circle in Northern Ireland and in Ireland, IT@Cork and the emergence of a medical devices cluster around Galway with its interactions between multinationals, indigenous firms and HEIs.

The small size of the island and the proximity of businesses to one another and to other actors in the ecosystem suggest there are likely to be benefits to the development of all-island clusters or, to use the terminology in this report, sectoral ecosystems. The concept of sectoral ecosystems used here merges the spatial dimension behind cluster theory and practice with ideas about the web of relationships which have the firm at the centre interacting with other businesses, individuals and institutions for mutual benefit.

To date however, there has been little research on the potential benefits of all-island clustering or on the areas and sectors in which they can be developed. This report, which is based on a more detailed project commissioned by InterTradeIreland, seeks to begin this discussion. It proposes a framework which sets out how and what potential benefits can be expected from all-island sectoral ecosystems and using a new measurement index, it identifies and maps sectoral concentrations on an all-island basis. Finally, based on a detailed case study analysis of three prominent sectors, the report presents a series of potential opportunities which could enhance the development of new all-island sectoral ecosystems with mutual benefits for both jurisdictions. Realising these benefits will not be without its challenges but InterTradeIreland will now begin to assess how they might be delivered and the resources required to do so.

[1] OECD, *Competitive Regional Clusters: National Policy Approaches* (2007), p. 24.

SECTION

1

FRAMEWORK FOR ALL-ISLAND SECTORAL ECOSYSTEMS

Framework For All-Island Sectoral Ecosystems

Introduction

The framework developed in this section reflects and is built upon a changing understanding of economic development which judges interaction at varying spatial scales – local, regional, national and international – as important. The focus on interaction is relevant particularly for peripheral border regions or in a relatively peripheral location such as the island of Ireland. This research has given rise to the idea of a sectoral ecosystem where individuals, enterprises and other organisations interact for mutual benefit and is influenced by research in biology, to create a picture of a web of symbiotic relationships in which businesses operate and grow. Recent policy documents have also picked up on the ecosystem concept to highlight the importance of interaction and collaboration, particularly for innovation.[1]

The benefits to be derived from such sectoral ecosystems are naturally related to economic development at the aggregate, enterprise and spatial levels. While the aggregate level of economic development in any place is largely determined by the number, size and performance of individual enterprises, this process has been found to be uneven across geographical spaces. Industrial districts were identified in the early writings on economic geography for example by Alfred Marshall[2] and emerged from observations of industrial development during the industrial revolution of the 18th and 19th centuries. More recently the pursuit of such clusters of economic activity has had a significant influence on policy, particularly since the publication of Michael Porter's *The Competitive Advantage of Nations* (1990). Porter proposed a mutually reinforcing system comprising of the strategy, structure and competition of enterprises; demand conditions; related and supporting industries; and factor conditions. The intensity and depth of the interrelationships between these four factors within the national or regional 'competitive diamond', has a profound impact on regional economic performance. Furthermore, the closer geographically the four factors are to each other (and the enterprise), the higher is the interaction between them, which implies that the most successful industries in a country are often the most geographically 'clustered' (concentrated).

[1] Forfás, *Making it Happen: Growing enterprise for Ireland* (2010); Department of Enterprise, Trade and Investment, *Northern Ireland Innovation Strategy* (2014).
[2] A. Marshall, *Principles of Economics* (1890).

The concept of sectoral ecosystems within this report uses the spatial perspective behind cluster theory and practice. The benefits of this clustering can include access to an appropriately skilled and highly mobile labour pool, local supplier linkages and the acceleration of the diffusion of information and knowledge leading to the development of new products and services. This last is linked to changes in the way that enterprises undertake innovation. In a more open model internal resources and capabilities are being complemented by external resources and knowledge. This means that inter-organisational relationships become critical to effective knowledge transfer into the enterprise. Clusters, it is believed, provide an environment that increases the effectiveness of inter-organisational knowledge flows.

Critical factors include the level of specialisation or diversity within the cluster, the level of intensity of network ties in the cluster and characteristics of businesses, including absorptive capacity for external knowledge.

A specific limitation in the literature around clusters or sectoral ecosystems, that is particularly relevant to the all-island context, is that it has little to say about cross-border spillovers. Nevertheless, some research is identifying how co-operating neighbouring regions, even across borders, can improve economic performance of the regions and, if cross-border social and business linkages are strong, can compensate for peripherality.[3] For example the Oresund region, comprising Copenhagen and Zealand in Denmark and Skane in Sweden, that actively cooperates to promote cross border-labour market integration and research collaboration, has higher levels of R&D activity and firm formation than the national averages.[4] Other successful cross-border collaborations include the Belgium-Germany-Netherlands (Eindhoven-Leuven-Aachen)[5] border region and the France-Germany-Switzerland (Basel) region[6] both with a focus on research, technology and innovation cooperation.

[3] U. Blum, 'Borders Matter- Regional Integration in Europe and North America', *Jahrbücher für Nationalökonomie und Statistik*, 223:5 (2003), 513-531; A. Strihan, 'A Network-based Approach to Regional Borders: The Case of Belgium', *Regional Studies*, 42:4 (2008), 539–554; OECD, *Regions and Innovation: Collaborating across Borders (2012).*

[4] C. Nauwelaers, K. Maguire and G.A. Marsan, *The Case of Oresund (Denmark-Sweden) – regions and Innovation: Collaborating Across Borders (2013).*

[5] C. Nauwelaers, K. Maguire and G.A. Marsan, *The Case of the Top Technology Region/Eindhoven-Leuven-Aachen Triangle (TTR-ELAt) – Regions and Innovation: Collaborating Across Borders* (2013).

[6] J. Driscoll, F. Vigier and K. Leith, *The Basel Metropolitan Area: Three Borders – One Metropolitan Area* (2011).

Analytical Framework

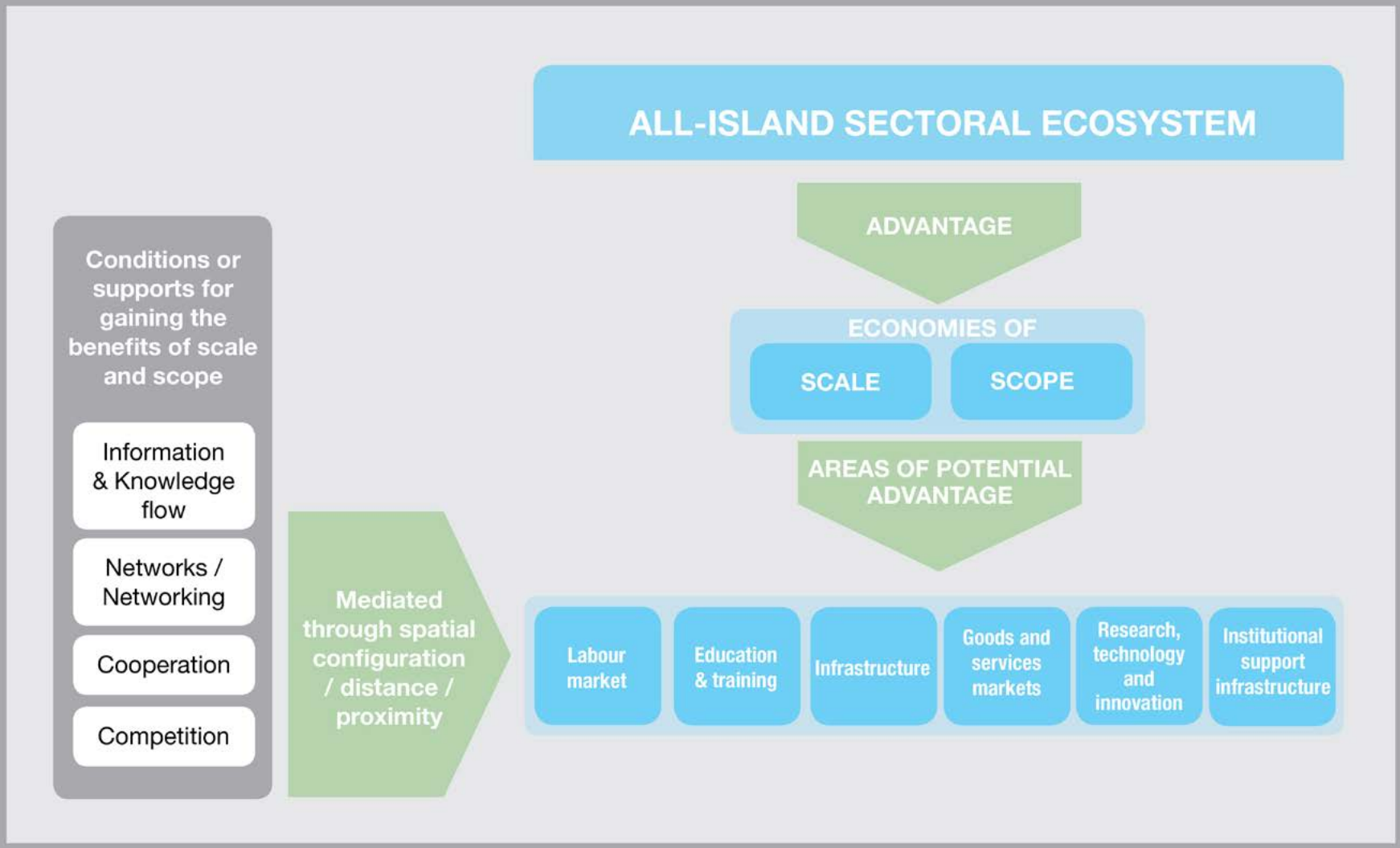
This report builds on the tradition of Marshallian economic analysis and on Porter's concept of clusters to develop the concept of sectoral ecosystems. An analytical framework outlined in Figure 1, sets out the areas in which potential benefits of sectoral ecosystems would be expected to emerge and the conditions or supports necessary for achieving these benefits which will arise through economies of scale and scope. Most of the ecosystem factors are subject to some degree of scale economies. For example an all-Island labour market would encompass a larger labour pool while an all-island product market would imply more customers and more suppliers. Specialised infrastructure is also more viable with a larger group of users. The scope economies are closely related in that greater scale also implies the possibility for greater variety.

The degree to which mutual benefits from scale and scope will be achieved is contingent on the strength of interaction that can be established between the two parts of the island and is mediated through proximity or spatial configuration. Such efforts will only be successful if they are of mutual benefit. The following are critical areas of interaction which will shape the extent of potential benefits.

1. **Information and Knowledge Flow:**
   The benefits of innovation and other knowledge are enhanced through information and knowledge flows (on product or process innovation, market development, access to finance, legal and regulatory issues) both within and between enterprises.
2. **Networks and Networking:**
   Formal and informal networks, such as industry associations, are one way to increase information flows as well as to enable businesses to organise joint marketing campaigns, develop labour market links, connections with third level institutions, etc.
3. **Cooperation:**
   Enterprises as well as other stakeholders can derive significant benefits from cooperating in some of the areas of potential advantage, ranging from the development and sharing of specific infrastructure to mutual education and training initiatives.
4. **Competition:**
   Competition among enterprises, particularly in product and labour markets, can result in increased productivity and innovation, which can spill over to other firms with a beneficial impact on a sector.

The benefits, conditions and flows that manifest are mediated through spatial configuration. They can be bounded locally or at the regional or national scale, or some potential advantages can operate at a level that transcends the boundaries of individual countries. For example, the advantages related to a pooled market of workers may be regionally bounded, benefiting a regional grouping of firms, even if the workers involved are from outside the region or country. In contrast, although informal interactions, which can be a powerful source of knowledge transfer, are significantly facilitated by proximity, many operate at a national scale and, potentially, the all-island scale. The geography of information flow and the level of spatial boundedness of benefits can also differ from sector to sector, depending on- market orientation; the spatial distribution of the firms and other actors; the level and number of spatial concentrations within the ecosystem; the spatial extent of the concentrations; and the spatial boundedness of the benefits, flows and networks.

Figure 1: Analytical framework for all-island sectoral ecosystems



The analytical framework suggests that the benefits of all-island interaction, which arise through economies of scale and scope and are mediated through proximity or spatial configuration, will arise in the following core areas:

1. Labour market
The provision of an adequate labour force, often supplemented by migration, is critical not only to individual enterprises but to dynamic economies in general.

2. Education & Training
In addition to a plentiful supply of labour is a highly skilled workforce, creating the value added needed to justify higher wages and providing the knowledge and skills which will support the productivity of the wider economy.

3. Infrastructure
Modern economies and their businesses rely not only on a range of basic public goods or infrastructures but, increasingly, on more specific requirements such as high speed telecommunications.

4. Goods & Services markets
Firms need large local markets or access to international markets to find both customers for their goods and competitive inputs for their production.

5. Research, Technology & Innovation
The role of the innovation system is becoming more important as growth in existing businesses or the emergence of new enterprises often comes through new ideas, products and services.

6. Institutional supports
The institutional and regulatory setting in which enterprises operate either facilitate their development (by alleviating market failures) or constrain their activities.

The spatial dimension is considered in Section 2 which looks at the spatial configuration of enterprises in each sector and the degree to which spatial concentrations have a cross-border or all-island dimension. This is accomplished by constructing and applying a new concentration measure using an all-island dataset. Section 3 examines in greater detail, through the use of case studies, the strength of interaction that is and can be established between the two jurisdictions in three important sectors.

SECTION

2

MAPPING SECTORAL ECOSYSTEMS

Mapping Sectoral Ecosystems

The concept of sectoral ecosystems was outlined in the previous section. It incorporates key findings of a number of literatures and posits that the ecosystem in which a firm operates is shaped by a wide range of actors, their interactions and their spatial distribution (e.g. agglomeration). Interaction among firms and other stakeholders is facilitated by geographic proximity, which implies that such interaction is often more intensive in spatial concentrations. Thus, concentration forms an important aspect of a sectoral ecosystem. Identifying industrial concentrations and their spatial extent requires empirical analysis using appropriate methods and data. In this section a new measure of spatial concentration is developed and applied to data for Northern Ireland and Ireland to give a cross-border or all-island perspective to sectoral concentration.

Existing measures of spatial concentration have a number of significant drawbacks. Firstly, being based simply on location and size they cannot identify the degree of interaction between firms which is an important component of clustering. Secondly, the extent of the spatial units is usually pre-specified to concord with administrative boundaries. As sectoral ecosystems can vary in size and may incorporate parts of different administrative units, restricting the analysis to predefined administrative units is not appropriate. Utilising administrative units also risks being subject to the so-called modifiable area unit problem, where the results are sensitive to the choice of spatial unit. Thirdly, existing measures tend to ignore the number of firms. Thus, a concentration in a particular spatial unit may be simply due to one very large (in terms of employment) firm. This gives rise to 'one firm clusters', while spatial units with many small firms in a particular sector may not be identified as concentrations.

In order to address some key shortcomings of existing measures, a new measure was devised. The starting point for this measure is that an industry is deemed over-represented in a spatial unit if the share of employment and number of firms is larger than expected on the basis of a random distribution. A cut-off equal to twice the share of employment and number of firms expected from a random distribution is applied. However, given that spatial units are not all equal sized we weight the cut-off by the physical size of the spatial unit. Thus, the cut-off varies by spatial unit on the basis of the physical size of the spatial unit (cut-off is

lower for smaller counties) and the level of industrial concentration (cut-off is higher for industries with a high industry concentration). The new concentration index is referred to as the CI index (the mathematical formula for the index is outlined in the full report). The inclusion of an overrepresentation of firms is a significant departure from existing measures.

In order to identify concentrations the CI index is applied at the county level. However, as counties are relatively large spatial units and given that we want to avoid using predefined administrative boundaries the spatial extent of concentrations is determined by creating labour fields around each plant in a county where a concentration is found. These labour fields are based on travel-to-work data related to the electoral district in which the plant is located. As small insignificant plants can link two or more otherwise discrete labour fields, the smallest 1% of firms are removed for the identification of the labour field extent but these are included in the calculation of the CI index.

Data Issues

The data for the Republic of Ireland comes from the Forfás Annual Employment Survey. The data is collected via a survey of firms, which have had contact with the enterprise agencies, and thus constitute a sample of firms concentrated in exporting sectors. The data for Northern Ireland is drawn from the Census of Employment which covers employment in the entire economy. For 2012 the Forfás Annual Employment Survey data covers over 8,000 firms with almost 270,000 full time employees. The firms have been geocoded which means that their exact location can be utilised in order to identify their labour fields using the commuting data.

The Northern Ireland Census of Employment covers 680,000 employees across 62,000 firms. However, the data supplied only recorded the ward in which firms were located and the total employment in each ward in each sector. Thus, the data was neither the required point data nor could firm size be identified, which requires some alterations to the method of identifying concentrations in Northern Ireland.

To deal with the fact that the data for Northern Ireland was missing point information a pragmatic solution was applied. Firstly, artificial points were created by using the centroid of each ward as the location for the firms. As with the data for the Republic of Ireland the smallest firms are ignored.

In order to maintain consistency between the two parts of the island the size for firms that are not considered is the same for both Northern Ireland and the Republic of Ireland. The data are then combined to generate the spatial extent of the concentration, and the results can be readily mapped. Data limitations for Northern Ireland are nevertheless apparent in the fact that the concentrations in Northern Ireland are less well defined than those in Ireland with more labour fields overlapping due to the lack of access to point data. Access to this data on the same basis as in Ireland would greatly enhance the accuracy of the analysis and policy conclusions.

Maps for all sectors drawn on an all-island basis are arranged and presented into categories as follows:-

Category 1:
Dispersed significant concentrations

Category 2:
Concentrations with a cross-border element

Category 3:
Ubiquitous across the island

Category 4:
Ubiquitous in Northern Ireland with significant concentrations elsewhere

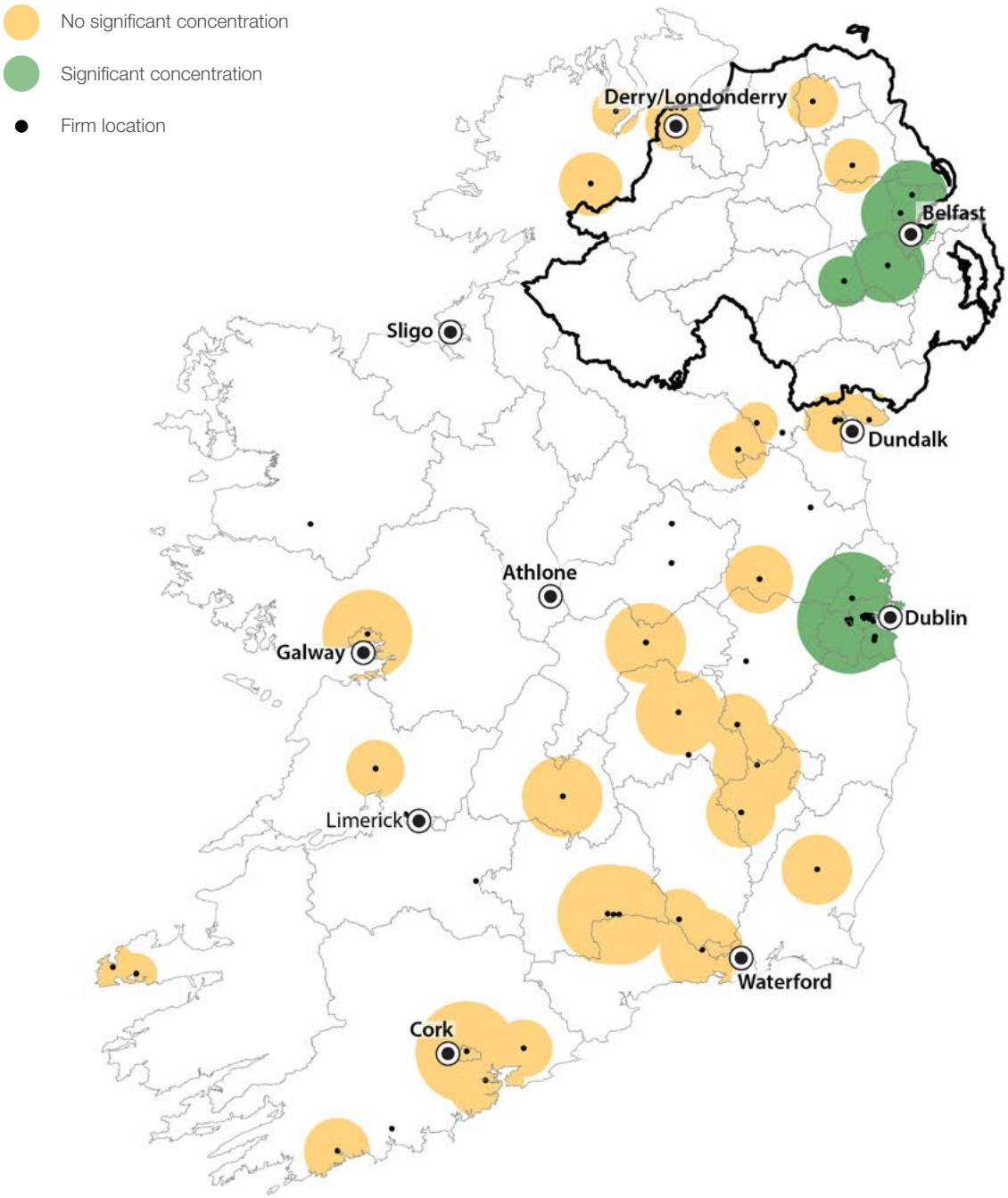
CATEGORY 1
Dispersed significant concentrations

SECTOR		CONCENTRATIONS
1.	**Manufacturing of beverages**	Two significant concentrations in Dublin and Belfast
2.	**Manufacturing of medical devices**	Four concentrations: Dublin, Midlands almost joining the West concentration and Cork
3.	**Information service activities**	One concentration in Dublin
4.	**Motion picture, video and television programme production, sound recording and music publishing activities**	Three concentrations: Galway, Mid-Ulster and East Ulster.
5.	**Printing and reproduction of recorded media**	Two concentrations in Dublin and much of Northern Ireland.
6.	**Manufacture of chemicals and chemical products**	Four concentrations: Belfast-Portadown-Newry, Dublin-Dundalk-Cavan-Athlone, Cork, and Limerick

CATEGORY 1: Dispersed significant concentrations

1. Manufacturing of beverages

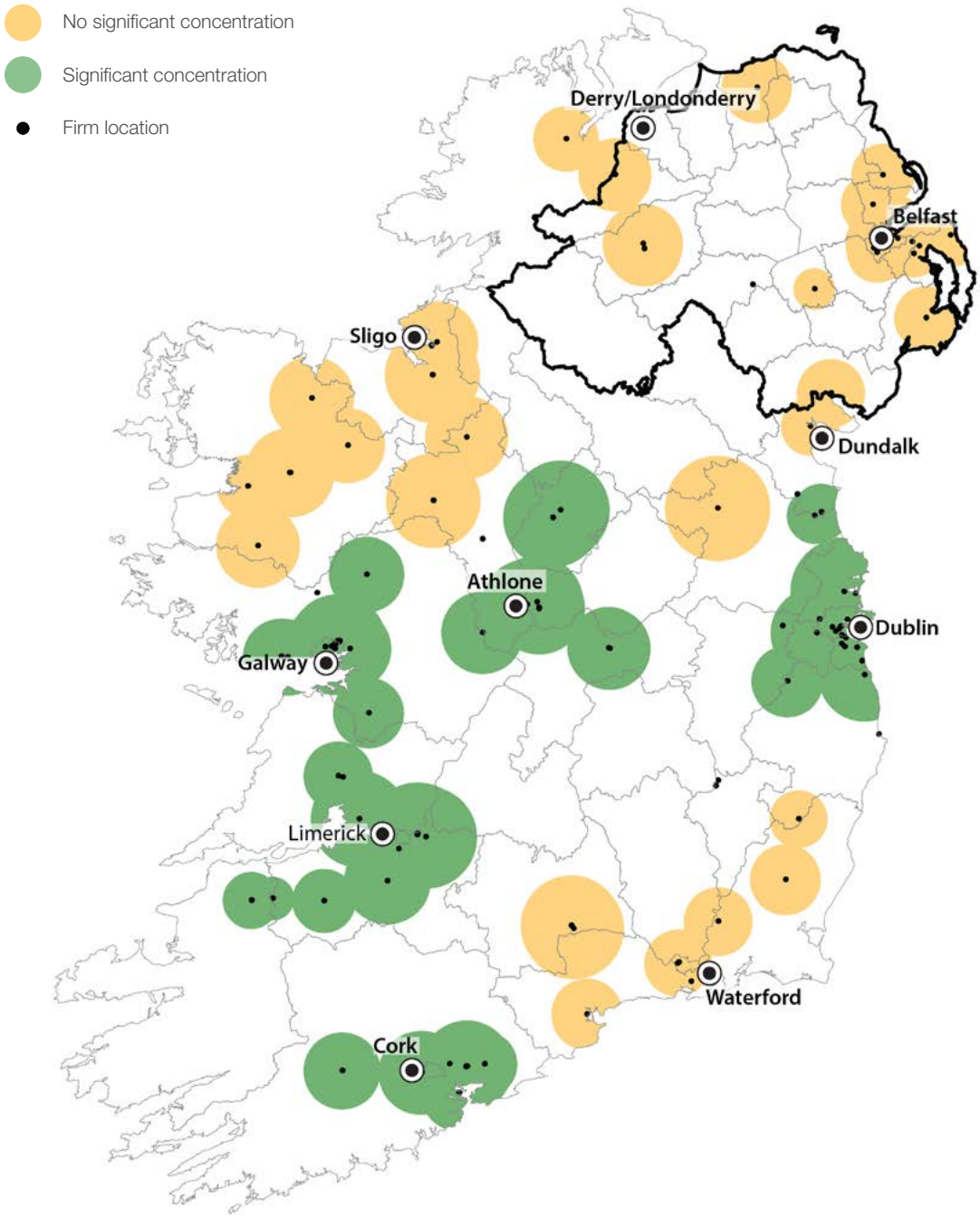
Two significant concentrations in Dublin and Belfast.



CATEGORY 1: Dispersed significant concentrations

2. Manufacturing of medical devices

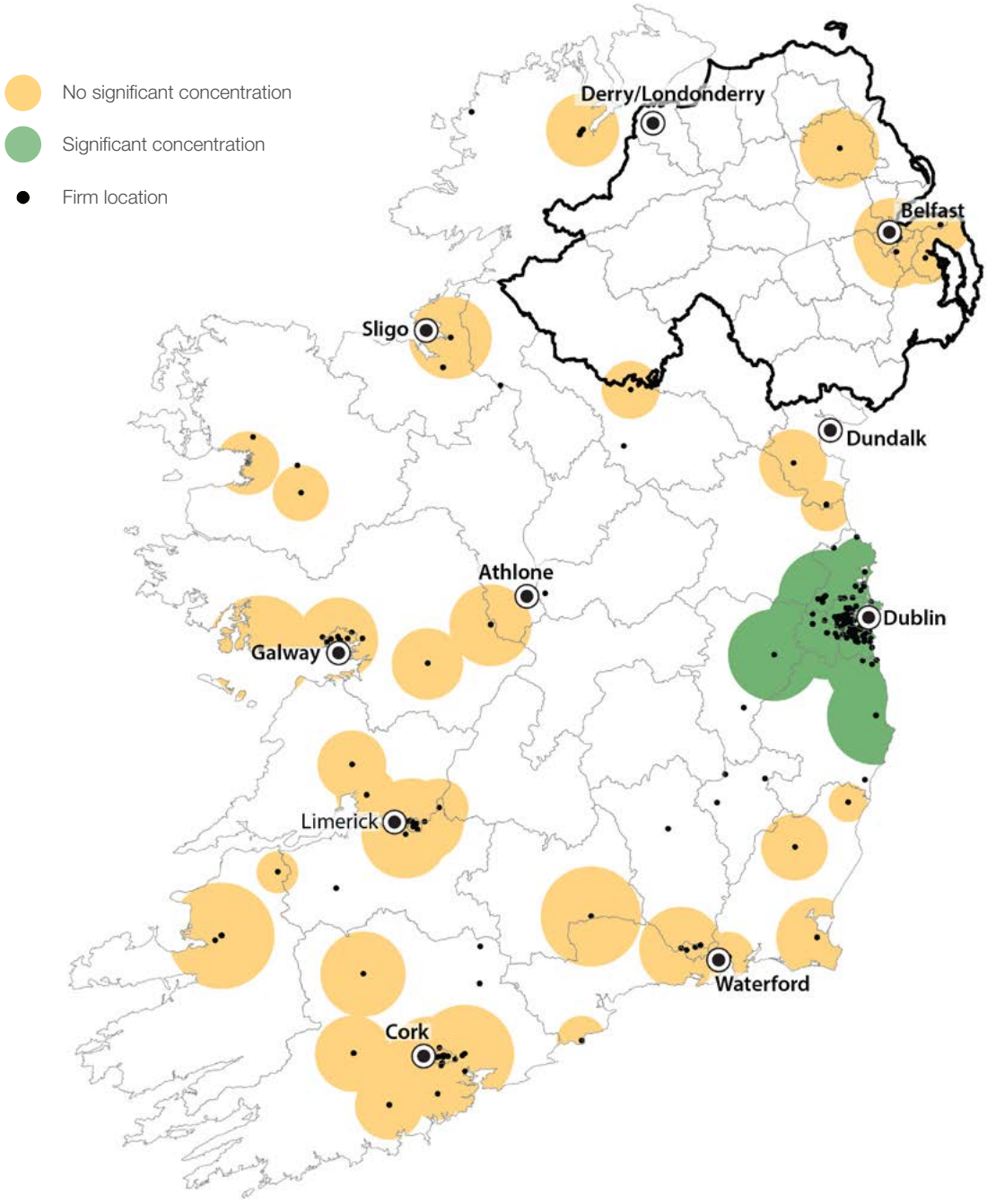
Four concentrations: Dublin, Midlands almost joining the West concentration and Cork



CATEGORY 1: Dispersed significant concentrations

3. Information service activities

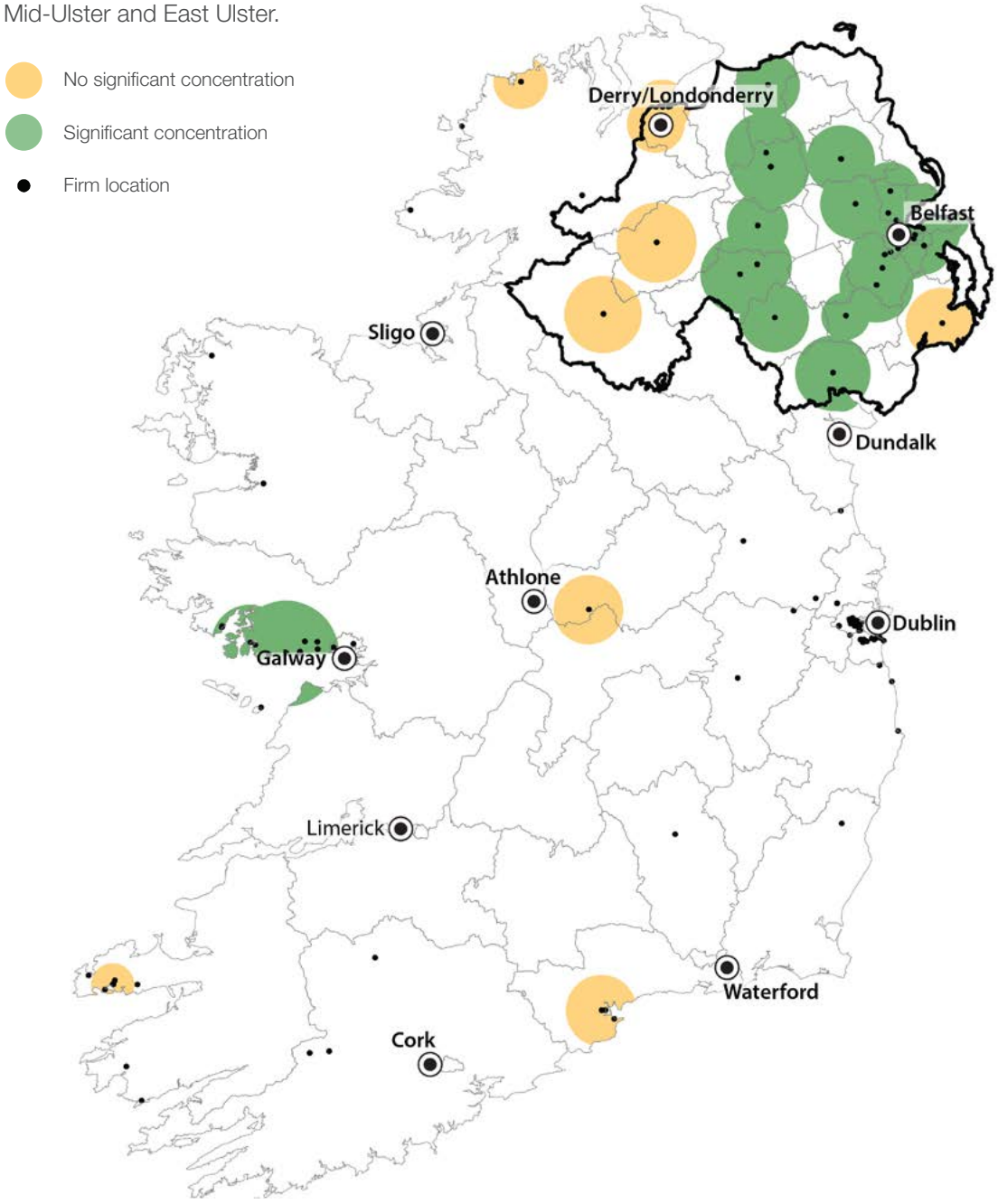
One concentration in Dublin



CATEGORY 1: Dispersed significant concentrations

4. Motion picture, video and television programme production, sound recording and music publishing activities

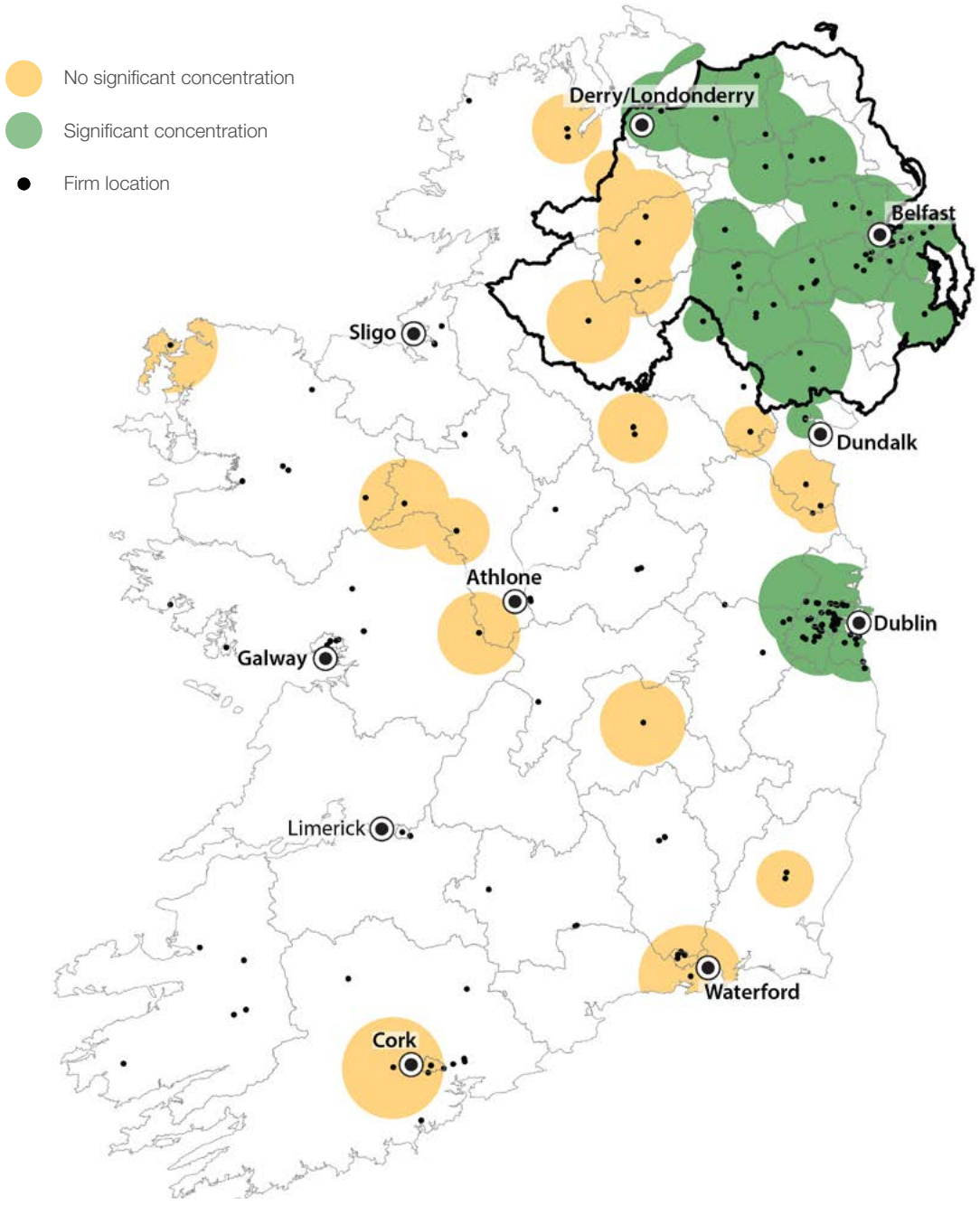
Three concentrations: Galway, Mid-Ulster and East Ulster.



CATEGORY 1: Dispersed significant concentrations

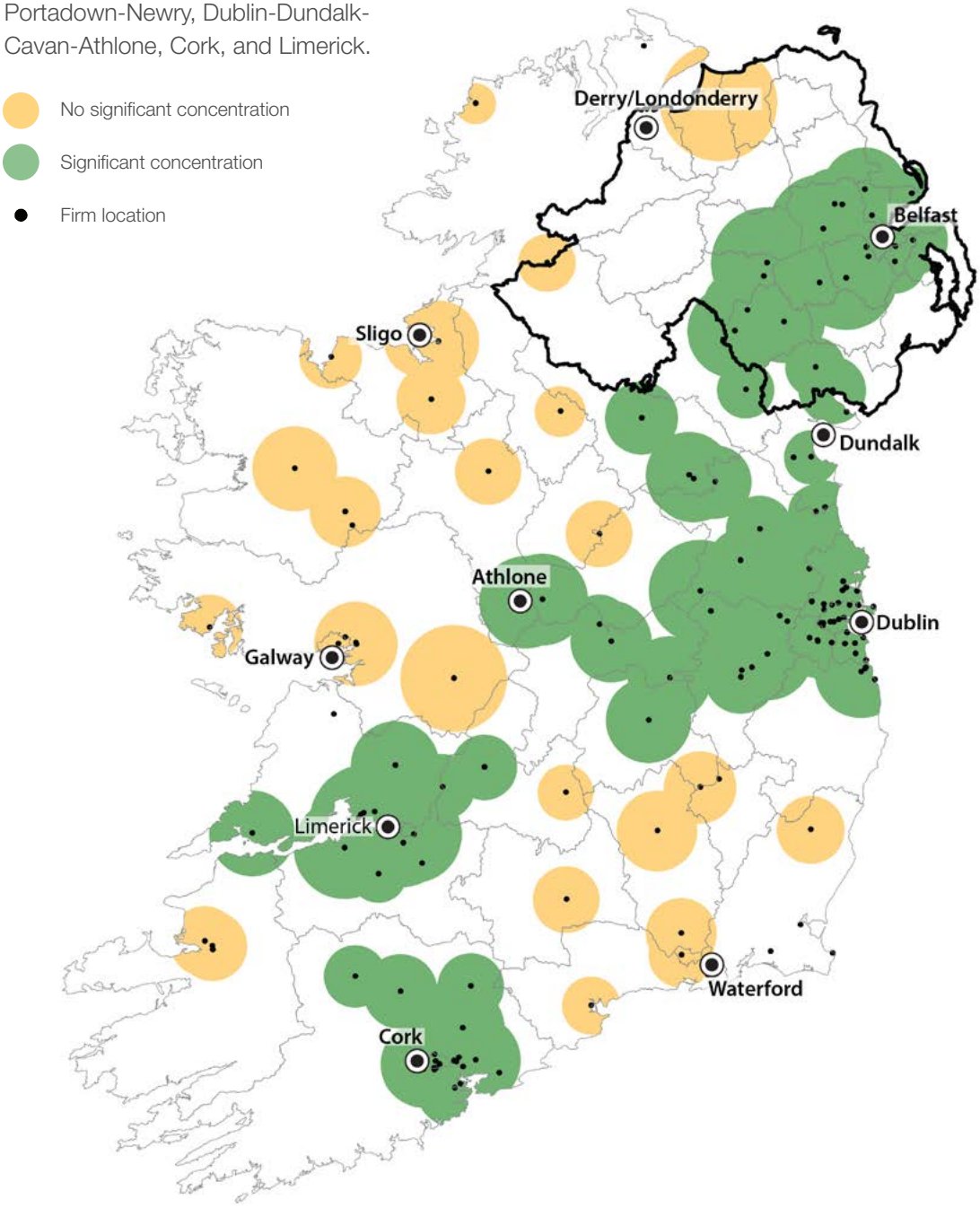
5. Printing and reproduction of recorded media

Two concentrations in Dublin and much of Northern Ireland.



6. Manufacture of chemicals and chemical products

Four concentrations: Belfast-Portadown-Newry, Dublin-Dundalk-Cavan-Athlone, Cork, and Limerick.



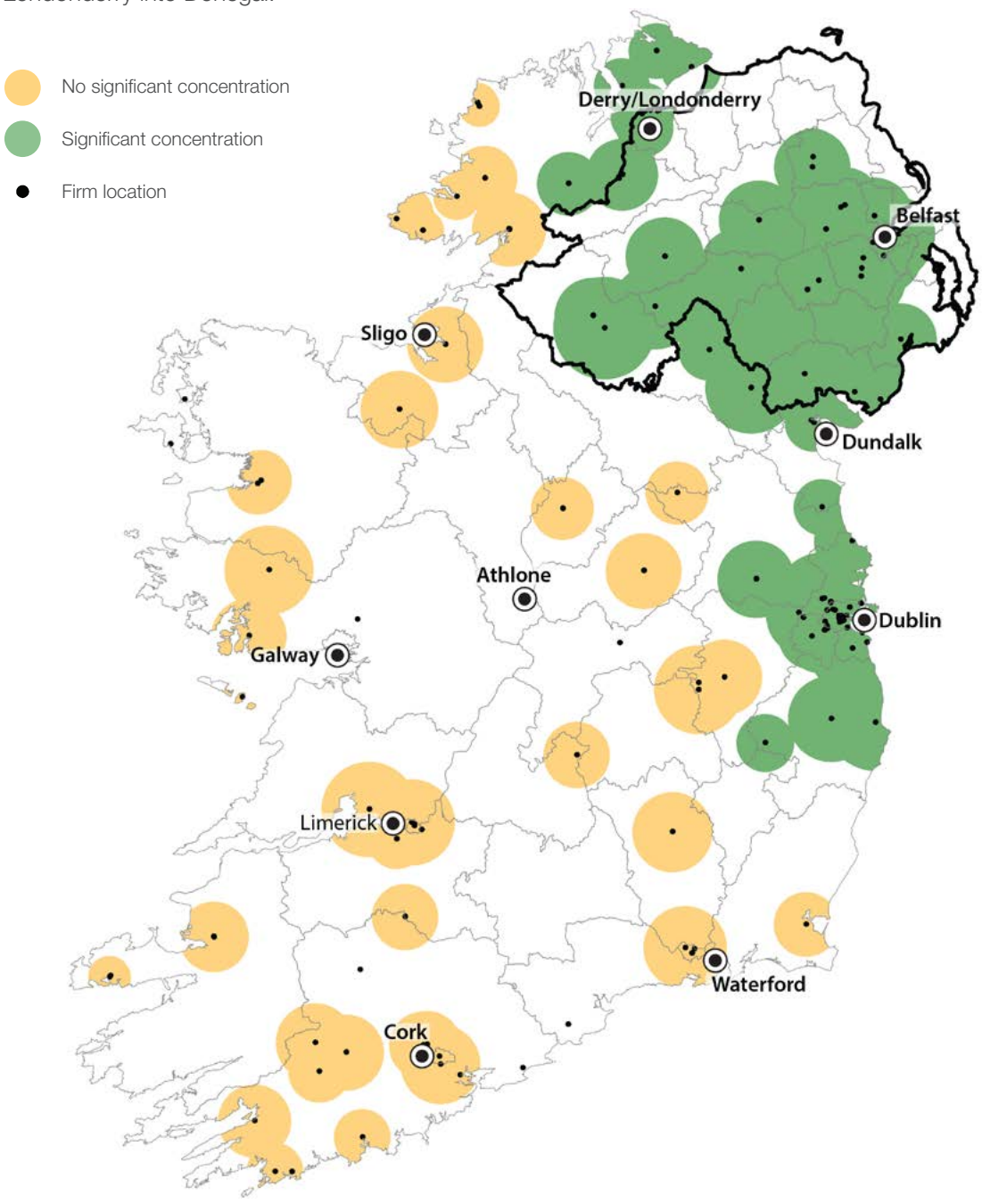
CATEGORY 2
Concentrations with a cross-border element

SECTOR		CONCENTRATIONS
7.	**Manufacturing of wearing apparel**	Three concentrations in Greater Dublin, East Ulster across the border to Dundalk and Derry/Londonderry into Donegal.
8.	**Manufacturing of textiles**	One concentration stretching from Derry/Londonderry to Belfast to Wicklow.
9.	**Manufacture of paper and paper products**	Two concentrations in Greater Dublin and Belfast to Dundalk.
10.	**Publishing activities**	Two concentrations almost merging into a Dublin-Belfast corridor.
11.	**Manufacture of basic pharmaceutical products and pharmaceutical preparations**	Four concentrations: Dundalk-Newry, Dublin, Cork and Waterford/South East.
12.	**Manufacture of rubber and plastic products**	Three concentrations, Northern Ireland into Midlands plus Monaghan, Dublin/East coast, and Cork.
13.	**Computer programme, consultancy and related activities [Software]**	Three concentrations: much of Northern Ireland with two cross border spurs – Dundalk-Newry and Enniskillen-Cavan, Dublin/Mid East, Cork.

CATEGORY 2: Concentrations with a cross-border element

7. Manufacturing of wearing apparel

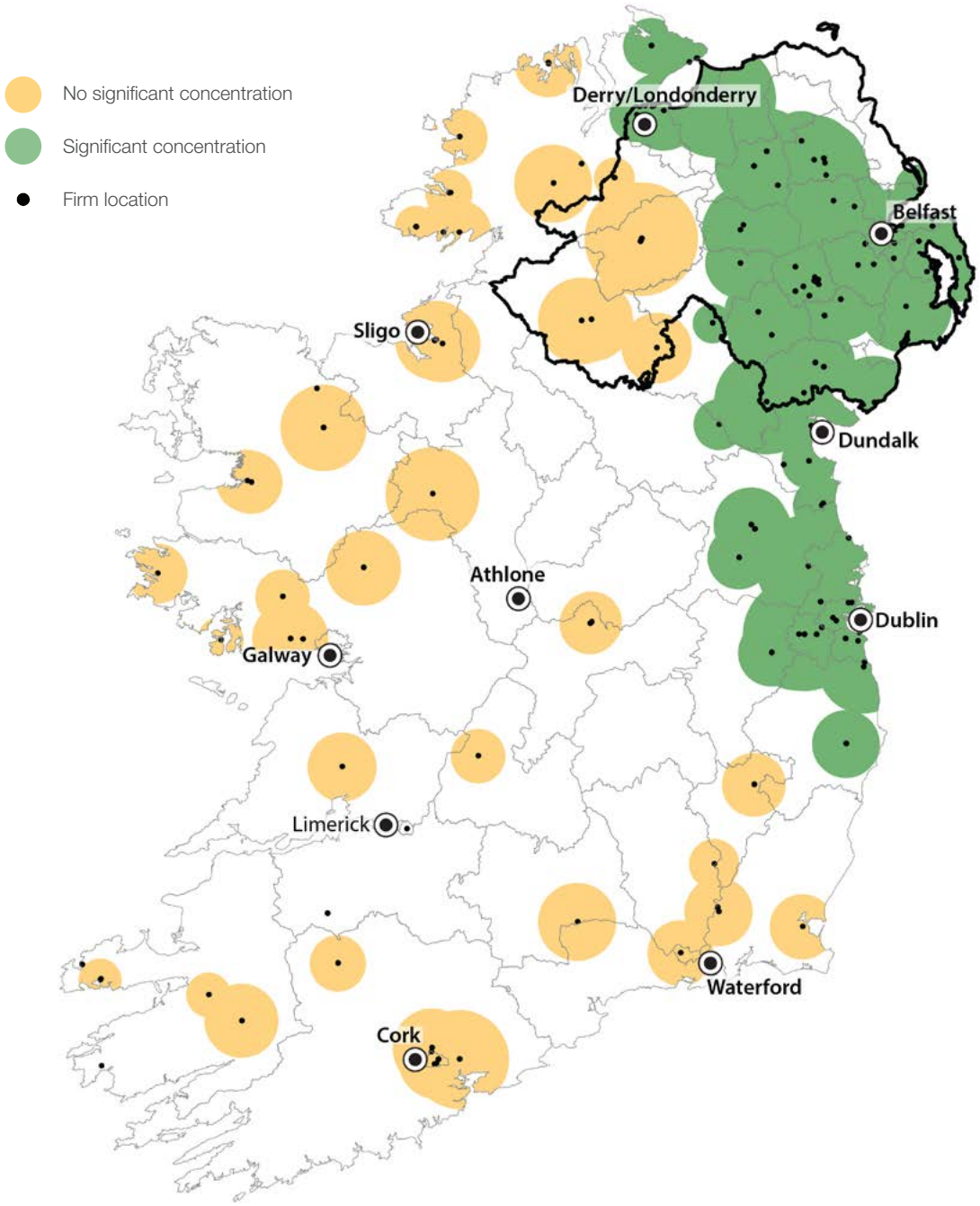
Three concentrations in Greater Dublin, East Ulster across the border to Dundalk and Derry/ Londonderry into Donegal.



CATEGORY 2: Concentrations with a cross-border element

8. Manufacturing of textiles

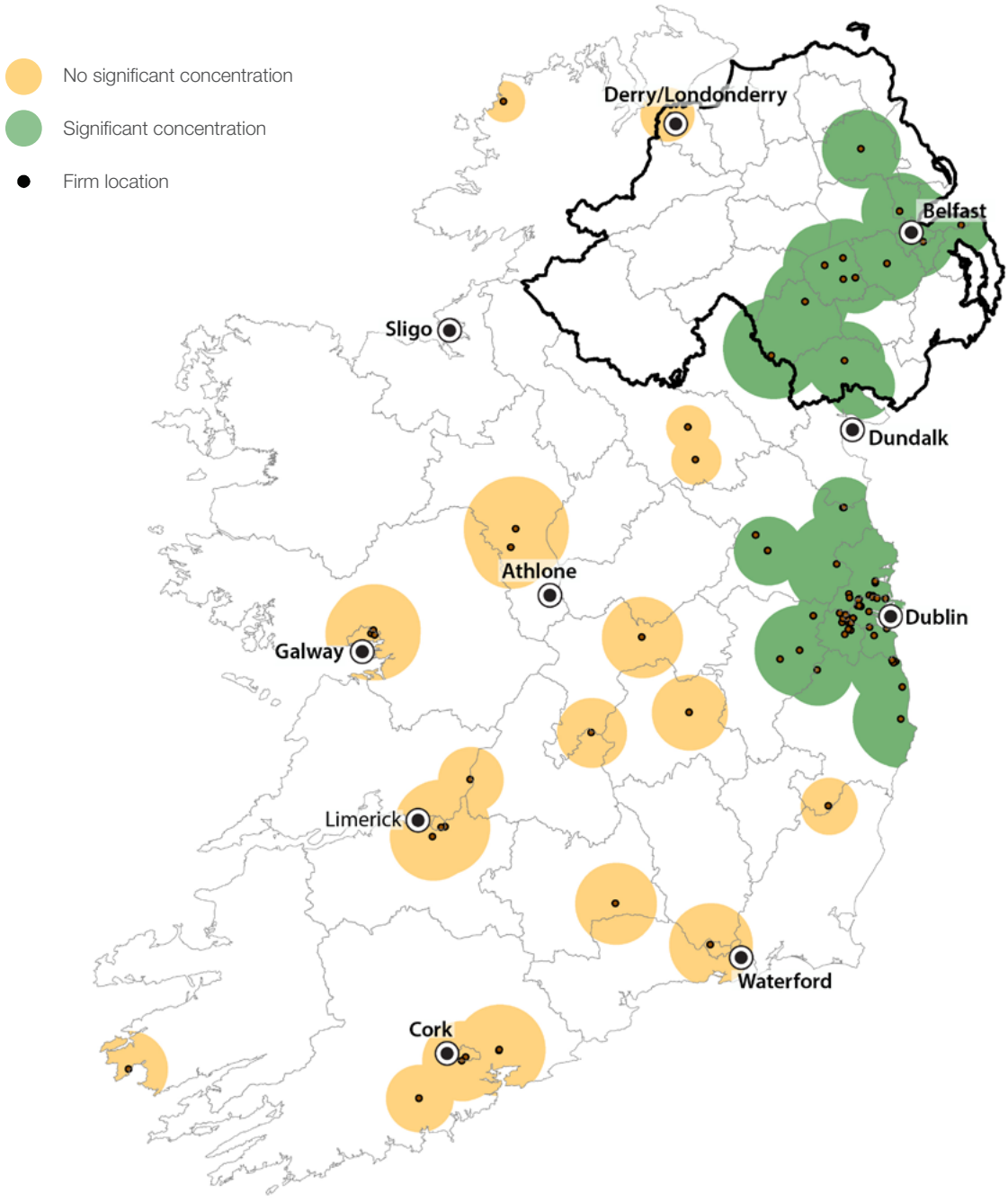
One concentration stretching from Derry/Londonderry to Belfast to Wicklow.



CATEGORY 2: Concentrations with a cross-border element

9. Manufacture of paper and paper products

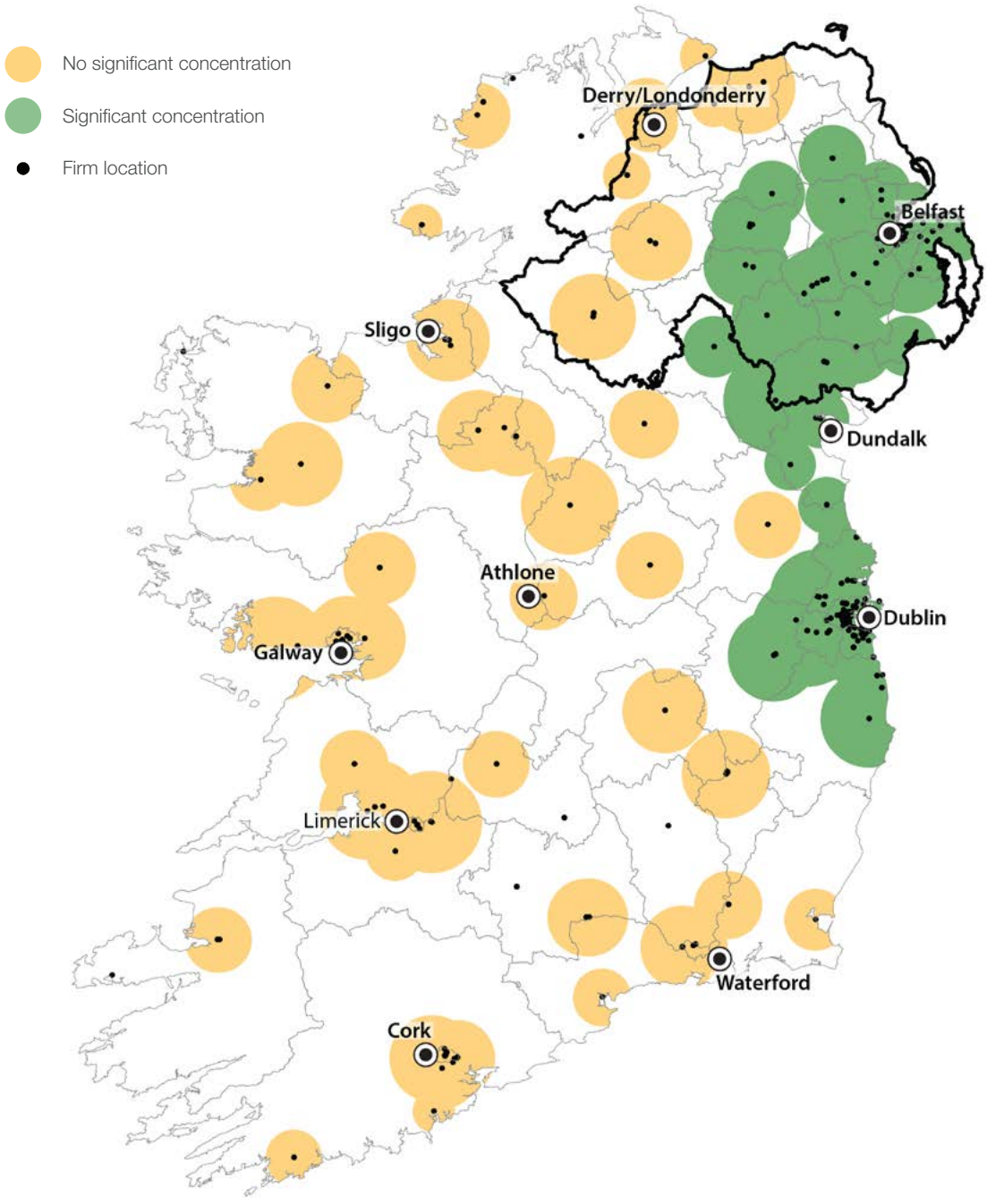
Two concentrations in Greater Dublin and Belfast to Dundalk.



CATEGORY 2: Concentrations with a cross-border element

10. Publishing activities

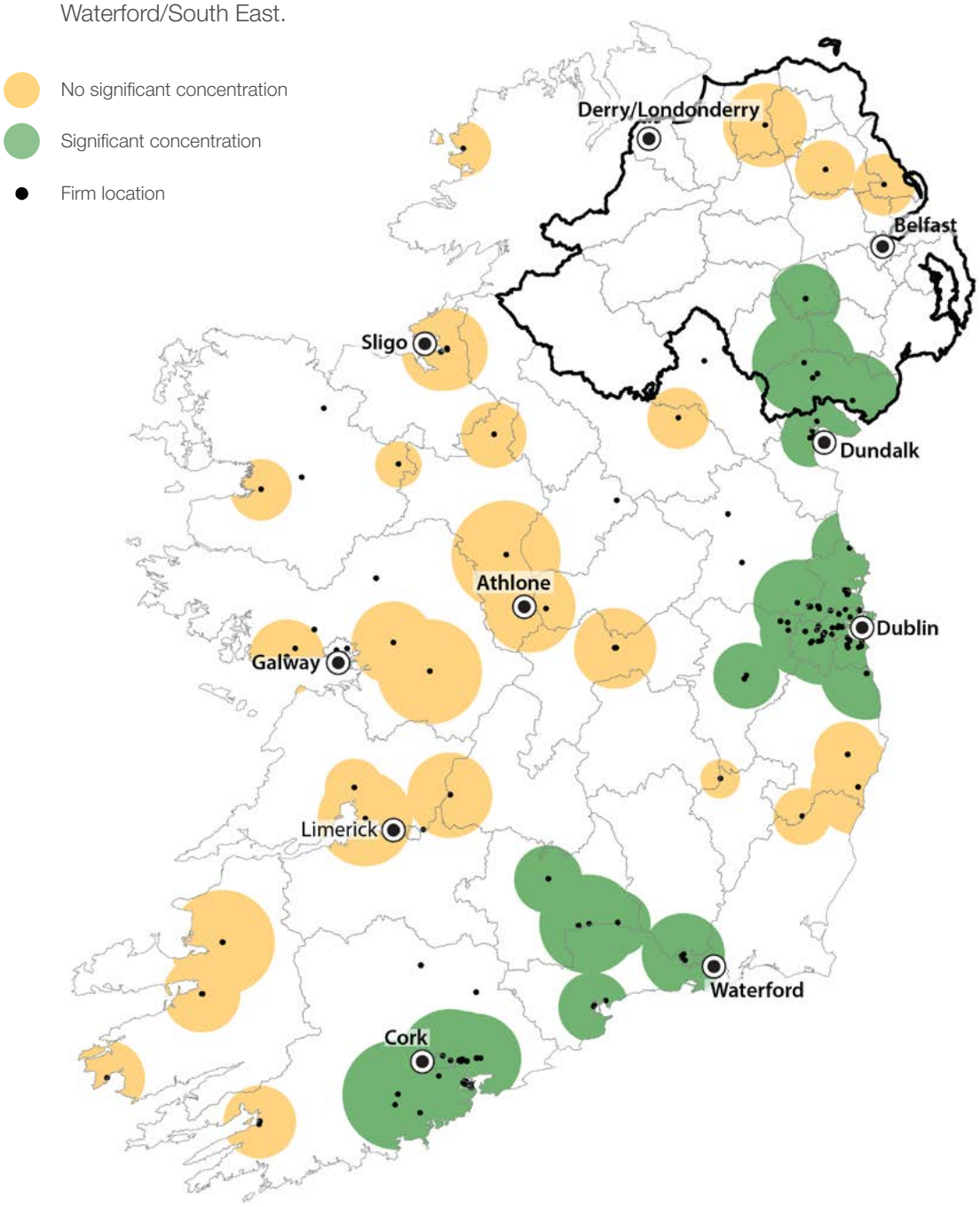
Two concentrations almost merging into a Dublin-Belfast corridor.



CATEGORY 2: Concentrations with a cross-border element

11. Manufacture of basic pharmaceutical products & pharmaceutical preparations

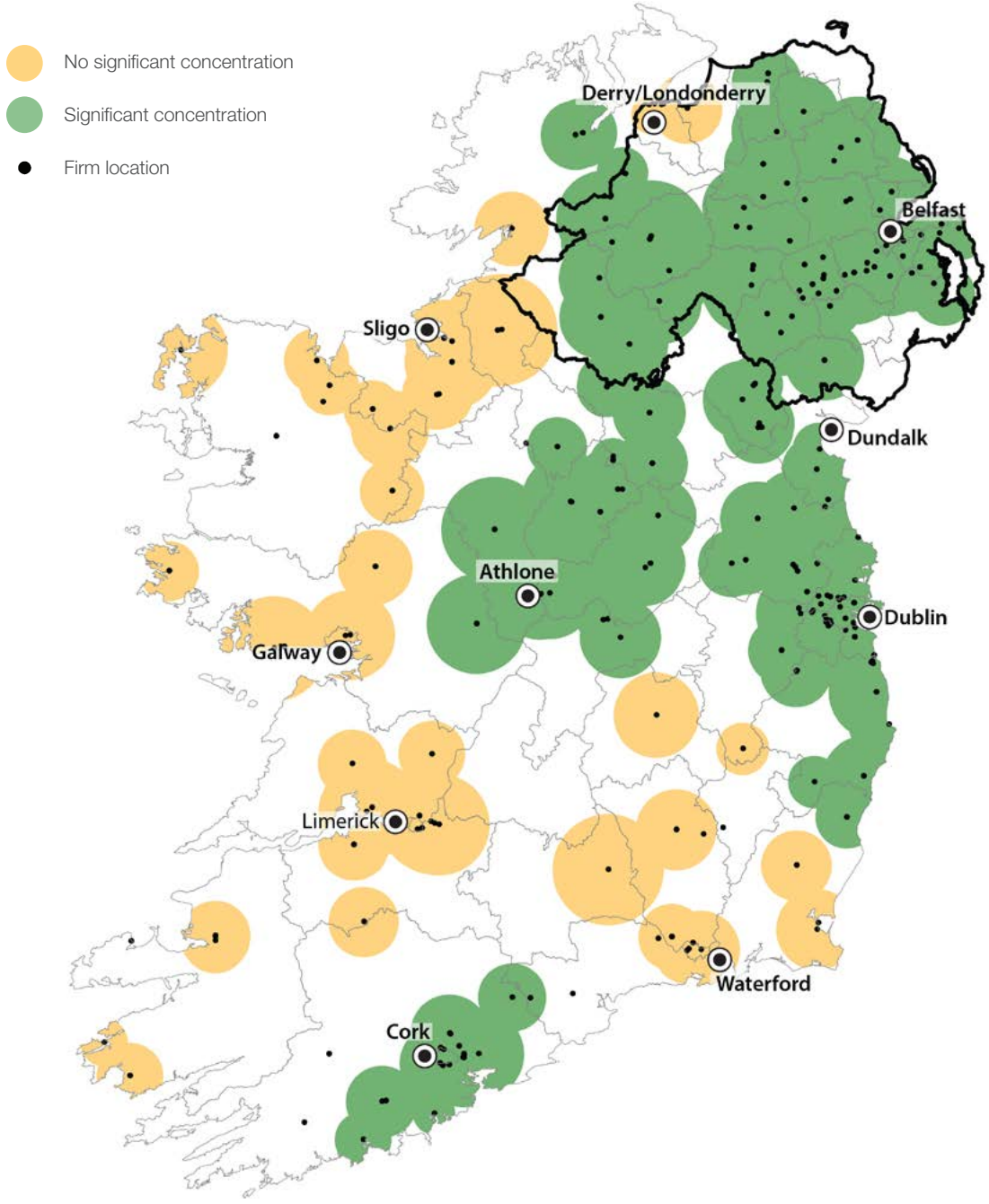
Four concentrations: Dundalk-Newry, Dublin, Cork and Waterford/South East.



CATEGORY 2: Concentrations with a cross-border element

12. Manufacture of rubber and plastic products

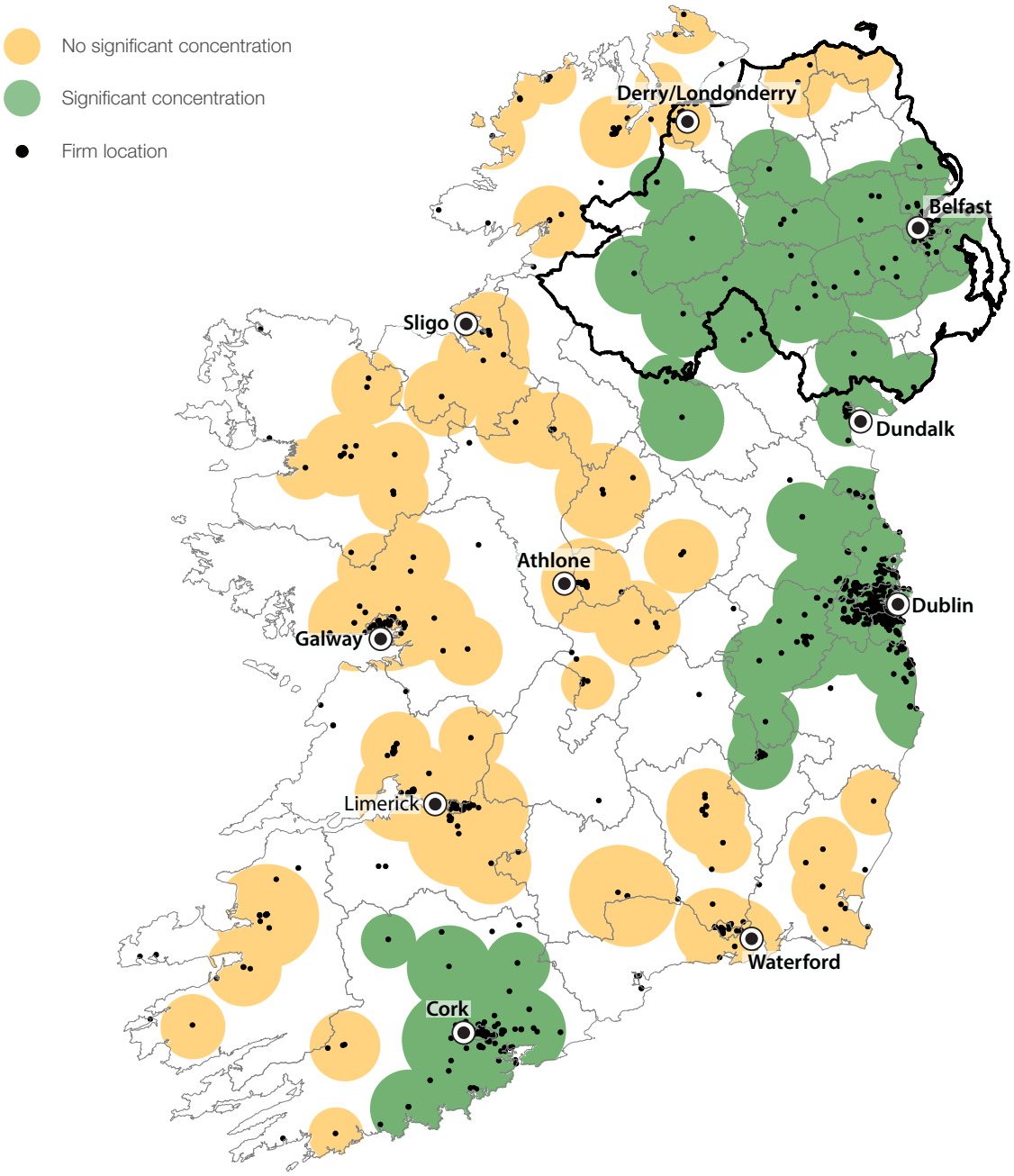
Three concentrations, Northern Ireland into Midlands plus Monaghan, Dublin/East coast, and Cork.



CATEGORY 2: Concentrations with a cross-border element

13. Computer programme, consultancy and related activities [Software]

Three concentrations: much of Northern Ireland with two cross border spurs – Dundalk-Newry and Enniskillen-Cavan, Dublin/Mid East, Cork.



CATEGORY 3

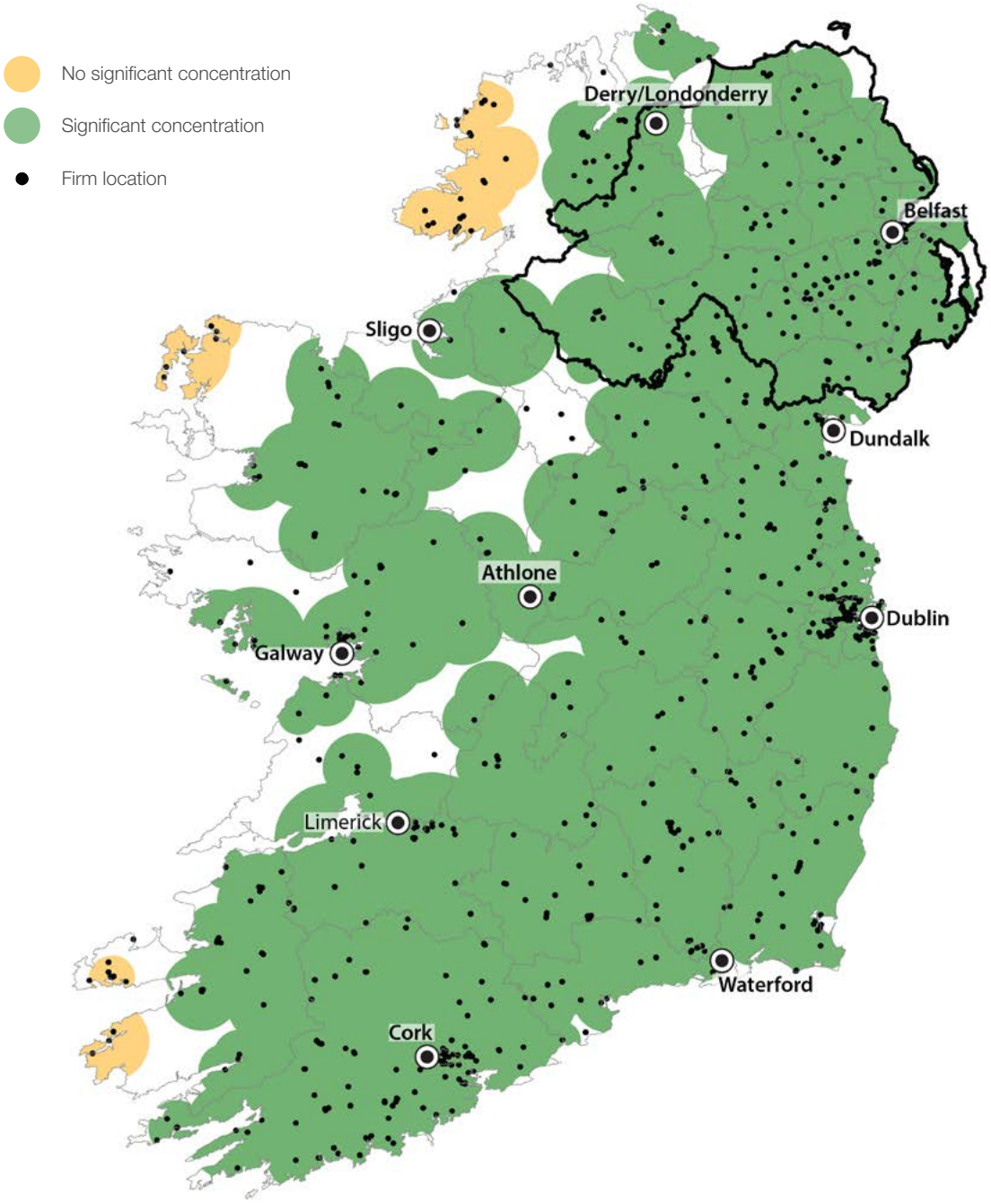
Ubiquitous across the island

SECTOR		CONCENTRATIONS
14.	**Manufacturing of food products**	Ubiquitous
15.	**Manufacture of other non-metallic mineral products**	Almost ubiquitous except the West and South
16.	**Manufacture of furniture**	One very extensive concentration covering all of Northern Ireland, reaching into south Donegal, East coast including Monaghan and Down to Waterford plus Midlands.
17.	**Manufacture of fabricated metal products, except machinery and equipment**	Almost ubiquitous
18.	**Manufacturing of wood and wood products, except furniture**	Very extensive concentration covering all of Northern Ireland, Leinster, West and West Cork.

CATEGORY 3: Ubiquitous across the island

14. Manufacturing of food products

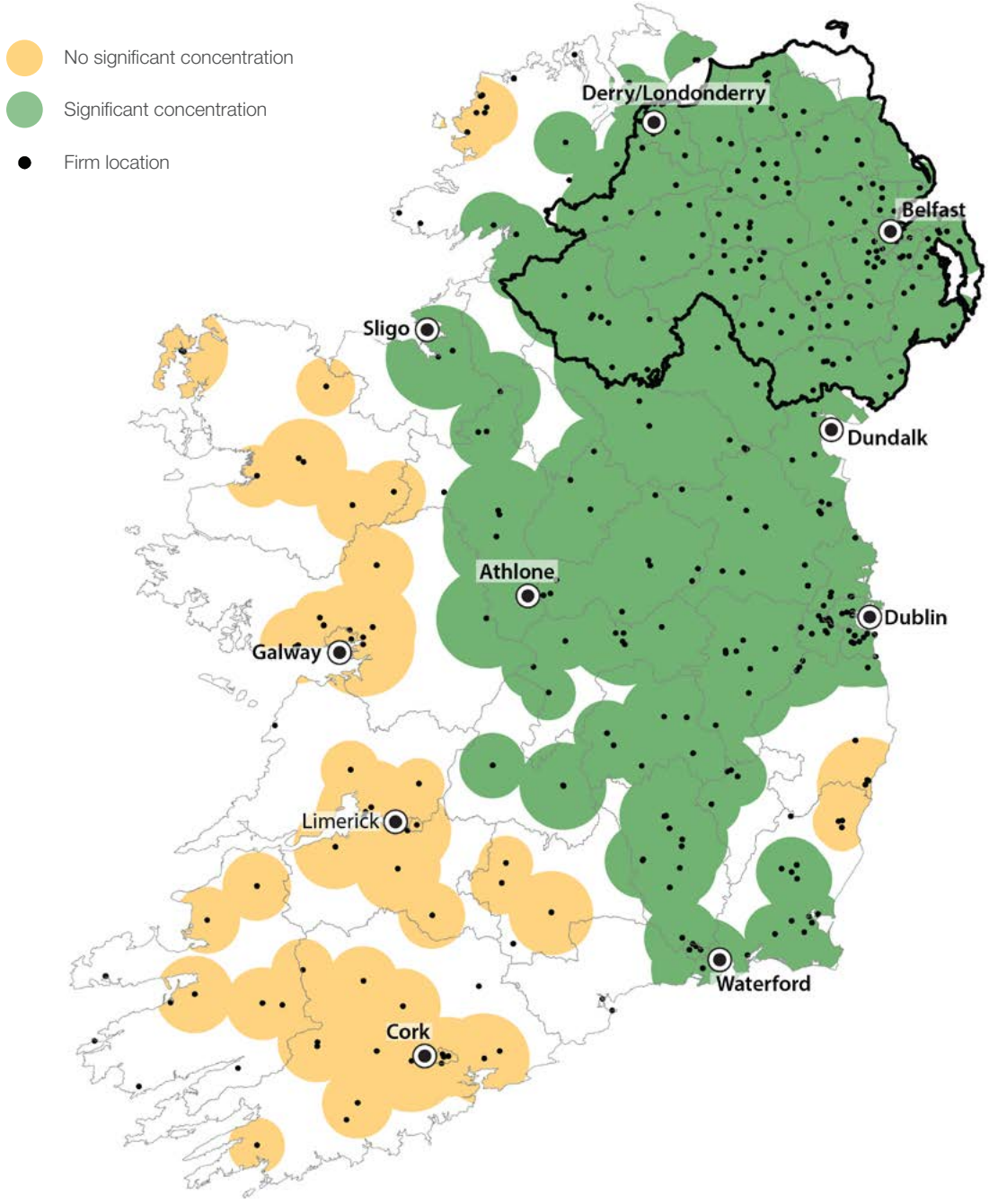
Ubiquitous



CATEGORY 3: Ubiquitous across the island

15. Manufacture of other non-metallic mineral products

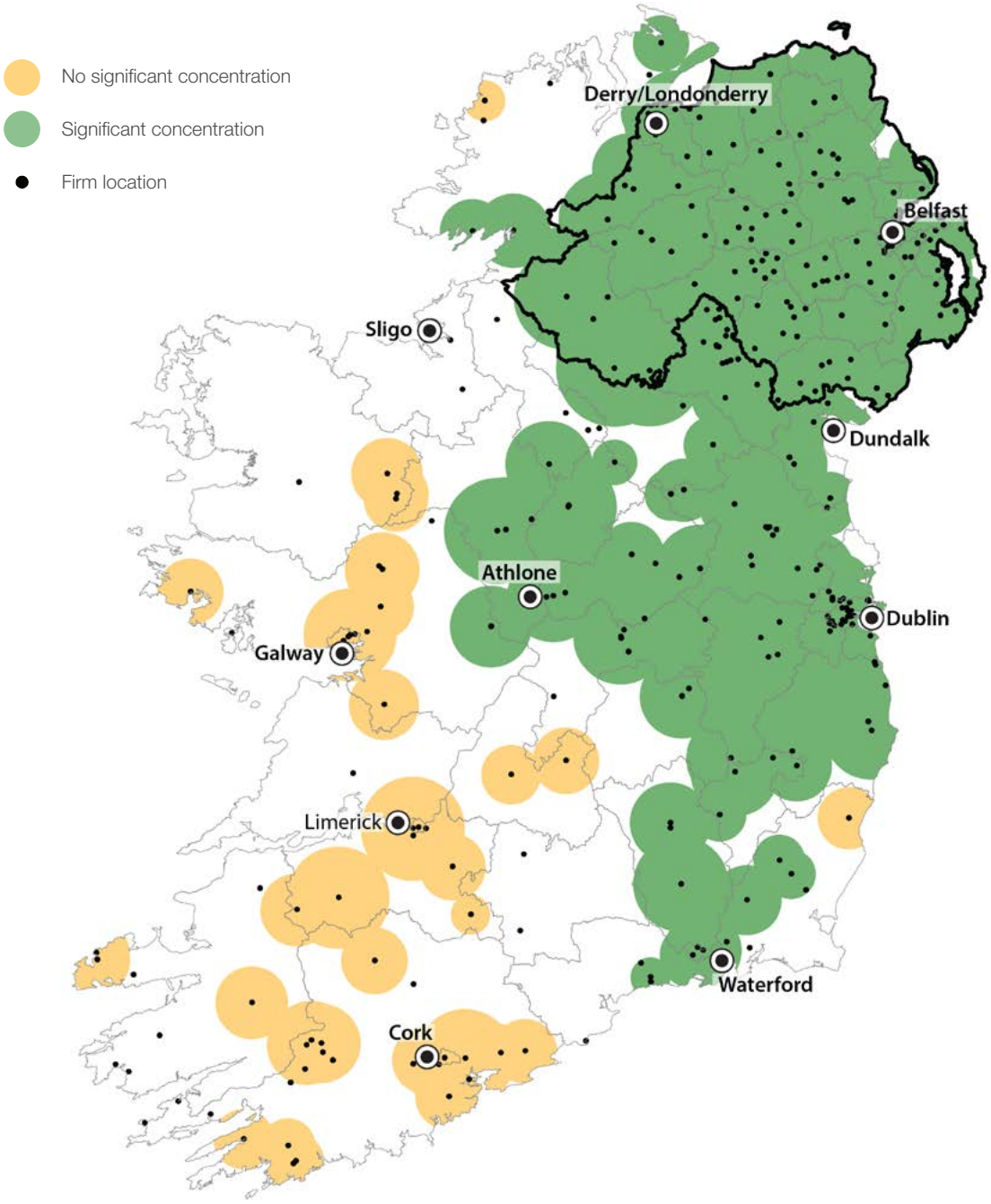
Almost ubiquitous except the West and South



CATEGORY 3: Ubiquitous across the island

16. Manufacture of furniture

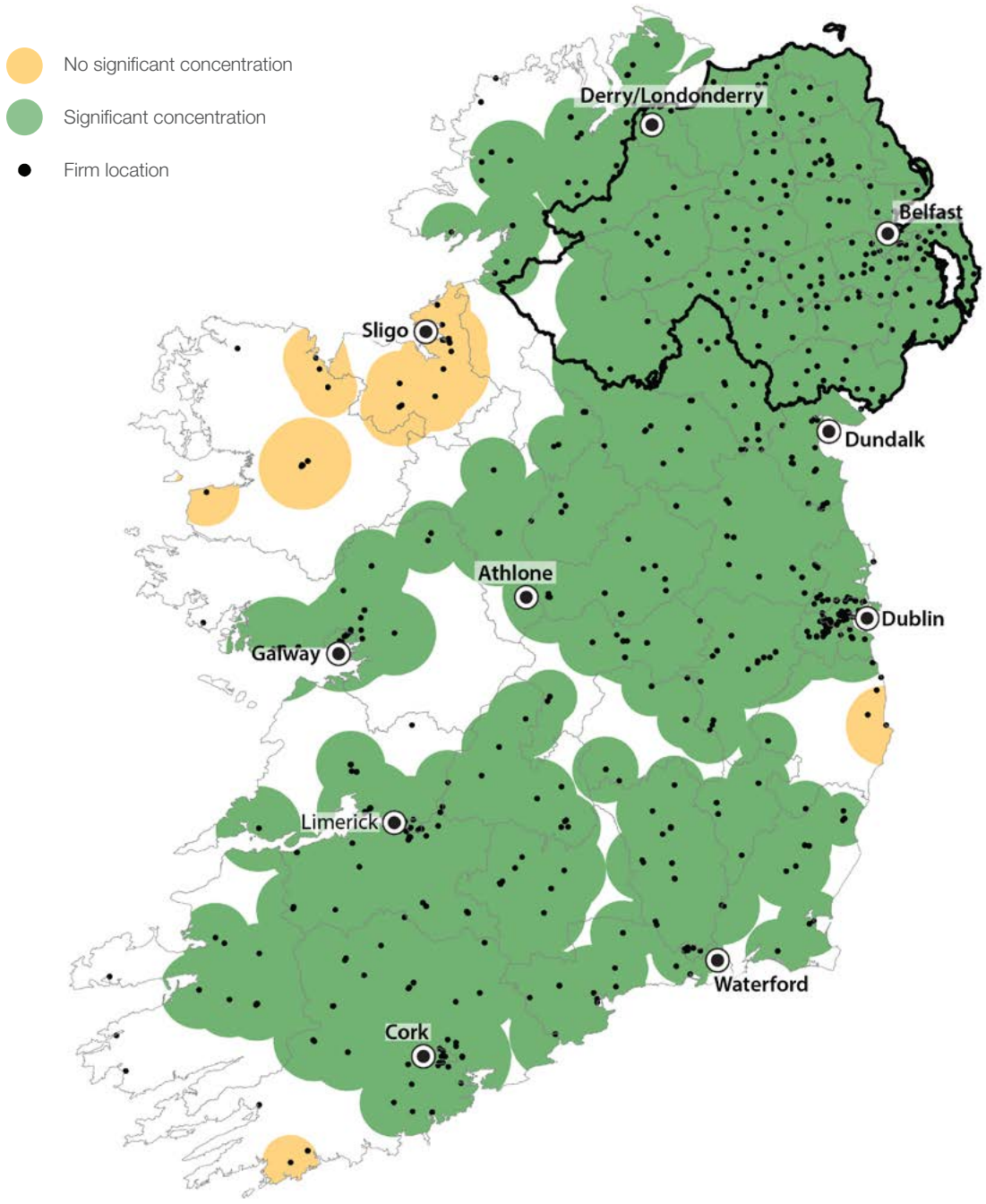
One very extensive concentration covering all of Northern Ireland, reaching into south Donegal, East coast including Monaghan and Down to Waterford plus Midlands.



CATEGORY 3: Ubiquitous across the island

17. Manufacture of fabricated metal products, except machinery and equipment

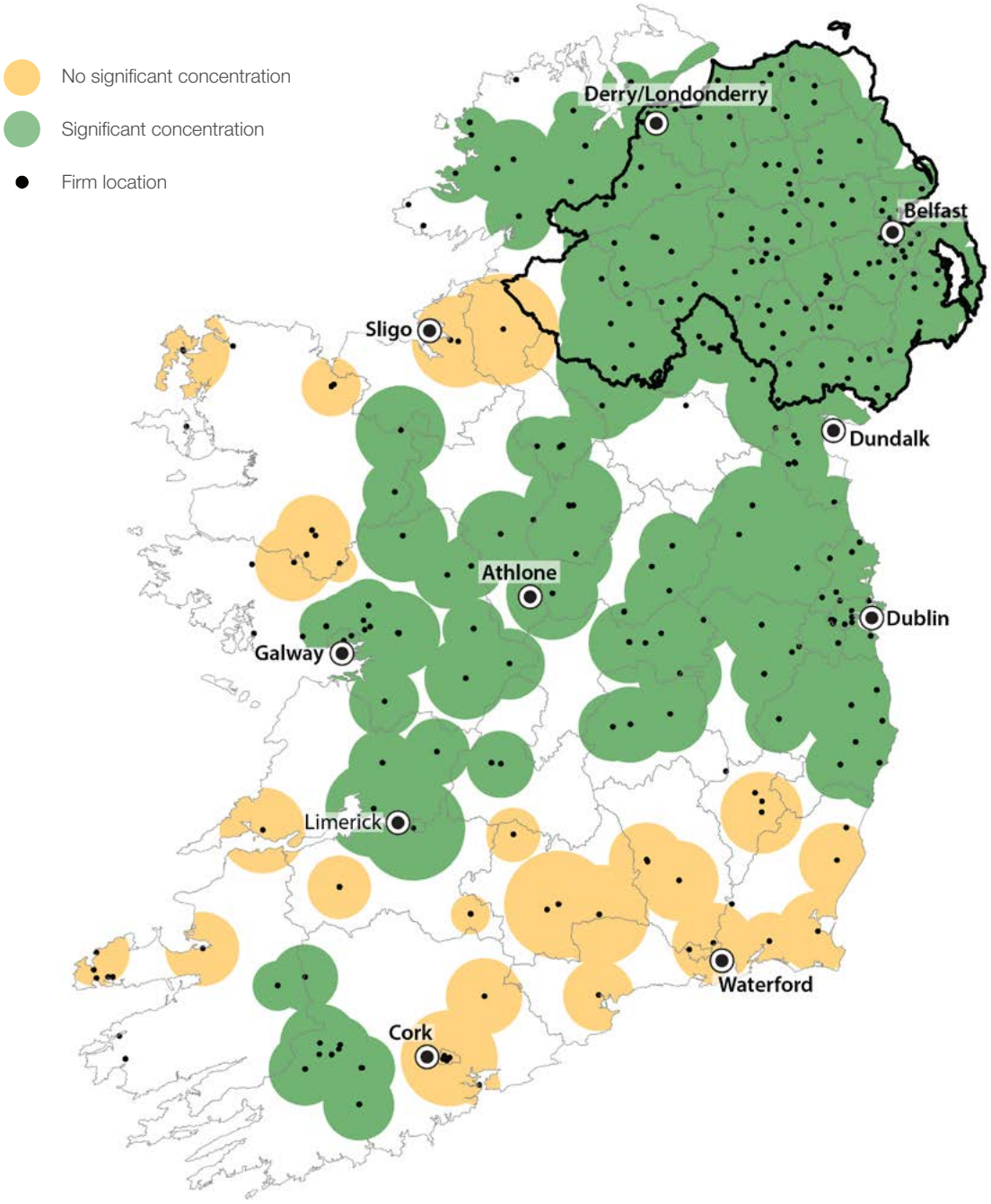
Almost ubiquitous



CATEGORY 3: Ubiquitous across the island

18. Manufacturing of wood and wood products, except furniture

Very extensive concentration covering all of Northern Ireland, Leinster, West and West Cork.



CATEGORY 4

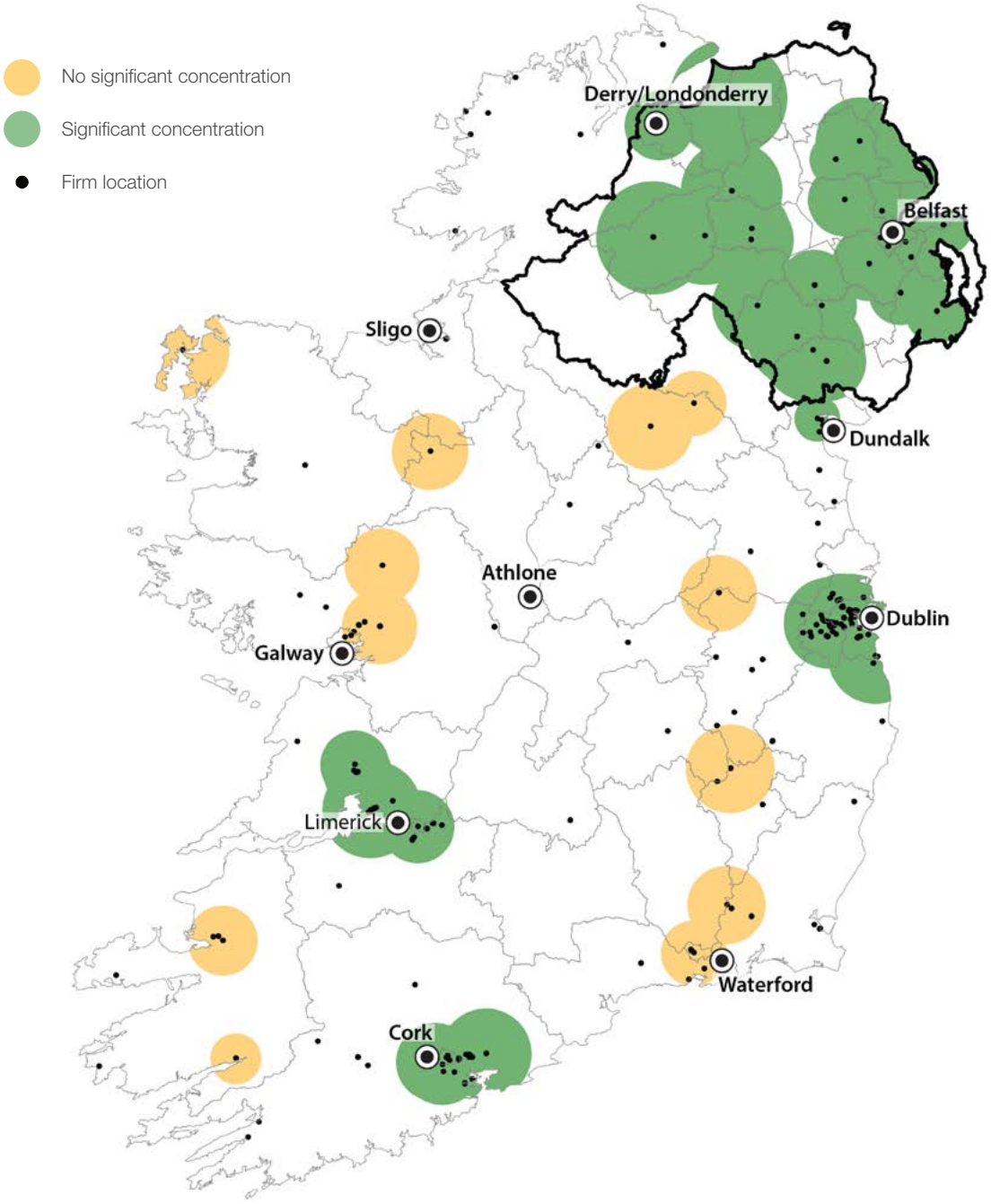
Ubiquitous in Northern Ireland with significant concentrations elsewhere

SECTOR		CONCENTRATIONS
19.	**Manufacture of electrical equipment**	Four concentrations, extensive in Northern Ireland, Dublin, Cork and Limerick.
20.	**Office administration, office support and other business support activities**	Two concentrations, one covering most of Northern Ireland and Dublin.
21.	**Financial services activities, except insurance and pension funding**	All of Northern Ireland reaching south to Enniskillen-Cavan and Dundalk-Newry, Dublin.
22.	**Activities of head offices; management consultancy activities**	Most of Northern Ireland, and Dublin.
23.	**Architectural and engineering activities; technical testing and analysis**	Most of Northern Ireland plus Dundalk-Newry, Dublin reaching south to Carlow and into the Midlands, Cork.
24.	**Manufacture of motor vehicles, trailers and semi-trailers**	Three concentrations, North-West Cork/Kerry, Dublin, and large parts of Northern Ireland.
25.	**Repair and installation of machinery and equipment**	Two concentrations, extensive Northern Ireland concentration, and Dublin.

CATEGORY 4: Ubiquitous in Northern Ireland with significant concentrations elsewhere

19. Manufacture of electrical equipment

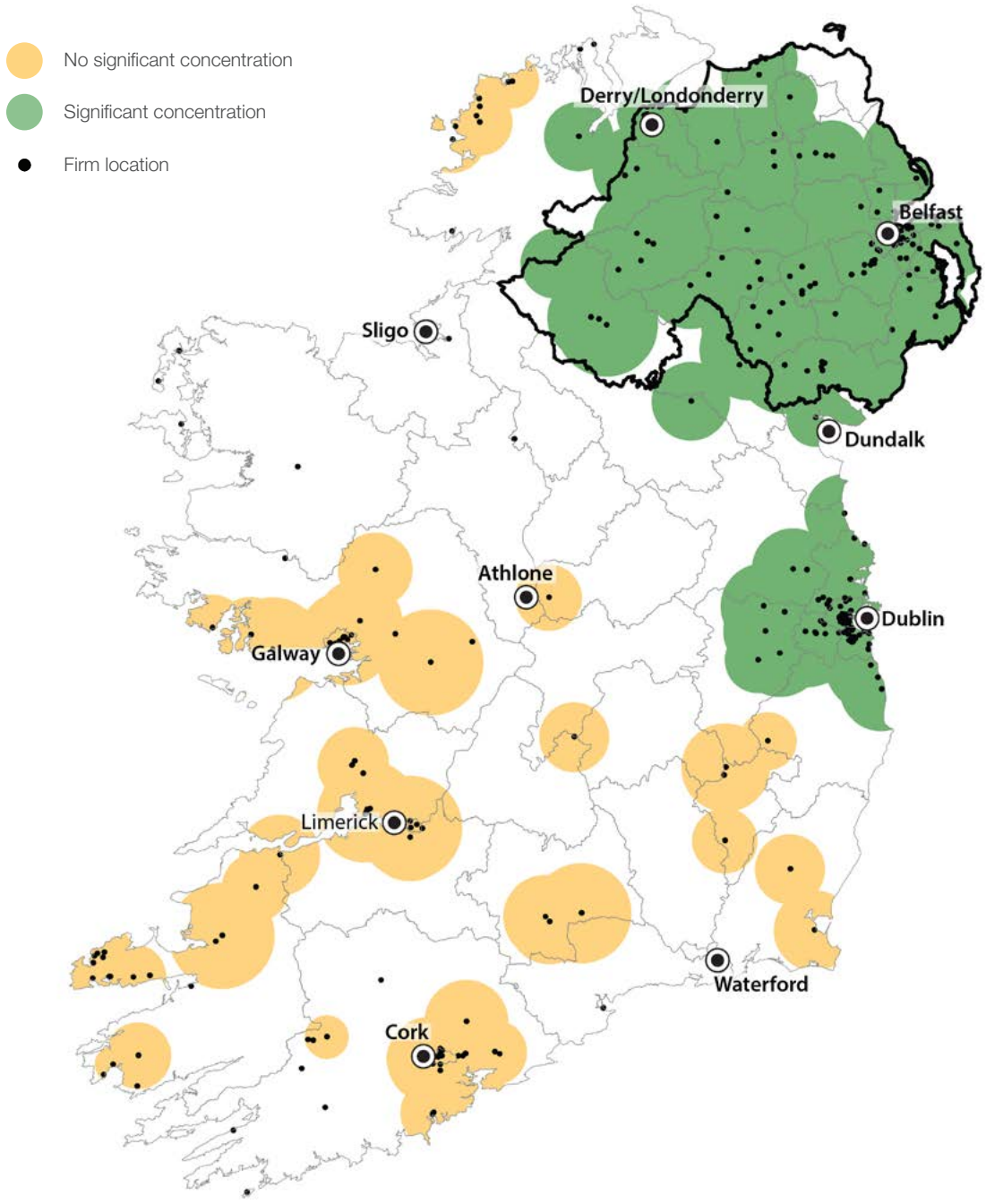
Four concentrations, extensive in Northern Ireland, Dublin, Cork and Limerick.



CATEGORY 4: Ubiquitous in Northern Ireland with significant concentrations elsewhere

20. Office administration, office support and other business support activities

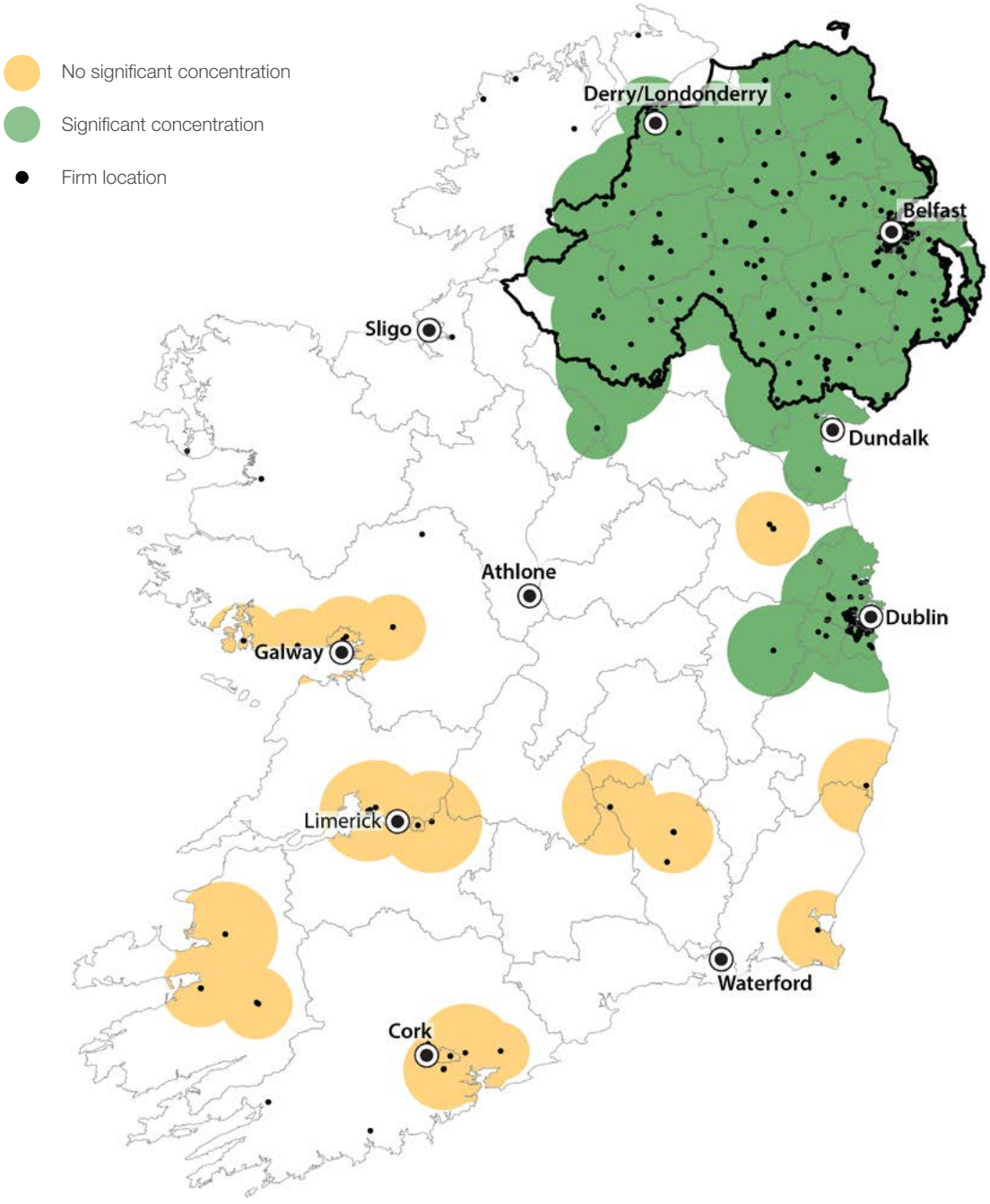
Two concentrations, one covering most of Northern Ireland and Dublin.



CATEGORY 4: Ubiquitous in Northern Ireland with significant concentrations elsewhere

21. Financial services activities, except insurance and pension funding

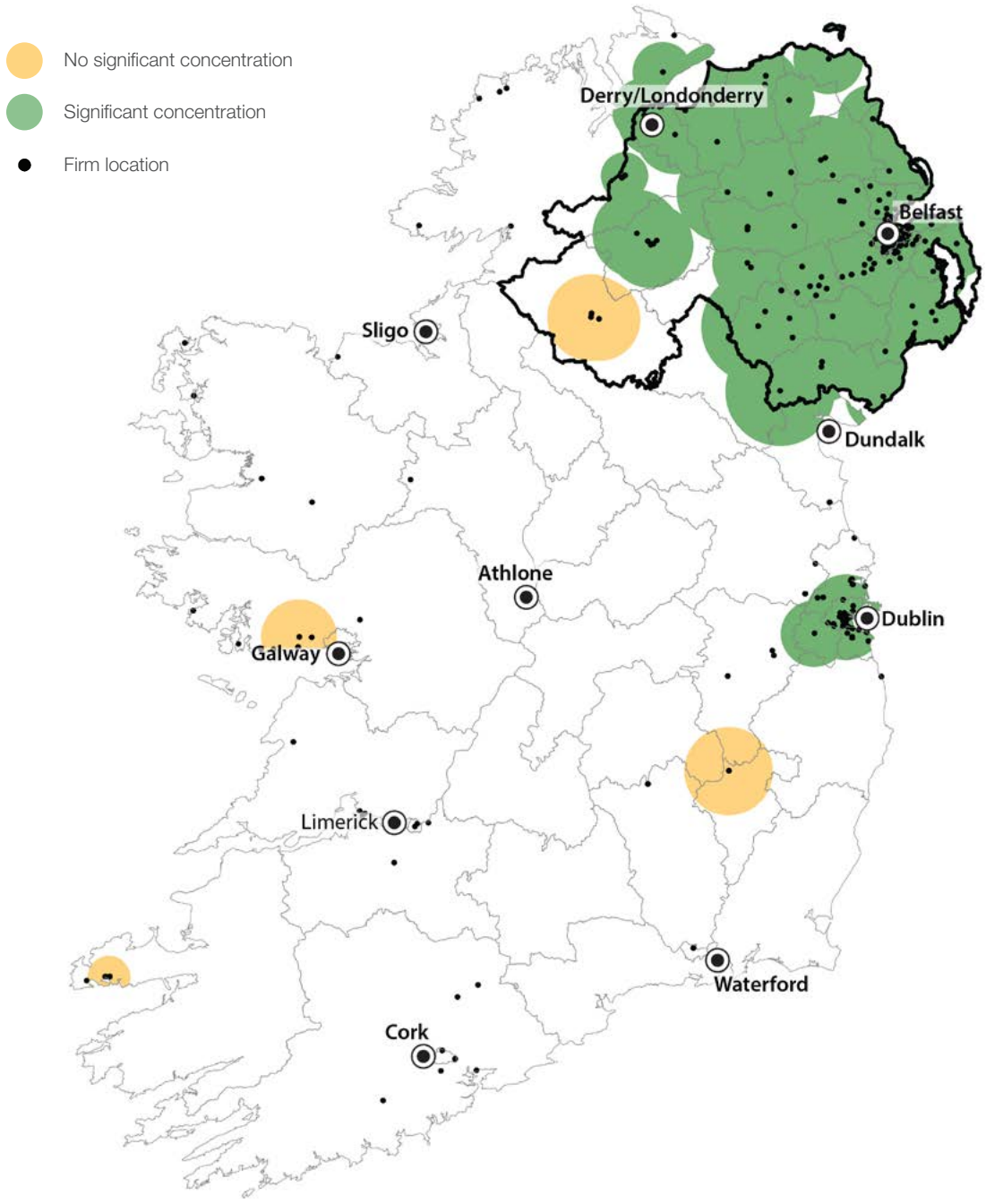
All of Northern Ireland reaching south to Enniskillen-Cavan and Dundalk-Newry, Dublin.



CATEGORY 4: Ubiquitous in Northern Ireland with significant concentrations elsewhere

22. Activities of head offices; management consultancy activities

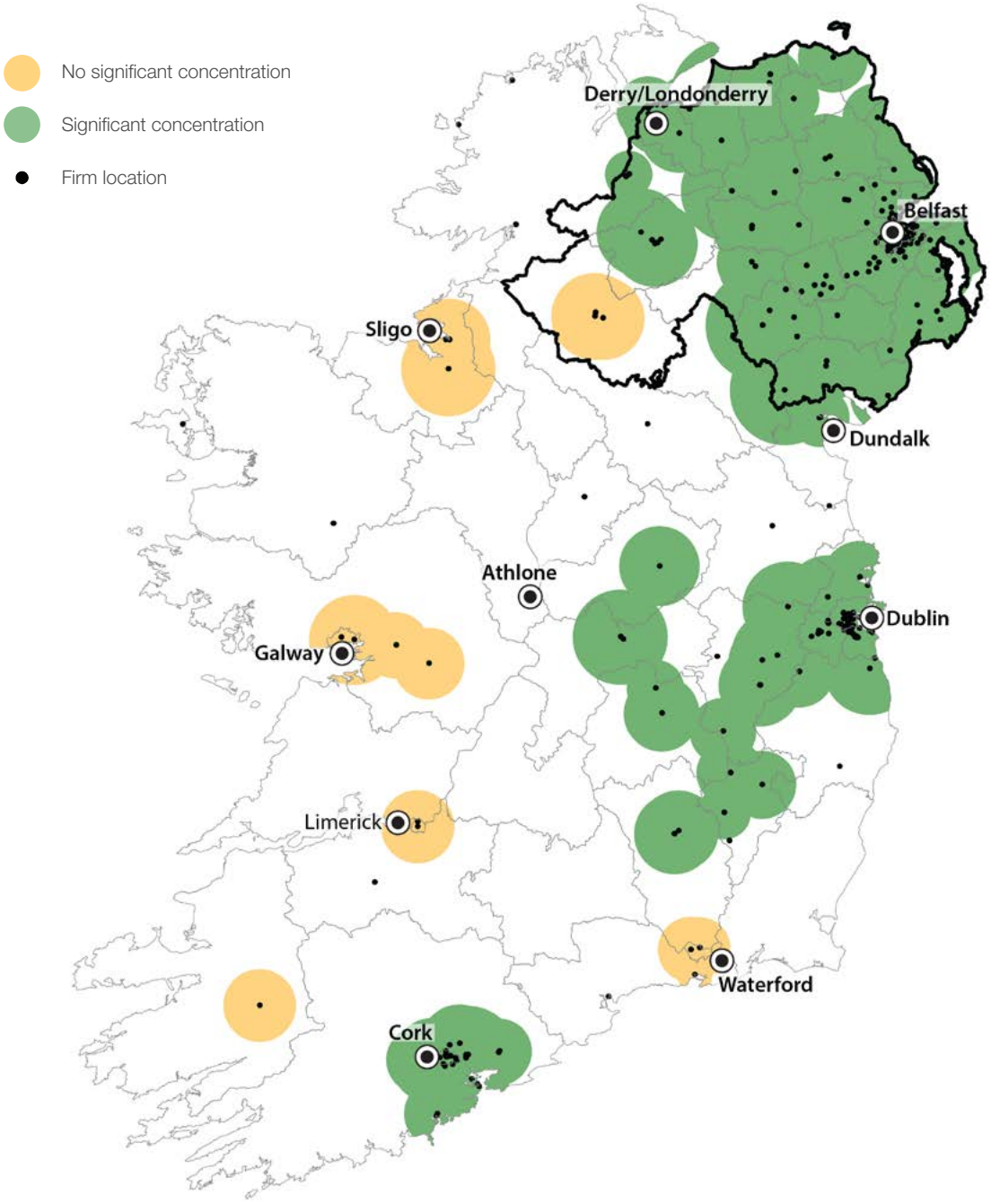
Most of Northern Ireland, and Dublin.



CATEGORY 4: Ubiquitous in Northern Ireland with significant concentrations elsewhere

23. Architectural and engineering activities; technical testing and analysis

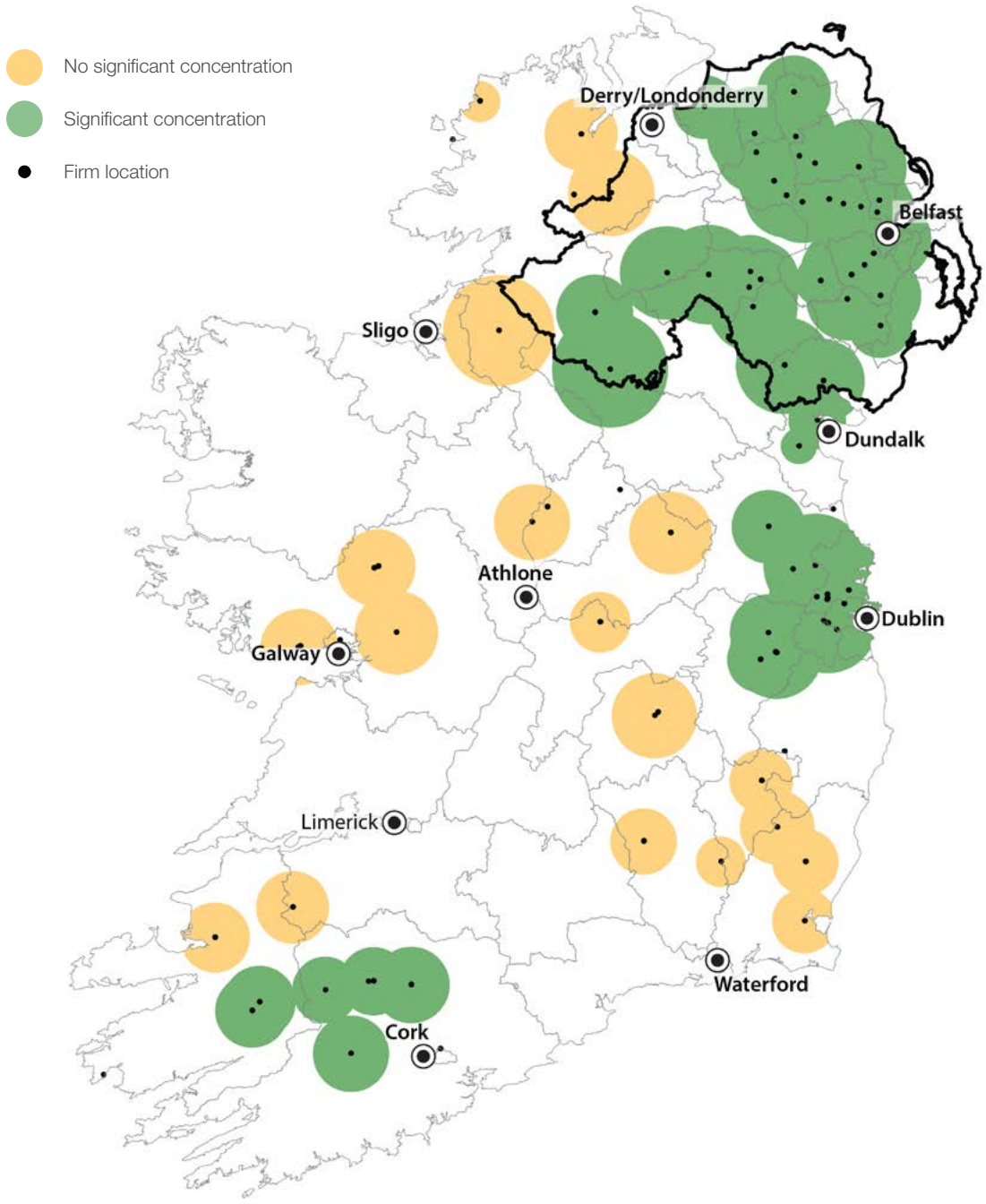
Most of Northern Ireland plus
Dundalk-Newry, Dublin reaching south
to Carlow and into the Midlands, Cork.



CATEGORY 4: Ubiquitous in Northern Ireland with significant concentrations elsewhere

24. Manufacture of motor vehicles, trailers and semi-trailers

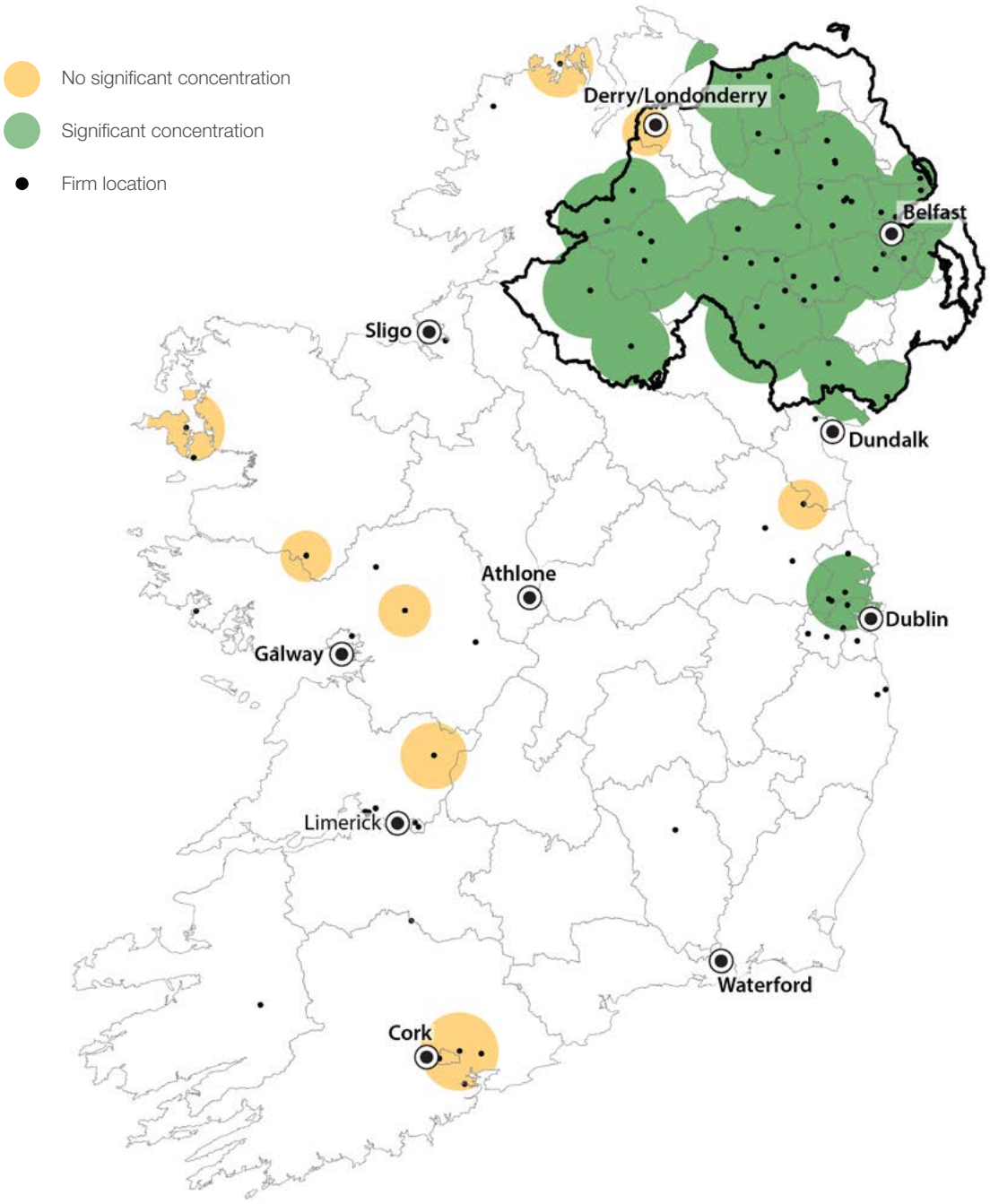
Three concentrations, North-West Cork/Kerry, Dublin, and large parts of Northern Ireland.



CATEGORY 4: Ubiquitous in Northern Ireland with significant concentrations elsewhere

25. Repair and installation of machinery and equipment

Two concentrations, extensive Northern Ireland concentration, and Dublin.



SECTION

3

SECTORAL CASE STUDIES

Sectoral Case Studies

This section summarises the results of a detailed case study analysis of three significant sectors Pharmaceuticals, Medical Devices and Software. These three sectors differ in size, enterprise composition and spatial characteristics. The analytical framework outlined in Section 1 (with its six core areas of benefit and focus on the extent and intensity of interaction) has been used as a basis for the case studies. The three case studies follow a similar structure. They outline the development of the sector, the key players in the ecosystem and opportunities to develop all-island sectoral ecosystems with benefits for the enterprises involved. The research has involved a series of structured interviews with key sectoral stakeholders and a desk review of academic and policy literature. The case studies assess the relative level of mutual benefit from additional cooperation across the core areas of potential advantage outlined in the analytical framework presented in section one.

PHARMACEUTICALS

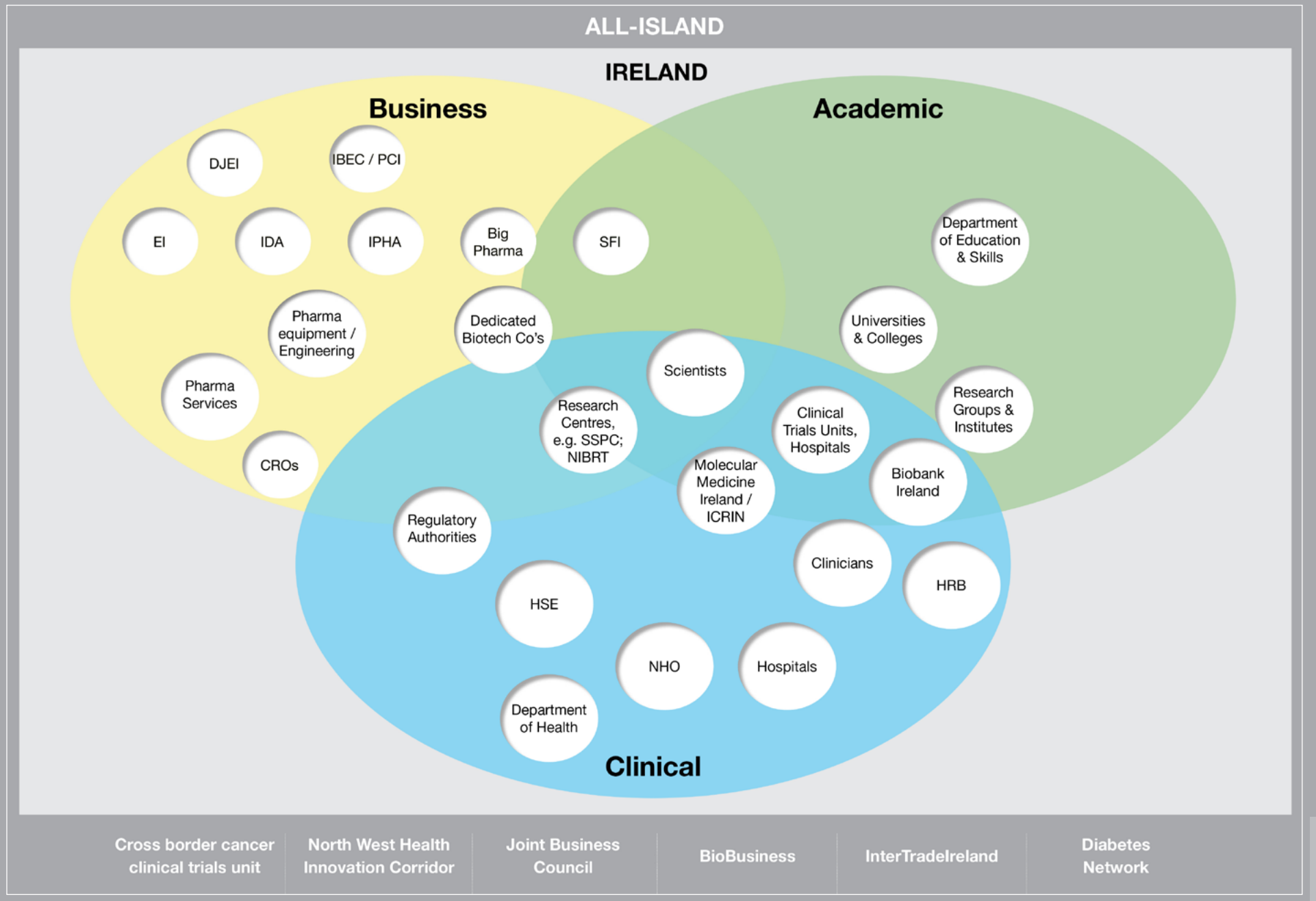
The pharmaceutical sector across the island, as illustrated in Figures 2 and 3 is a highly complex interaction of academics, businesses and clinical stakeholders. Academic institutions develop the requisite human resources, knowledge and technology. The Business segment includes both 'Big Pharma' companies and smaller dedicated biotech companies. These depend strongly on the technology developed by pharmaceutical equipment vendors, engineering companies and services providers, all supported by enterprise agencies and focused business and employers associations. The Clinical segment includes hospitals, clinical trials units, medical and para-medical staff. The various segments share a significant overlap. For example research groups, research institutes and clinical trials units straddle the three segments. In addition to these actors, a range of organisations outside Ireland and Northern Ireland play an important role in the sectoral ecosystems, for example the UK Research Councils, Cancer Research UK, and EU institutions.

Ireland

In Ireland the pharmaceutical sector is substantial with the commercial segment of the sector employing about 17,600 workers in 88 companies in 2013 while a report in 2010 estimated that the broader Biopharma-Pharmachem sector employed 25,300.[7] Most employment is in foreign companies, mainly involved in production activities whose role in the high-value generating functions of drug discovery and product development has remained very limited. However, since the mid-1990s some of these businesses have begun to play an increasing role in process R&D functions, up-grading production facilities into global strategic launch sites and multi-product plants with the flexibility to produce clinical trials batches.[8] The indigenous pharmaceutical industry segment is relatively small, particularly since Elan was partly acquired by foreign interests, with only a few new indigenous small dedicated biotechnology companies, such as Opsona and Merrion Pharmaceuticals, active in pharmaceutical drug discovery.

[7] Expert Group on Future Skills Needs, *Future Skills Needs of the Biopharma-Pharmachem Industry in Ireland* (2010).
[8] C. Van Egeraat and D. Curran, 'Analysis of the Irish Life Sciences Sector', *Top 250 Exporters 2013* (2013).

FIGURE 2: Ireland pharmaceuticals sectoral ecosystem – selected actors



In the early 2000s, the vision and related strategy for the pharmaceutical industry in Ireland changed from the development of the chemical pharmaceutical production cluster to one of a less truncated industry. One of the resulting strategies was to stimulate multinational pharmaceuticals companies to upgrade the production activities of the subsidiaries by adding upstream activities, notably process R&D, in order to position Ireland as a global centre for process development and new product launch. Ireland was also to become a centre for bio-pharmaceutical production. In parallel, the major science and technology funding program, through Science Foundation Ireland (SFI), was envisaged to become the source of university spin-outs that would add an indigenous research-based element to the pharmaceuticals sector. Ten years on, the number of university pharma spin-outs remains limited and the enterprise strategy is now being rebalanced, with more attention being paid to the production/process development cluster. For example, the research prioritisation exercise in Ireland chose "therapeutics – synthesis, formulation, processing and drug delivery" as one of the 14 priority research areas. SFI's commitment to applied research in pharmaceuticals can be seen in the €30m funding for the Synthesis and Solid State Pharmaceutical Centre (SSPC).

Northern Ireland

The official data available for the pharmaceutical industry in Northern Ireland used in the mapping exercise shows that the pharmaceutical sector (SIC 21) employs about 1900 employees in 16 companies. Taking a broader view the MATRIX science panel has found that the combined Life and Health Sciences sector employs 7,500 employees in 130 companies.[9] Most of the employees are concentrated in a handful of large indigenous pharmaceutical companies, notably Almac and Norbrook, established in the 1960s and 1970s and developed into successful, research active, multinationals. Very few foreign pharmaceutical companies operate in Northern Ireland (Actavis, one of a few foreign companies, has an indigenous background). The number of small dedicated biotechnology companies active in pharmaceutical drug discovery is also small.

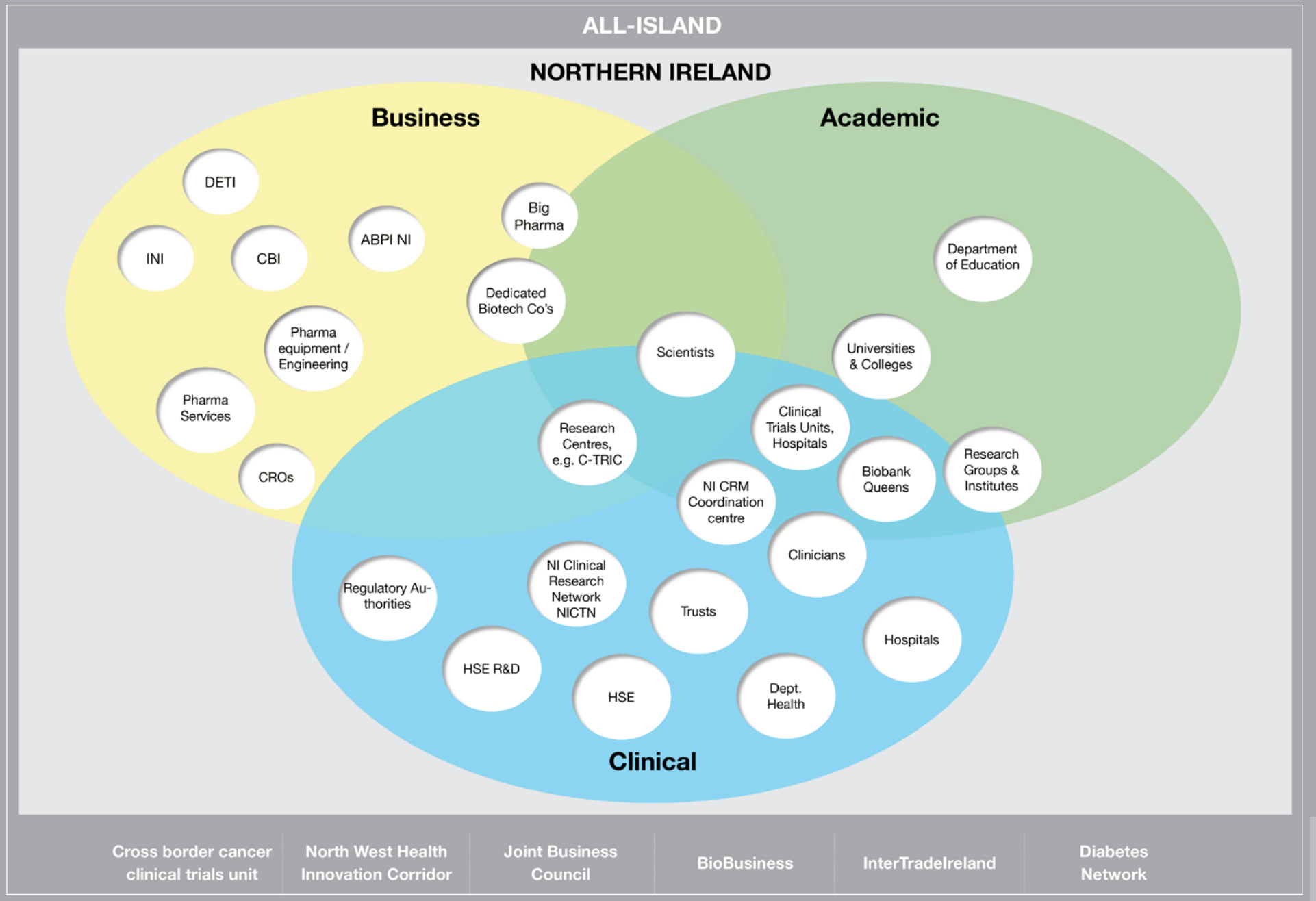
The vision is for Northern Ireland to become a centre for integrated R&D for Personalised Medicine[10] and a two-pronged strategy exists for developing the sector.[11] First, to attract substantial levels of foreign direct investment in the sector through a change in the corporate taxation regime while nurturing the development of existing indigenous players and stimulating new indigenous company formation, mainly through the university spin-off process. Second, to stimulate and develop public sector R&D activity in order to provide knowledge inputs for the commercial sector and to generate substantial direct employment. Both the private and public segments of the Northern Ireland ecosystem are oriented towards translational research activity, which necessitates an integration of basic research, applied research and clinical trials in order to make science useful for practical healthcare and pharmaceutical applications. In relation to Personalised Medicine, the Matrix Life & Health Sciences Panel argues that Northern Ireland has some of the building blocks in place but is lacking critical mass due to small geographical size. The solution to this is partly sought in effective networking to foster collaboration and establishing stronger ABC interfaces. Interviewees suggest that existing formal networks and collaborative programs have a predominantly local focus and support the view of Matrix that the realm of collaboration should extend beyond Northern Ireland, particularly to Ireland and GB.

[9] MATRIX, *Life and Health Sciences Northern Ireland* (2015).

[10] Personalised Medicine refers to the use of information about a person's genetic makeup to tailor strategies for the detection, treatment, or prevention of disease.

[11] MATRIX, *Life and Health Sciences Horizon Panel* (2008); MATRIX (2015). The updated Matrix report appeared after the case study was completed although the general vision for the sector remains in line with the strategies in the first report.

FIGURE 3: Northern Ireland pharmaceuticals sectoral ecosystem – selected actors



Opportunities for increased all-island development

The current spatial configuration of the pharmaceutical industry is characterised by four groupings each, to an extent, with distinct foci (see Category 2 map 11). The Cork grouping is involved primarily in the manufacturing of active pharmaceutical ingredients and drug products. The south-east grouping, linking Waterford and Kilkenny, focuses on drug product manufacturing. The Dublin grouping is involved in both active ingredients and drug products with a strong focus on biopharmaceuticals. Finally the cross-border grouping, stretching from Dundalk to Lough Neagh, has a strong services and research element alongside a strong manufacturing capability. In summary, both Ireland and Northern Ireland have built, and are developing, strengths in the area of translational research in pharmaceuticals. In Ireland this strength is concentrated in process research and development. In Northern Ireland, on the other hand, the focus is on product research and development.

The mapping exercise and interviews suggest that the spatial configuration of the industry is partly driven by labour market issues, although firms may derive some benefits from a pooled all-island market.[12] The interviews also suggest that firms currently enjoy technology spill-over effects which are not regionally bounded but operate at the national levels. However, currently very little technology 'spills over the border'. The research found more limited evidence of agglomeration economies related to specialised vendors, again operating at the national scale, which mainly involves pharmaceutical engineering and construction services companies.

The analytical framework provides the areas of potential benefits from developing the all-island orientation of the pharmaceutical ecosystem. Table 1 shows that initiatives in the areas of Research, Technology & Innovation; Education & Training; Markets for Products and Services (supply into the pharmaceutical industry) offer the greatest potential benefit. All three areas are currently characterised by a relatively low level of all-island co-ordination

TABLE 1

Relative level of benefit related to different areas of an all-island pharmaceuticals ecosystem

	CURRENT LEVEL OF ALL-ISLAND CO-ORDINATION	POTENTIAL BENEFITS OF FURTHER CO-ORDINATION
Labour Market	High	Small
Education & Training	Low	Large
Infrastructure	Low	Small
Product & service markets	High for end-products Low for supply	Small for end-products Large for supply
Institutional support	Low	Medium
Research, Technology and Innovation	Low	Large

[12] These findings are in line with existing research focussing on the Cork grouping; see C. Van Egeraat and D. Curran, 'Spatial concentration in the Irish Pharmaceutical Industry: The role of government intervention and agglomeration economies', *Tijdschrift Voor Economische En Sociale Geografie*, 104:3 (2013), 338-358.

and the potential benefits of further integration are relatively large. In relation to the labour market, the pharmaceutical industry is highly integrated and the potential benefits of further co-ordination are low. The level of co-ordination of the institutional support system is low but the potential benefits of further co-ordination are assessed only as medium because of the limited feasibility of aligning elements of the all-island enterprise support system. The level of integration of pharma-specific infrastructure provision is low and, apart from the all-island provision of specialised equipment, the potential gains of such co-ordination are considered small.

OPPORTUNITY 1: Strengthening the all-island co-ordination of research centres, institutes and networks

The interviews and literature behind the case study indicates that the research and innovation element of the pharmaceutical ecosystem is very complex, involving a large number of research centres, other actors, lines of co-ordination and funding streams. In particular, most of the current research centres, institutions and many of the networks have primarily a national orientation. Similarly, although most researchers would nurture their own informal international networks, the formally created networks tend to have a strong national focus. The main exceptions concern the pharma-related projects funded under the US-Ireland R&D Partnership Programme, the small number of SFI-funded projects which include a Northern Ireland company or Principal Investigator, and cross-border networks, such as the North West Health Innovation Corridor and the Diabetes Network, which are relatively small actors within the overall ecosystem.

Interviewees have argued for strengthening the level of all-island co-ordination of research centres and networks. Benefits include significant economies of scope as the centres, institutions and researchers in each jurisdiction have different and complementary strengths. Also centres, groups and researchers would benefit strongly from shared efforts and experience in applications for funding, notably under EU Horizon 2020 funding where being part of operational all-island research centres and networks would mean that only a partner in one additional jurisdiction would be needed.

There are few institutional governance related barriers to strengthening all-island co-ordination, either for the research side or for the funding bodies. However, the softer barriers include a very low level of cross-border familiarity across the research landscape which is partly related to a lack of cross-border visibility and there is a role here for InterTradeIreland and other enterprise agencies to increase the visibility of North South collaboration opportunities. Any strategy to strengthen the co-ordination of research centres would include the following elements:

1. To develop visibility, trust and familiarity. Existing programmes, such as SFI's Industry Fellowships (one-year placement of PhD and post-doctoral researchers in industry and academia anywhere in the world), could offer a good vehicle to build informal networks. The cross-border uptake of these programmes is currently very low and this relates to a lack of awareness and the need to better promote these offerings through, for example, all-island show-casing events dedicated to the pharma industry, where centres, institutions, companies, researchers, and funding bodies can connect.

2. Fostering of all-island formal centres, institutions and networks. Again, existing programmes can assist in the delivery of this, such as the agreement that SFI has reached with the Department of Employment and Learning (DEL) to encourage

applications, co-funded by the two organisations, between groups in Ireland and Northern Ireland. Likewise, the SFI Research Centre Spokes programme offers opportunities for companies and researchers from anywhere in the world to become involved in the SFI Research Centres such as SSPC. There may be other opportunities here with no obvious governance barriers, other than a lack of awareness.

3. The development of all-island research or technology centres as single-entity virtual centres. Such centres would be designed for North-South joint funding from establishment under single management. The DEL-SFI proposal to develop an all-island research centre for personalised medicine that would be joined funded by the RCUK Catapult Program and the SFI is the first potential example of this.

As illustrated in Figure 4, the main actors for exploring this opportunity include in Northern Ireland, DEL, HSC R&D; Invest NI; and any of the existing research centres, institutions and existing formal networks. In Ireland the main actors would include, amongst others, SFI; HRB; IDA Ireland; Enterprise Ireland; and the existing research centres, institutions and formal research networks. The most suitable champions for such initiatives would include DEL and SFI.

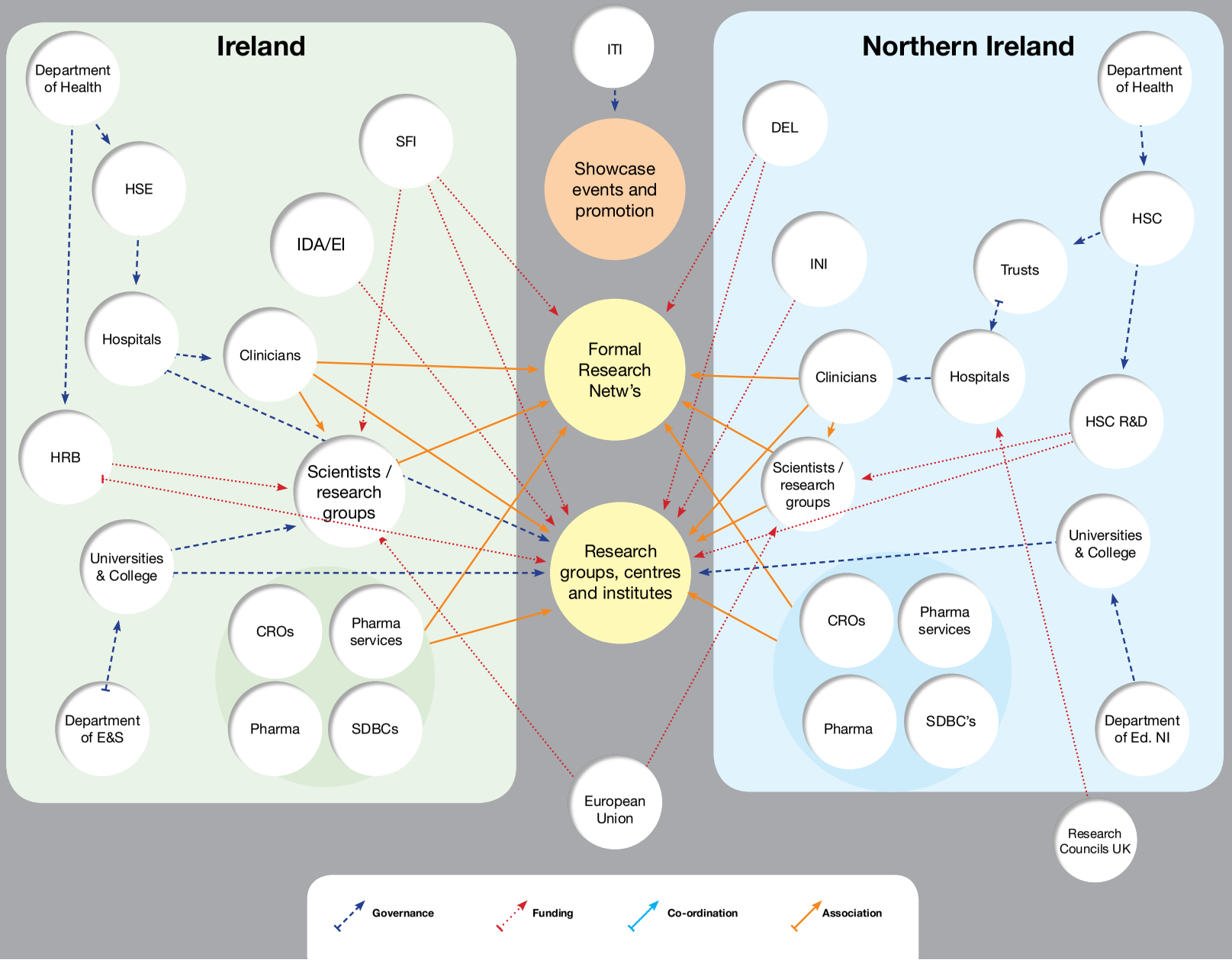
OPPORTUNITY 2: All-island interoperable clinical trials co-ordination network

Clinical trials which support the drug discovery and development functions of research institutes and firms are an important component of the pharmaceutical sectoral ecosystem. The trials are generally conducted in units linked to hospitals which offer researchers and firms, often from other markets, access to patients. A developed clinical trials sector would offer businesses a range of clinical research organisations; other clinical trials services companies involved in the co-ordination of the trials, data collection and analysis; the packaging of the clinical trial material; the logistics and distribution of the clinical trial materials; and quality employment to medical and scientific staff.

The case study research suggests that the island of Ireland is not reaching its full potential for clinical trials activity. The main barriers for further development include the limited scale of recruitment and system fragmentation. International pharmaceutical companies and other users are attracted by an optimal population of about 6 million (equivalent to the island of Ireland) and a one-stop-shop organisation that can provide efficient access to patient recruitment. However, the current systems are fragmented and do not provide the desirable one-stop-shop access. For example, in Northern Ireland the sites are provided by the five hospital trusts while a number of other actors deliver the trials including the Northern Ireland Clinical Research Network (NICRN) and the Cancer Trials Network (NICTN), or offer services including the NI Clinical Trials Unit, the NI Clinical Research Facility and the Clinical Translational Research and Innovation Centre (C-TRIC). A single clinical trials co-ordination centre, operated by NICRN, does not take away the need for pharmaceutical companies to deal with the trusts on an individual basis. In Ireland this situation is being addressed by the Department of Health with a five year research strategy which is out for consultation.

An all-island interoperable clinical trials co-ordination network would further reduce the fragmentation and offer recruitment at a more efficient scale. Such an all-island ecosystem would be more competitive for attracting business from the pharmaceutical industry but establishing such a network would be challenging. First, as illustrated in Figure 5, the clinical trials ecosystems are complex, involving a substantial

Figure 4: Co-ordination of research centres and institutes



number of institutions, governance structures and funding streams. Second, the two health systems are organised differently, with a different balance between public and private provision. And, finally, there is the fact of the two legal jurisdictions leading to issues related to contracts with pharmaceutical companies.

The main actors of such an all-island clinical trials ecosystem in Northern Ireland include, amongst others, the Department of Health, HSC R&D, hospital trusts, C-TRIC; private sector CROs (such as Celerion, Biokenetic, Almac), NICRN, the NI Clinical Trials Network, Centre and Unit, and clinical and academic institutions. In Ireland the main actors include, amongst others, the Department of Health, the Health Research Board, private sector CROs (e.g. ICON, PPD), the Irish Clinical Research Infrastructure Network (ICRIN), and clinical and academic institutions. The actual co-ordination of such an interoperable system is likely to be in the hands of ICRIN and the NICRN, but the main champions and drivers must come from the Health Research Board and the HSC R&D, supported by the two relevant Departments.

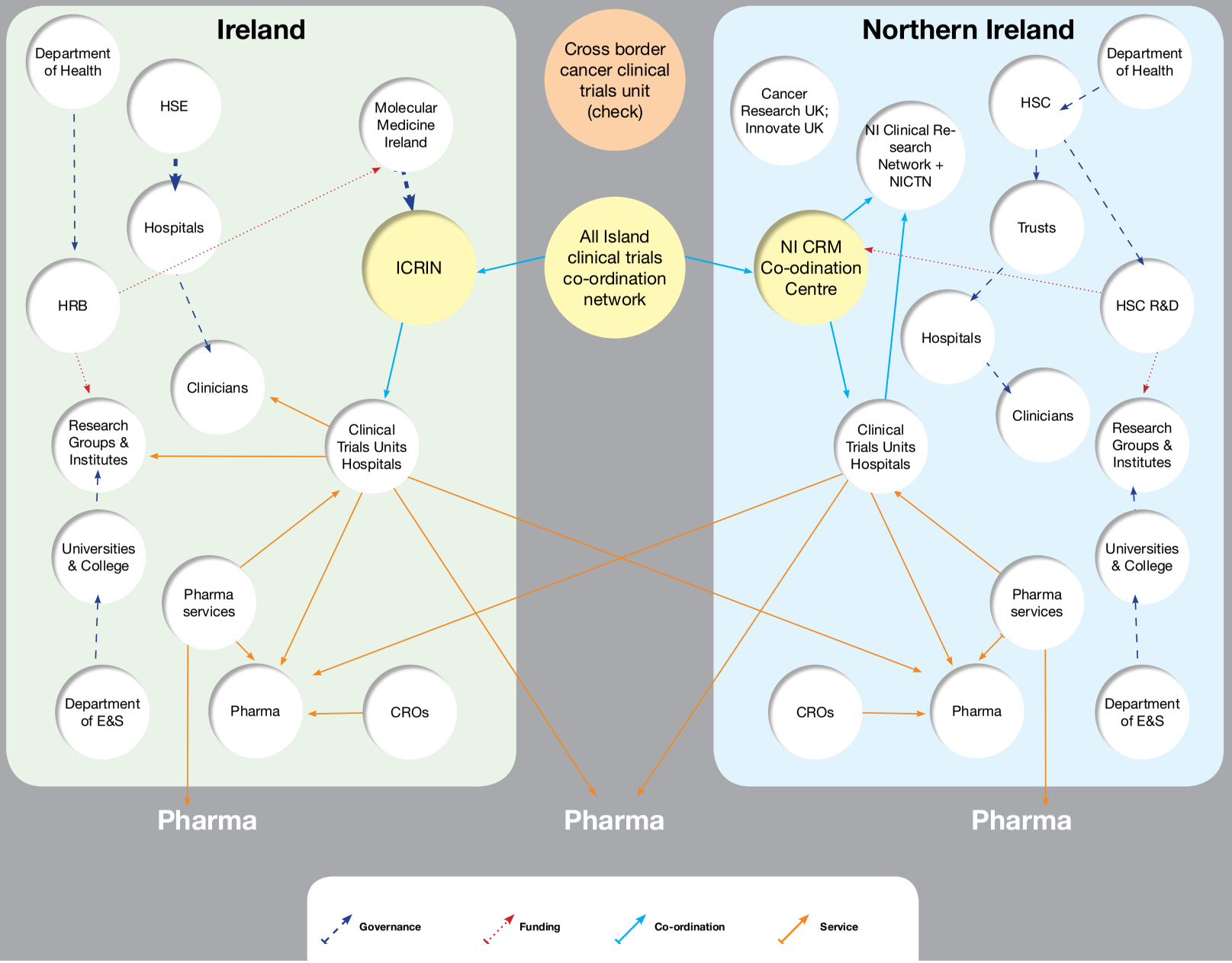
OPPORTUNITY 3: Further integration and development of vendor sector

Given that the island is host to a substantial number of pharmaceutical production companies which spend billions of dollars on procurement of sophisticated works, goods and services, an opportunity may lie in the further integration of the vendor markets and the development of the vendor sector on both sides of the border. A number of companies have already tapped into this market and gone on to develop into export markets (for example, PM, DPS and Ostick and Williams). However most of the advanced engineering and process control technology and services continue to be imported, creating substantial opportunities for existing or new indigenous companies.

A lack of visibility with regard to opportunities, due to the global sourcing strategies of the multinational companies has been one barrier to development. There has been significant work to address this, including the Global Sourcing initiative in Ireland (IDA and EI), the work of PharmaChemical Ireland, the cross-border supply chain network programme run by Craigavon Council aimed at Almac and Norbrook, and the BioIreland initiative, organized through IBEC and supported by InterTradeIreland, Enterprise Ireland and Invest NI in the 2000s. However, there is room for further cross-border integration of the vendor markets, which could provide important economies of scope and synergies as well as stimulating competition and innovation into more advanced, products and services. Indeed, the strong indigenous engineering tradition in Northern Ireland could play an important role in cultivating related variety. To address the need for greater cross-border visibility of the vendor market to the pharmaceutical sector the organisation of all-island show-casing or “speed-dating” events involving potential vendors, MNEs, and research centres could be a first step. A more ambitious step could be to expand the EI/IDA Global Sourcing Initiative to cover firms in Northern Ireland.

Figure 6 identifies the main participants of such all-island show-casing events, including the vendors, engineering companies, multinational pharmaceutical companies, enterprise agencies, and relevant research institutes with a service remit. The initiative could be championed by InterTradeIreland and the actual organisation of the events outsourced to Biobusiness, in association with other industry and employers organisations, Pharmachemical Ireland, ABPI and CBI.

Figure 5: All-Island clinical trials co-ordination network



A longer-term element of this initiative would be the establishment of an All-island Advanced Manufacturing Research Centre aiming to realise the opportunities in the advanced engineering and process control technology and services areas. The Centre would have engineering and automation at its core, as well as creating capabilities in frontier technologies (e.g. continuous processing) relevant to the pharmaceutical manufacturing sector. The Centre would be established from the outset as an all-island centre along the lines of Opportunity 1 and could be championed by SFI and DEL.

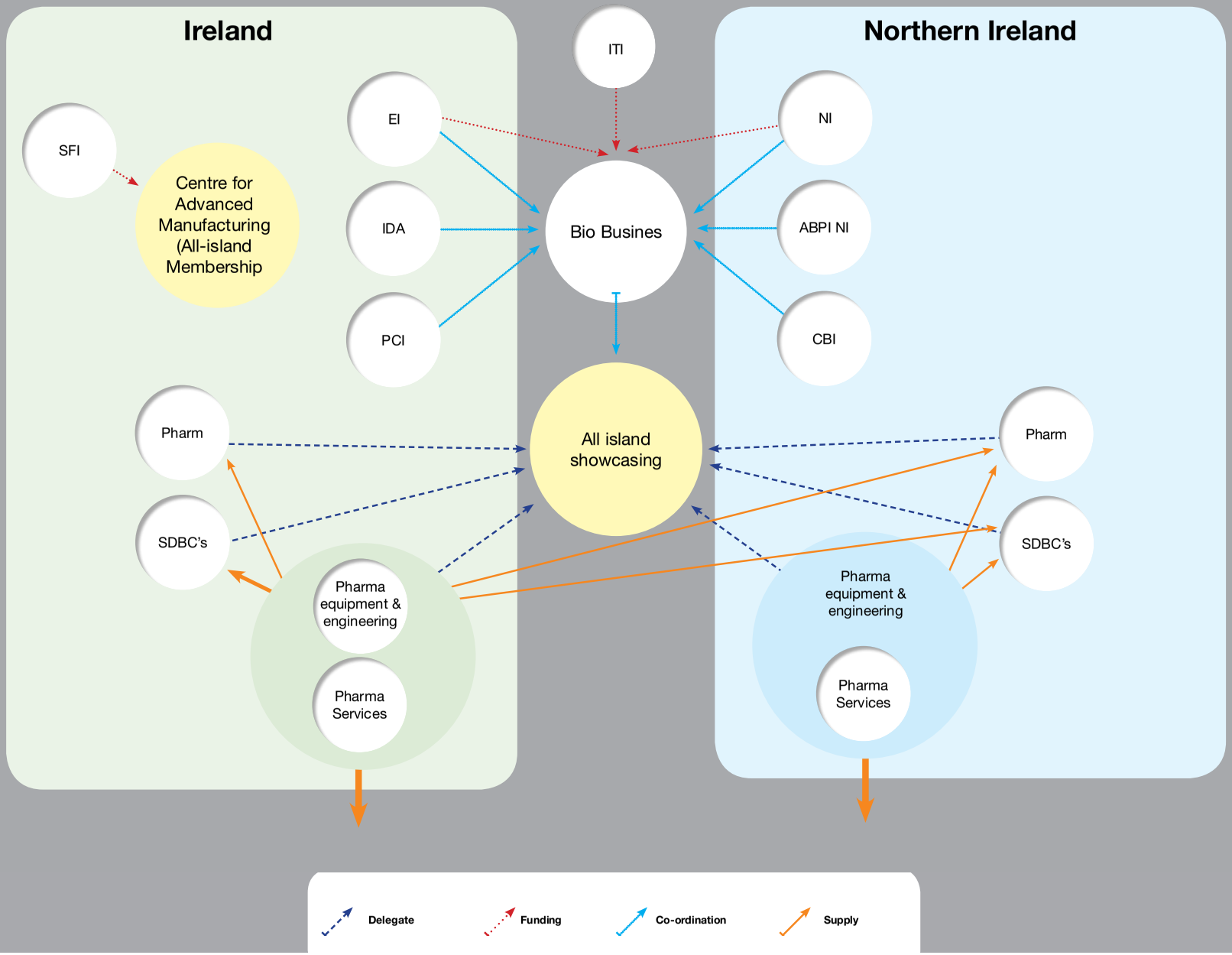
OPPORTUNITY 4: Greater co-ordination of education and training

Interviewees noted the experience across the island of significant skills shortages in certain areas of the pharmaceutical labour force. This is particularly the case for high calibre (MSc and PhD level) staff in areas such as chemistry, chemical engineering, bio-informatics and regulation, while the industry is also calling for 'industry ready' graduates. The provision of skills education and training is subject to economies of scale with two separate systems for education and training. Interviewees pointed to limited levels of co-ordination between the two systems, of cross-border promotion of education and training programmes and courses and of all-island industry-academic partnering. To realise the opportunity of greater co-ordination of education and training across the two jurisdictions the following elements have been suggested:

1. An all-island skills needs assessment, integrating the findings of the Expert Group on Future Skills Needs and the Matrix panel, to identify the critical shortages across the island that could be addressed by the provision of specialised post-graduate courses and programmes.
2. All-island promotion of specialist post-graduate training programmes, such as those offered by the National Institute for Bioprocessing Research and Training (NIBRT) in UCD and the Clinical Translational Research and Innovation Centre (C-TRIC) in Derry/Londonderry. NIBRT is the only specialist bioprocess training facility on the island while C-TRIC provides the only specialist translational medicine programme on the island. The primary orientation of their training provision may remain national, but the training institutions would develop a strong cross-border orientation.
3. Developing all-island specialised Masters/ PhD development programmes relevant to the pharmaceutical industry. This would be more ambitious, perhaps taking the form of a flexible Masters program in, for example, bioprocess engineering, delivered by an all-island virtual centre, where academics from individual institutions offer a set of core modules and/or optional modules within their area of specialism in a centrally located institution with academics travelling to that location.
4. All-island industry-academia partnering (industry placement and course provision) with companies in the South offering industry placements to students from the North and vice versa. Another aspect could involve staff from private sector pharmaceutical companies being involved in teaching provision in both jurisdictions.

As illustrated in Figure 7, the project could be championed and co-ordinated by the Higher Education Authority (HEA) and the Department for Employment and Learning (DEL) Northern Ireland.

Figure 6: Integration and development of the vendor sector



MEDICAL DEVICES

The development of this industry in recent years has been shaped by a number of characteristics specific to medical device products and their usage. On the supply side, these include the innovation process from basic research through to clinical trials and design of prototypes, the high craft content of medical devices products and the regulatory environment; on the demand side, the increased drive towards cost-containment, the reimbursement arrangements of national healthcare systems, and changing demographics have come to the fore. The usage of medical device products – currently 500,000 of these from syringes to orthopaedic implants – is connected to prevention, diagnosis, monitoring and treatment of diseases and medical conditions, in order to reduce hospital stays and rehabilitation times. Given the cost pressures facing national health systems, these medical technologies must combine cost effectiveness with improved healthcare delivery.

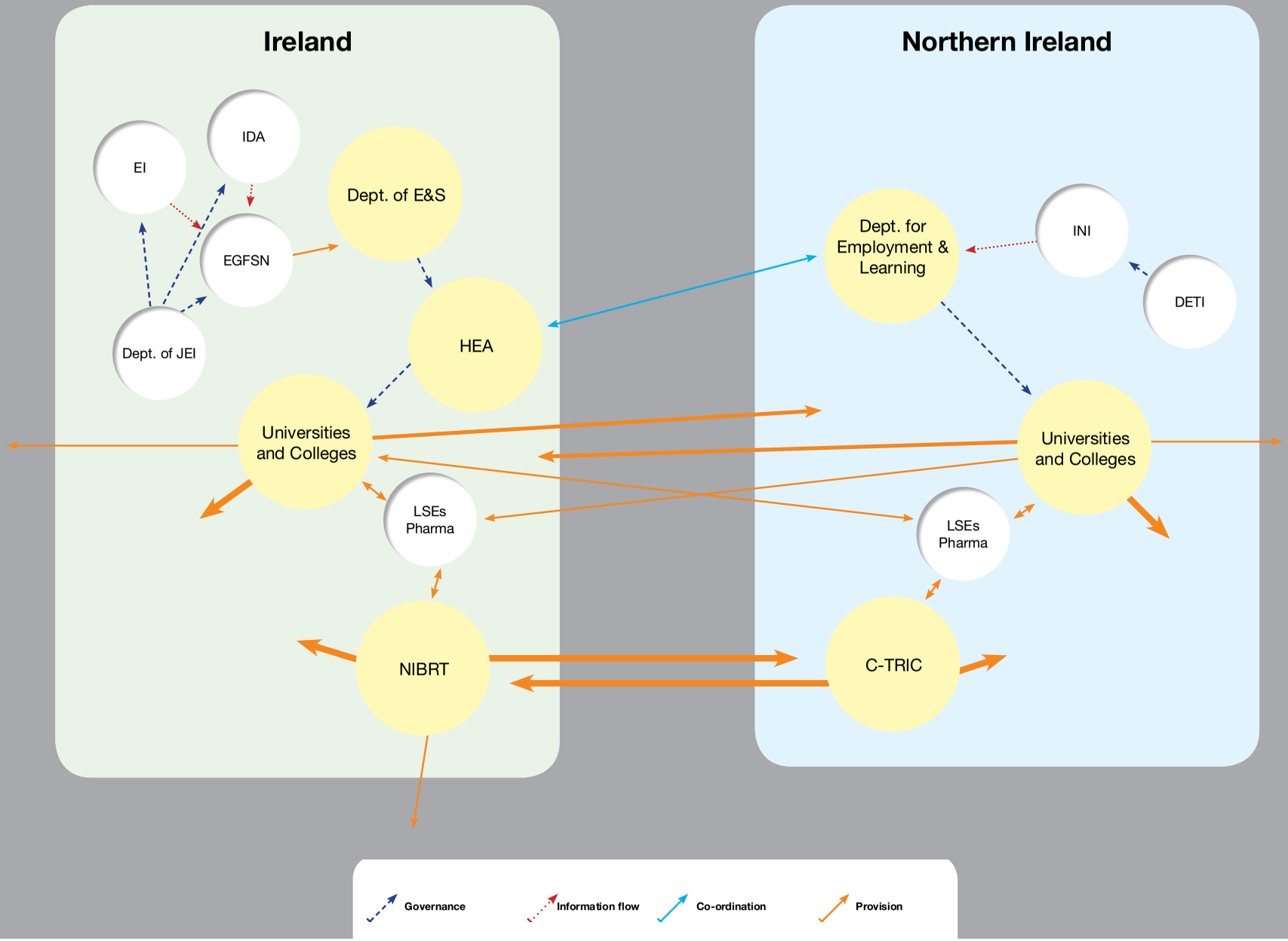
Ireland

In Ireland the medical devices sector has become an important sector, employing over 22,000 people (14% of the total engaged in manufacturing) and accounting for 20% of total manufacturing gross value added.[13] In the mapping exercise, 71 of the 112 firms recorded in the relevant category (NACE 325) were foreign-owned and accounted for 95% of employment. However, the medical devices sector goes beyond NACE 325 and overlaps with related sectors such as diagnostics and biotechnology. Thus estimates of the size of the sector tend to vary with an Enterprise Ireland 2010 profile identifying 160 firms[14] while, Irish Medical Devices Association (IMDA) speak of a broader Medical Technology sector consisting of up to 300 companies. The multinational firms are currently most active in high-value manufacturing of cardiovascular and diagnostics devices. The focus on high-value manufacturing activities in recent years is borne out by Irish export statistics where these devices accounted for 58% of medical devices exports in 2010, compared to 3% in 1990. In 2012 Ireland became the largest global exporter of these products. The €6.7 billion in medical devices exports in 2012 was to global markets with 82% destined for either the US or continental European markets.[15]

The map of the medical devices industry spatial configuration on the island shows domination by a small set of distinct firm concentrations (see Category 1 map 2). The largest of these are centred in Galway and Cork with smaller concentrations in Athlone, Dublin, Limerick and Waterford in the South, and Belfast and Derry/Londonderry in Northern Ireland. However, the distribution of individual firms is not limited to these clusters: the spread of individual medical devices firms in the West also extends into Mayo, Roscommon, and Sligo, while a similar extension beyond Dublin has taken place. This geography of medical devices firm concentrations in Ireland has been greatly influenced by the location choices of multinational firms with the development of supporting indigenous sub-supply, and developers occurring subsequently in Galway.[16] The attendant benefits of this firm concentration, such as labour pooling, business networks and reputational effects, then began to crystalise and, with the support of the national industrial development agencies, have contributed to a process of cluster development. By 2009 the Galway cluster was home to some 40 companies, with 24 of these being indigenous. Many of these are developers of products for global markets in their own right who derive benefit from

[13] CSO, *Census of Industrial Production* 2012 (2014).
[14] Enterprise Ireland, *Medical Devices Sector profile* (2010).
[15] Van Egeraat and Curran, 'Analysis of the Irish Life Sciences Sector'.
[16] For the Galway case study see M. Giblin, 'Inward foreign investment and the clustering process: the case of the medical technology sector in Ireland', *CISC Working Paper no. 29* (2008); Giblin, 'Local clusters and global entrepreneurship: The significance of spatial and relational propinquity in new firm formation', *CISC Working Paper no. 40* (2010); Giblin and P. Ryan, 'Tight clusters or loose networks? The critical role of inward FDI in cluster creation', *CISC Working Paper no. 35 (2010).*

Figure 7: All-island co-ordination of education and training



the local cluster, in terms of access to specialised skills and local knowledge transfer, business network formation, and a positive reputation internationally.

University and research institutes have responded to these developments in the sector by facilitating collaboration of scientists and engineers on technical and administrative issues.[17] A set of medical research institutions in NUI Galway – the 1999 National Centre for Biomedical Engineering Science (NCBES) and the 2004 Regenerative Medicine Institute (REMEDI), supported by SFI's Centres of Science Engineering and Technology (CSETS) programme – followed with strong matching specialisms and input from local firms.[18] Although the location pattern of the more than 20 medical devices research institutes reflects the pre-existing location of higher education institutions, the specialisms of these are indicative of the activities predominating amongst the firms in a given region. For example, polymers and materials research are represented at the Athlone Institute of Technology; biomechanics are represented in research centres in NUI Galway and Dublin City University, as well as Ulster University; and bioengineering is represented at Cork Institute of Technology and University of Limerick. However, there are also national dimensions to Irish medical devices research centres, such as the Tyndall Institute and INSIGHT, which operate across universities as well as across sectors.[19] Likewise the Biomedical Diagnostics Institute (BDI) based at Dublin City University, where multidisciplinary research is focused on the development of next generation biomedical diagnostic devices. The activities of BDI as an education and skills provider and a research and commercialisation centre provide a useful insight into the different geographies which have to be taken into consideration in any all-island medical devices ecosystem. Physical proximity is particularly important for certain activities where tasks must be undertaken shoulder to shoulder (for example, education, mentoring, observation), while it may be less important for commercial activities, such as contract research services.

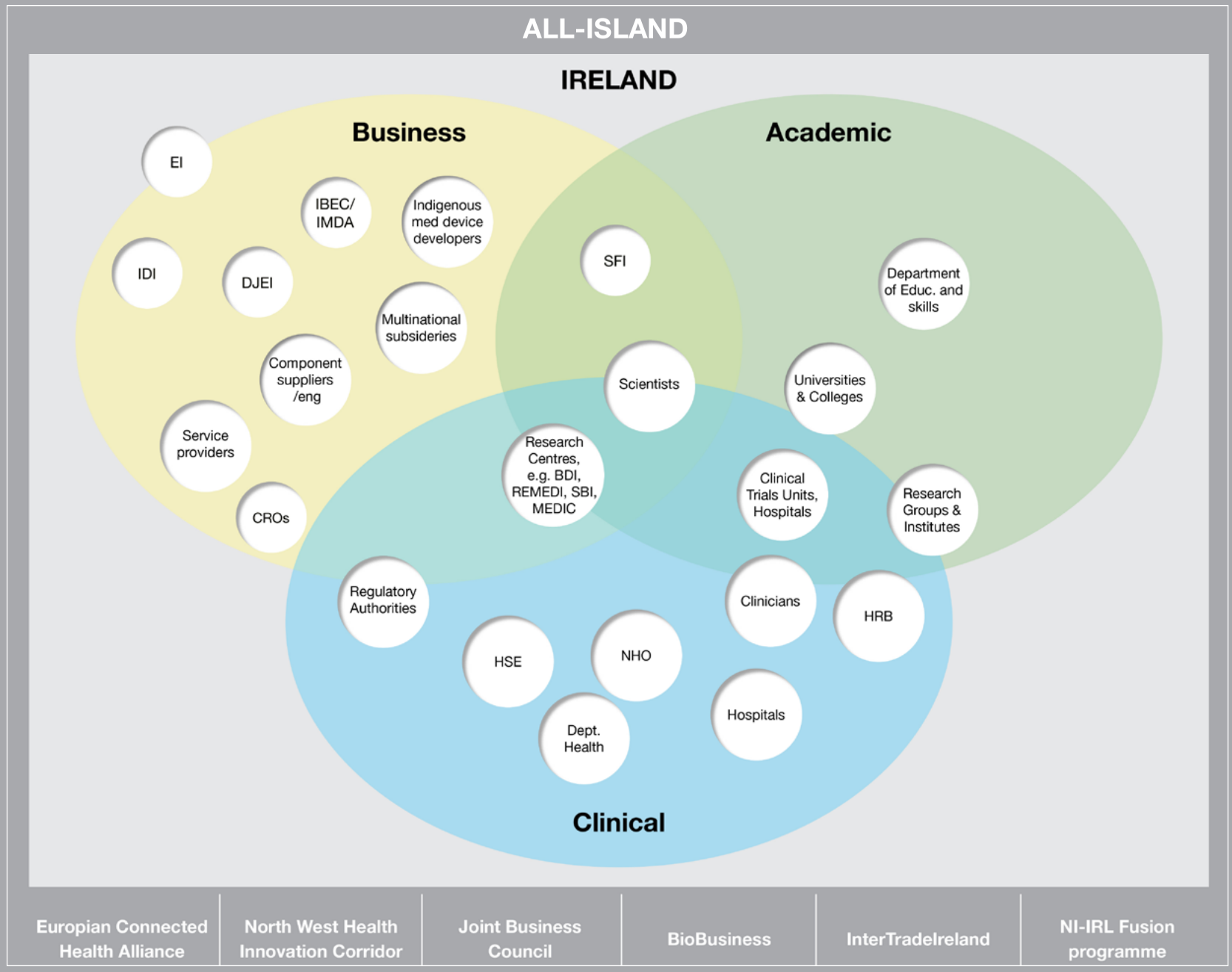
As well as the firms and research centres, a fuller depiction in Figure 8 of the Irish medical devices ecosystem makes reference to the industry support agencies as well as the Irish Medicines Board, Health Information and Quality Authority (HIQA), the Health Services Executive (HSE), and the Health Research Board (HRB).

[17] O. Tulum, 'Foreign Direct Investment, indigenous growth and regional entrepreneurial capabilities: A study of Irish medical device industry entrepreneurs', *CISC Working Paper no.39 (2010)*.

[18] S. Das and P. Ryan, 'The role of MNCs in knowledge accumulation, absorption and utilisation in indigenous Irish firms: A case study of the Galway medical technology cluster', *CISC Working Paper no. 39 (2010)*.

[19] Van Egeraat and Curran, 'Spatial concentration in the Irish Pharmaceutical Industry'.

Figure 8: Irish medical devices sectoral ecosystem – selected actors



Northern Ireland

Unlike the medical devices sector in Ireland, the Northern Irish medical devices sector is dominated by indigenous SMEs and operates at a much smaller scale. Data from the Census of Employment for 2013 shows that 800 people were employed (full and part time) in possibly 25-30 firms belonging to NACE category 325. As noted above the MATRIX science panel has found that the broader Life and Health Sciences sector employs 7,500 employees in 130 companies.[20]

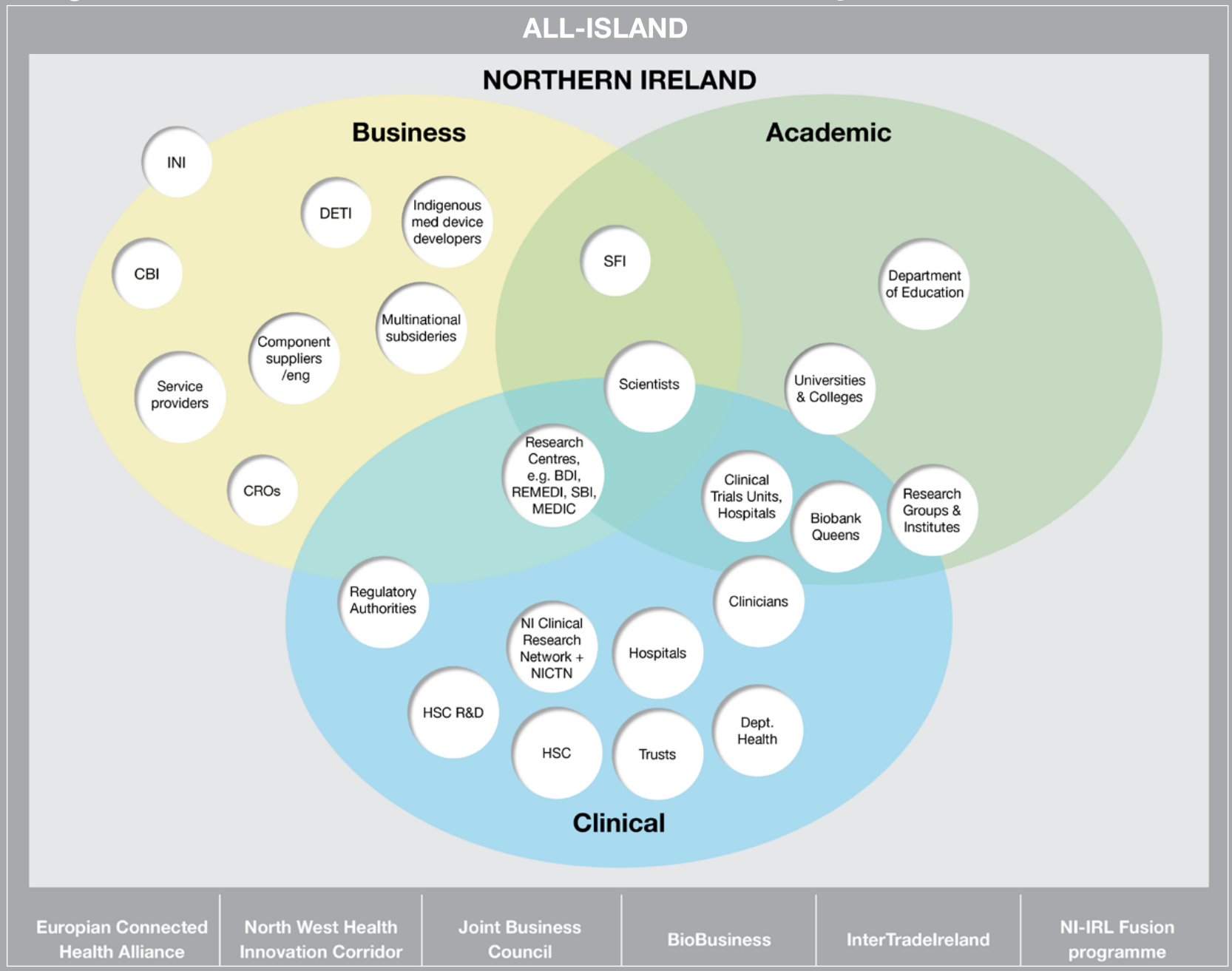
In contrast to the industrial policy origins of the medical devices sector in Ireland, the Northern Irish medical devices sector owes its origins to expertise in the areas of cardiology and bioengineering (behind cardiovascular devices), as well as specific individual innovations by clinicians (dating back to Prof. Frank Pantridge's development of the mobile defibrillator in the 1960s). This has led to the development of a university research centre built around this stream of innovation, and ultimately an on-going flow of university-industry spin-offs and spin-ins, as well as collaborative research, licensing agreements, and patents.[21] The founding of the Nanotechnology and Integrated Bio-engineering Research Centre (NIBEC) at the Ulster University in 2003 (replacing the Northern Irish Bio-engineering Research Centre, which was established in 1990) has generated three spin-outs – HeartSine, Heartscape and Intelesens – one spin-in and an IP portfolio of 35 patents.

Within the sector there is also a growing expertise in the area of Connected Health. The resulting initiatives include the founding in 2013 of the Connected Health Innovation Centre (CHIC), a leading role in the ECHAlliance, the 2014 roll-out of an Electronic Care Record (assembling patient information from existing systems to make them available to authorised staff wherever the patient is located), and the emerging development of a Connected Health Interoperability Platform (CHIP). Northern Ireland has also adopted the largest mainstreamed tele-health service procurement in the UK, involving an £18 million remote tele-monitoring contract awarded in 2011 to a consortium of Tunstall, FoldHousing and S3.

The wider medical devices ecosystem in Northern Ireland (as shown in Figure 9) has built outwards from an initial clinician-led breakthrough to public sector initiatives, a strong set of indigenous medical devices companies (including Armstrong Medical, BlueScope, Clearway, Perfecseal, Sepha, and TG Eakin, among others), research institutions, such as the school of Biomedical Research Institute, and CHIC. The latter epitomises the ecosystem being the result of a £6.8 million investment by a consortium of technology companies and £5 million R&D support from Invest Northern Ireland. On the policy front, Invest Northern Ireland and the Department of Enterprise, Trade, and Innovation (DETI), the Department of Health, Social Services and Public Safety (DHSSPS), the Department for Employment and Learning (DEL); and the business association, Biobusiness, all support the sector.

[20] MATRIX, *Life and Health Sciences Northern Ireland* (2015).
[21] For this history see B. Shurlock, 'Pioneers in cardiology: Frank Pantridge', *Circulation: Journal of the American Heart Association* (2007), 145-148.

Figure 9: Northern Ireland medical devices sectoral ecosystem – selected actors



Opportunities for increased all-island development

The concentrations of medical device firms display a certain regional 'boundedness'. However, the scope for all-island co-ordination across these clusters lies within the complementarily of activities which these firms specialize in, as well as in the potential for existing public/private research initiatives to benefit from scale economies. The compositional difference, in terms of multinational firms and indigenous firms, of the two medical devices and related Software and Data Analytics sectors also presents cross-border opportunities which are more nuanced than that suggested by the mere spatial distribution of medical devices firms across the island.

The analytical framework provides the areas of potential benefits from developing the all-island co-ordination of the medical devices ecosystem. Table 2 shows that initiatives in the areas of Education & Training (in complementary education programmes) and Research, Technology & Innovation (particularly in the area of health information research) offer the greatest potential benefit. Both areas are currently characterised by a relatively low level of all-island co-ordination and the potential benefits of further co-ordination are relatively large.

OPPORTUNITY 5: Increasing all-island co-operation in the health information and data analytics sector

The movement of the medical devices sector into the areas of medical software and data analytics has gained momentum in recent years, in response to demands for greater efficiencies and cost containment across the entire health system, the move with an aging population towards a monitoring and mitigation (reducing hospital stays) role of devices, and the increase in chronic diseases – arising from obesity, smoking, and alcohol consumption – across the advanced economies. Enhanced and efficient functioning of health systems becomes ever more dependent on accurate data and information. A European study from 2011 documented initiatives to harness this synergy between medical devices and information technologies, including Denmark's successful development - in contrast to unsuccessful attempts in UK, France and Germany - of a functioning electronic patient records system covering almost the entire population, which has been seen to help medical professionals to provide better, faster care.[22] The other major impetus into medical devices–data analytics relationship is the strategies of businesses, such as Google, Apple, and Samsung, to focus on the areas of health care and life sciences, on the basis they are able to meet the stringent regulatory requirements for developing medical devices in terms of accuracy of the information provided.

[22] Economist Intelligence Unit, *Future-Proofing Europe's Healthcare* (2011)

TABLE 2
Relative level of benefit related to different areas of an all-island medical devices ecosystem

	CURRENT LEVEL OF ALL-ISLAND CO-ORDINATION	POTENTIAL BENEFITS OF FURTHER CO-ORDINATION
Labour Market	Medium	Small
Education & Training	Low	Large
Infrastructure	Low	Small
Product & service markets	High	Small
Institutional support	Low	Medium
Research, Technology and Innovation	Low	Large

To capitalise on this industry shift will require the alignment of a number of distinct competencies: (i) software development via global industry leaders; (ii) 'Big Data' storage and analysis capabilities via cloud computing leaders; (iii) academic and clinical knowledge at the health-technology nexus; and (iv) knowledge of how to navigate wearable software devices through the EU medical devices regulatory system. Clearly there is an opportunity here for both North and South to combine their academic and clinical knowledge together with the unparalleled concentration of software development, 'Big Data' and medical devices firms, particularly those multinationals based in Ireland.[23]

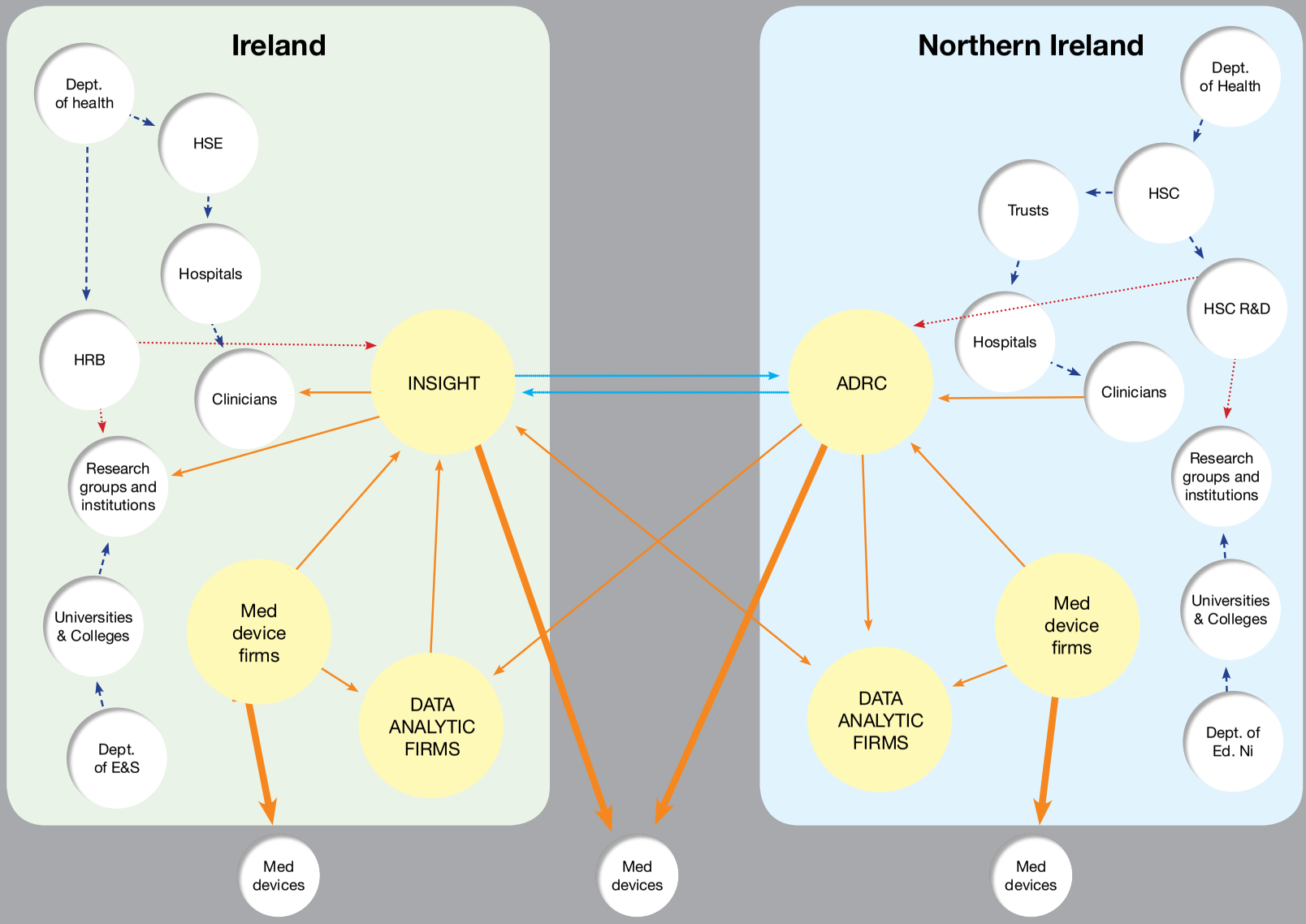
This rapidly emerging outshoot of the conventional medical devices industry offers potential opportunities to both Northern Ireland and Ireland. The simultaneous initiation of research by the Northern Irish medical devices ecosystem and the Irish one in the sphere of data analytics offers potential synergies for both jurisdictions. This arises from the establishment in 2013 of the Northern Ireland Administrative Data Research Centre (ADRC) by Queen's University and the Ulster University (with funding from a UK Research Council and the Health and Social Care Research and Development Division) and the Insight Centre for Data Analytics (INSIGHT) by UCD, NUI Galway, UCC and Dublin City University (with funding from SFI's Research Centres Programme and 30 industry partners).[24]

In order to develop the area of health information within the all-island medical devices ecosystem, a number of steps are necessary. First, the data analytics research centres in Northern Ireland and Ireland, such as INSIGHT and ADRC, should seek to exploit economies of scale and scope by establishing areas of mutually beneficial collaboration. Second, this collaborative grouping should then open dialogue with those global software companies, based predominantly in Ireland and operating in this space, through informal networking between institutions and the relevant industry players or by formal invite to collaborate on joint research projects.

Such an initiative will need to be championed by appropriate public research bodies both in Northern Ireland and Ireland. As illustrated in Figure 10, the main players in this initiative would be the Health Research Board (HRB) in Ireland and Health and Social Care Research and Development Division (HSCRD) in Northern Ireland, as well as the research centres in question (INSIGHT and ADRC) and their host universities. The appropriate champions for such an initiative would include the Department for Jobs, Enterprise and Innovation (DJEI) and the Department for Enterprise, Trade and Investment (DETI).

[23] The need for Northern Ireland to further develop this global FDI component was acknowledged in the 2008 MATRIX report.
[24] INSIGHT's industry partners include, among others, RTÉ, *The Irish Times*, Cisco, Microsoft, Alcatel-Lucent, Avaya, TE Labs and TreeMetrics.

Figure 10: All-island health data analytics sector



OPPORTUNITY 6: Enhancing all-island co-ordination of training in medical device commercialisation

Since 2011 Ireland has put in place a specialized medical devices training programme, BioInnovate Ireland, based on a Stanford University programme to develop needs identification skills, which leverages both the medical devices firm capabilities built up over recent decades and the positive international reputation that the multinational presence has cultivated in the sector for Ireland. BioInnovate is based on a university consortia with support from key industry sponsors and Enterprise Ireland and the Irish Medical Devices Association (IMDA). It has built a close relationship with Stanford to the extent of being the first Global Affiliate Programme to facilitate interaction between Fellows on both programmes. The ten-month Fellowship team-based training programme aims to identify new innovations in particular disease areas that have been sifted from hundreds of proposals based on their observations in hospitals. The key feature of the programme, in keeping with the original Biodesign, is its emphasis on identifying unmet market needs through observation and experiential learning in a clinical setting. This has led to one Galway based medical devices start-up, EMBO Medical, who have gone on to raise seed funding to enable the business to secure regulatory approval for their new product, enter the market and create employment for up to 20 people.[25] The development of BioInnovate Ireland is indicative of the links being forged between Irish medical devices research initiatives with leading US medical research institutes, such as the Cleveland Clinic and the Mayo Clinic.

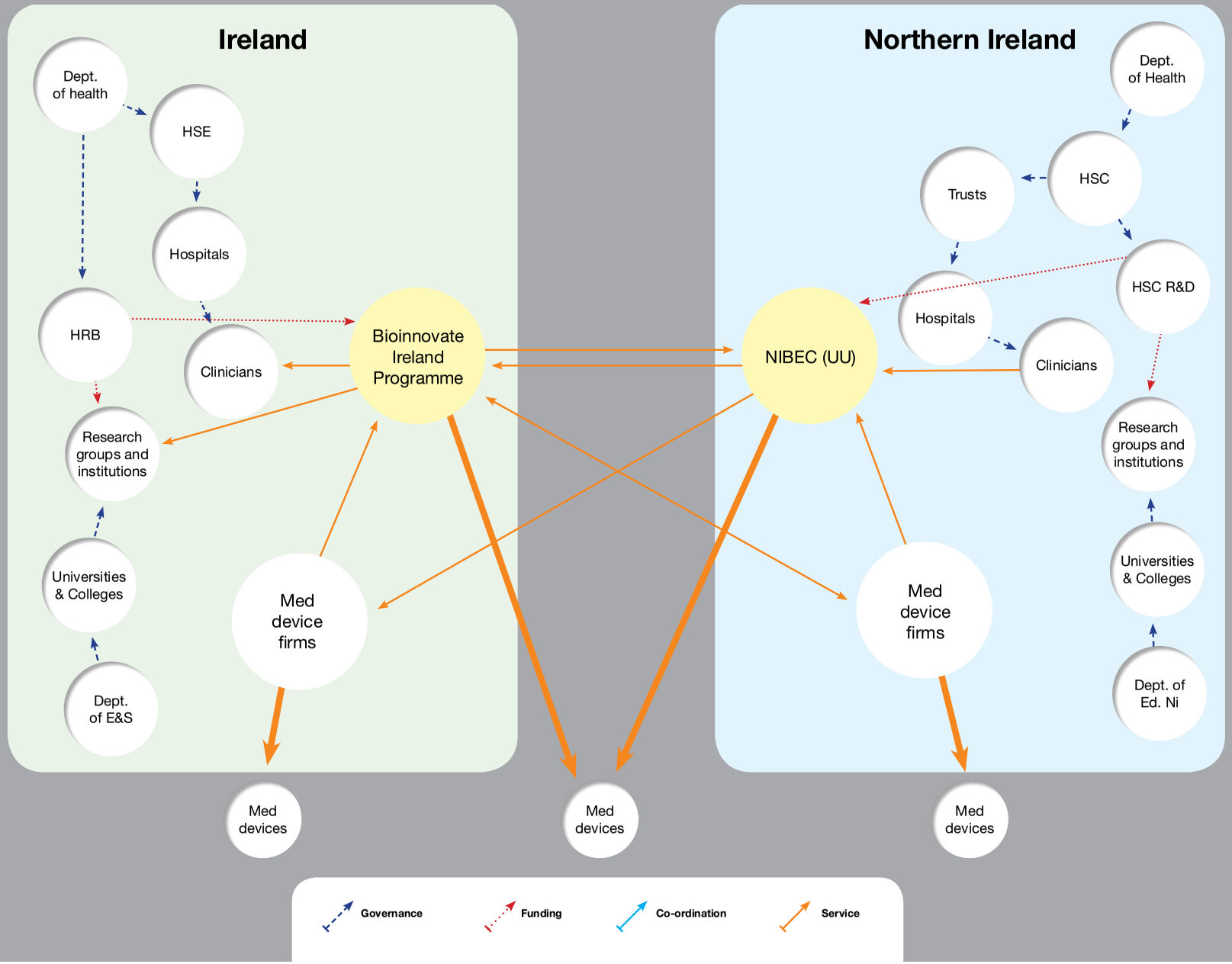
In terms of advantages arising from greater all-island co-ordination, there is an opportunity to develop synergies between BioInnovate Ireland initiative and an existing research organization such as the Nanotechnology and Integrated Bioengineering Research Centre (NIBEC) at the Ulster University. Here, progress has been made in medical devices technology transfer and commercialisation based on existing bioengineering and nanotechnology research capabilities. These synergies could be exploited by creating opportunities for BioInnovate Ireland students to undertake research in NIBEC and Northern Ireland's hospitals, with reciprocal opportunities being put in place for NIBEC students to engage in with the BioInnovate Ireland programme at, for example, the National Centre for Biomedical Engineering Science (NCBES) in NUI Galway and University Hospital Galway. This type of initiative has potential to increase the North South uptake of graduate-level programmes in areas such as Biomedical Engineering, and an increase in the scale of trained specialists in this area can add impetus to the flow of commercialisation and spin-off opportunities arising from both organisations' programmes.

The main players in this initiative would be the BioInnovate Ireland, its sponsors, and National Centre for Biomedical Engineering Science (NCBES) in NUI Galway from the South and NIBEC (Ulster University) and the Belfast Royal Victoria Hospital in the North (see Figure 11), and at a ministerial level the Department of Education and the Department of Employment and Learning in Northern Ireland and ireland, respectively.

An additional benefit of such an initiative could be the profiling for securing the necessary seed and venture capital by any resulting spin-off firms. While first round seed funding can often be secured both in Northern Ireland and Ireland the next stage of funding for larger scale investment can be more difficult for Northern Ireland start-ups as it tends to come from outside of the local environment, be it Ireland, Great Britain, or

[25] John Kennedy, "Med tech start-up Embo Medical raises €3m", Siliconrepublic.com, 6 October 2014.

Figure 11: All-island integrated training for medical device commercialisation



the United States. Here, the international recognition via links to global research centres such as the Mayo Clinic, Cleveland Clinic, or Stanford can attract venture capital for Irish spin-offs, and the economies of scale brought about by an all-island approach to biomedical training, innovation, and commercialisation could offer a means to fully exploit this positive reputational effect.

OPPORTUNITY 7: Cross border co-operation in health information innovation

The issue of interoperable standards for health information has received increasing attention from actors across the medical devices ecosystem. For industry the data flow facilitated by interoperability is seen as a prerequisite for integrated development across nanotechnology, big data and the life sciences. For the public sector eHealth, or the intersection of medical informatics, public health and business, is expected to benefit clinicians, patients and suppliers alike.[26]

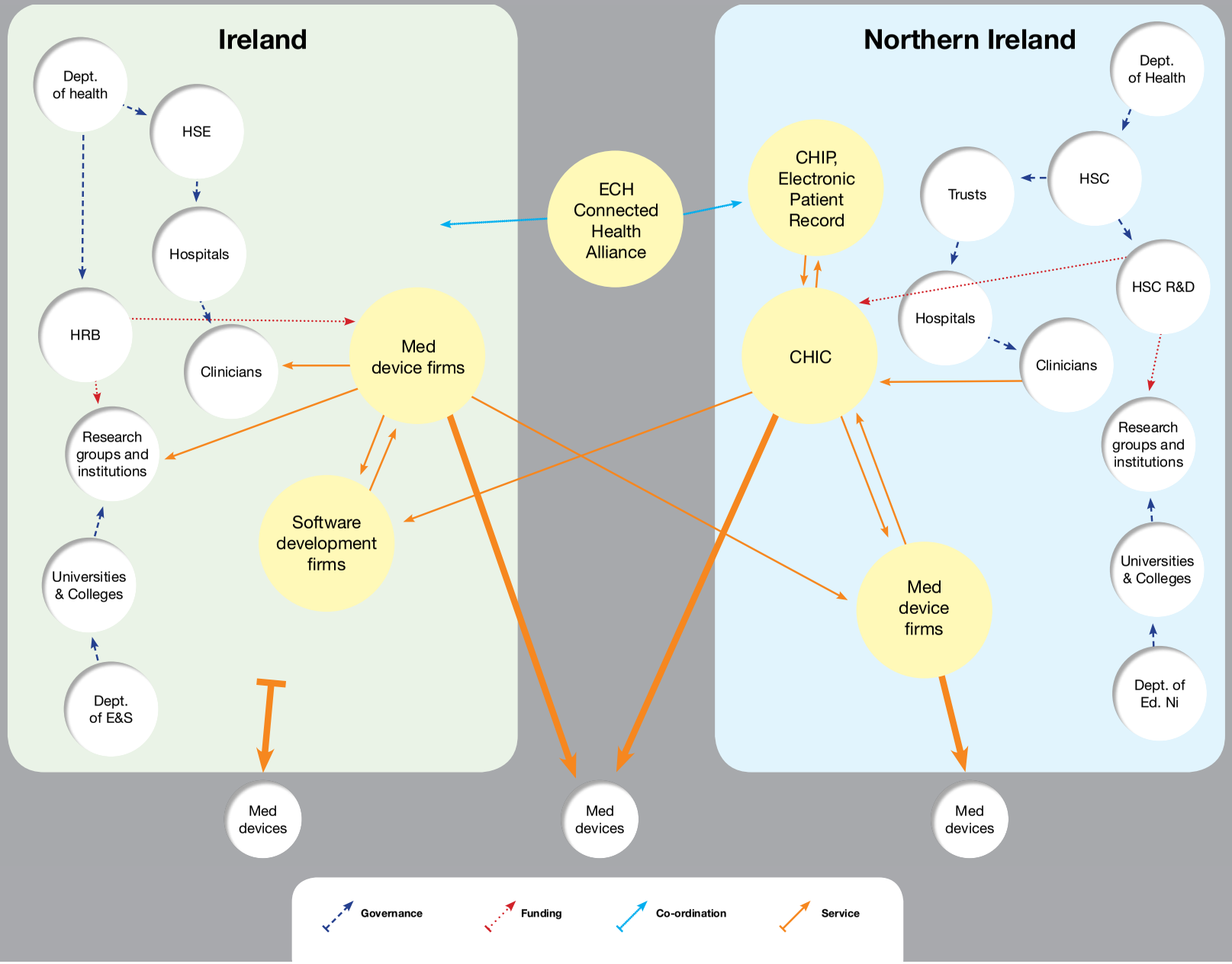
An opportunity arises for the Irish medical devices ecosystem in the transition towards interoperable standards regarding health information. Ireland and Northern Ireland possess the complementary sets of skills across research centres, software developers, consultancy, and support services which, if combined together, will place the all-island ecosystem in a strong position to develop the appropriate health software and systems required to meet this emerging market need.

In the first instance, what is required for the development of these new health information systems is a testing ground, or incubator environment. Northern Ireland has already taken the lead in this regard with the roll-out in 2014 of its own regional system of Electronic Care Records, the establishment of CHIC referred to above, and the ongoing Connected Health Interoperability Platform (CHIP). In addition, as a founder member of the European Connected Health Alliance, a memorandum of understanding (MOU) with the New York Health Department, establishing the Northern Ireland Massachusetts Connection (NIMAC) and links with connected health initiatives in Finland and Spain give Northern Ireland an important 'first-mover advantage'. A result of this has been the location of the European Connected Health Campus (ECHC) in Belfast. This combines international foundation industry members with local researchers and business organisations to provide leadership for the development of Connected Health markets and practice across Europe. Arrangements and initiatives such as those outlined above offer the potential for creating a health information incubator environment and offer great potential for these existing research centres and organisations to engage with the array of global software developers which have an established presence in Ireland.

While Ireland is playing catch-up in terms of interoperable standards and convergent health within its own health system[27], it possesses the private enterprise mix to deliver health information systems and software to the market (see Software case study below). Co-ordination in this area of emerging market need in health information systems could include several elements. First, to more directly introduce the ecosystem actors to the healthcare system and its information needed on the other side of the border. Second, software and consultancy firms based in the South could be inducted as formal members of the research institutes in Northern Ireland. Third, moving beyond membership of an alliance towards targeted research efforts, based on observation and experiential learning, to develop commercialisable solutions to problems such as those identified in

[26] European Communities ISaMD, *Connected Health: Quality and Safety for European Citizens* (2006); Health Information and Quality Authority, *Developing national eHealth interoperability standards for Ireland* (2011).
[27] EHIQA, *Overview of healthcare interoperability standards* (2013).

Figure 12: All-island development of health information system products



the Irish healthcare system (which might include the development of cost-efficient systems of unique identifiers that can be incorporated into the legal system or enhanced security around health data storage and the use of digital signatures, etc).

There is potential here for a mediator to explore the potential for both indigenous firms who currently collaborate with multinational software partners and global software firms that are based in Ireland to engage in joint research with research institutes in Northern Ireland. Institutional actors who would be key to the success of such an arrangement would include the medical device business associations (BioBusiness and IMDA), the relevant public sector healthcare bodies - the Health Service Executive (HSE) in the South and Health in Social Care (HSC) in the North (see Figure 12). The champions for such an initiative would include the Health Research Board (HRB) in Ireland and the Health and Social Care Research and Development Division (HSCRD) and Digital 2020 in Northern Ireland, with Department support for the initiative from DETI and DJEI.

SOFTWARE SECTOR

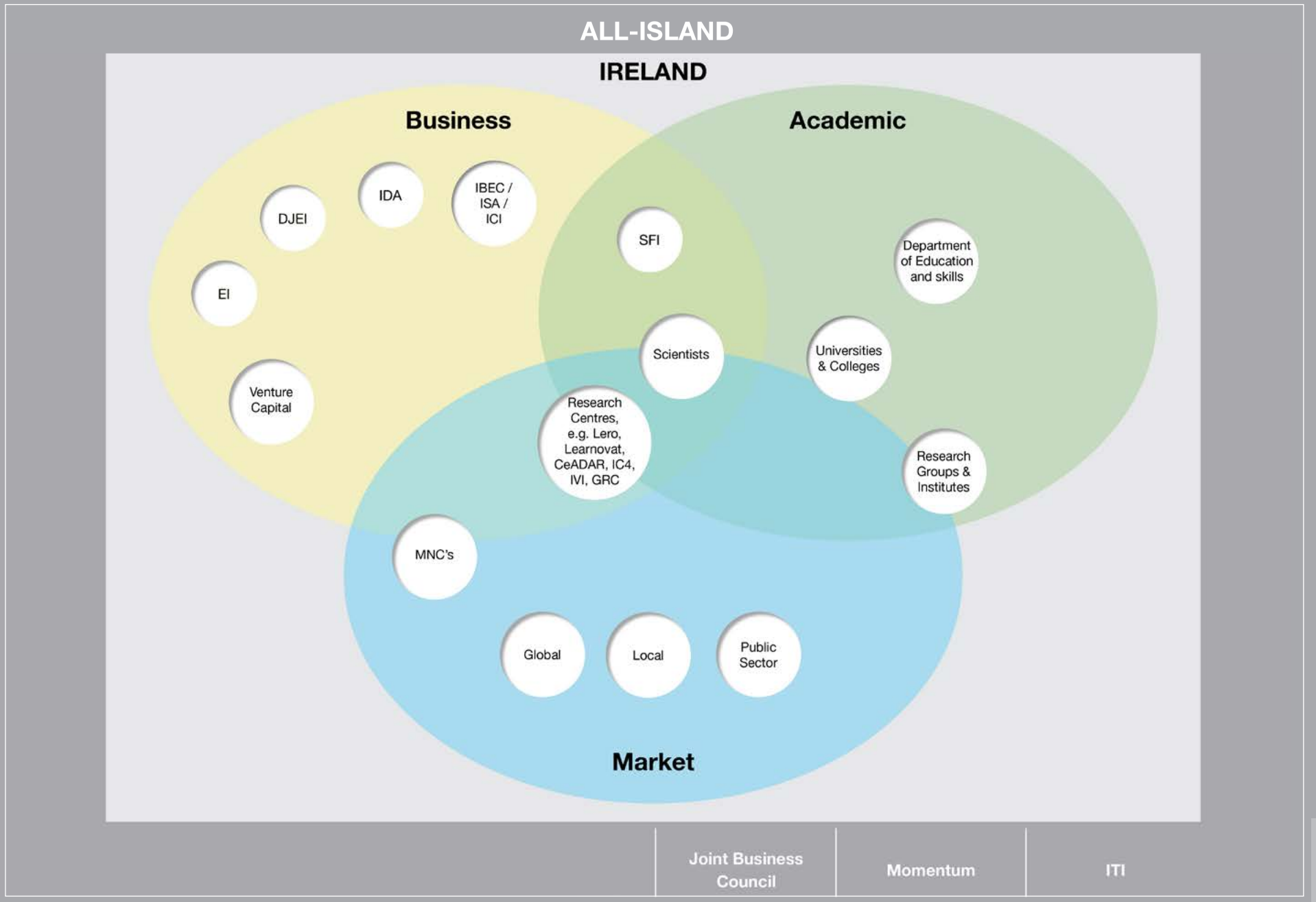
The software sector is now integral to the modern economy both in terms of value creation and enhancing the quality of life through technology, e.g. high speed Internet, web semantics, cloud computing, etc. The ever-present nature of the technology means that software development is embedded in most sectors and creates a measurement problem for NACE and SIC sectoral classifications. Even within the narrowly defined software sector there is significant heterogeneity, with activities ranging from the localisation of products, to customer support, to product development. It is thus challenging to tightly define the ecosystem of this sector.

The data analysis outlined in the previous section identified three distinct concentrations (see Category 2 map 13): a concentration focused on Dublin and incorporating the East coast from Drogheda to Wicklow town along with parts of counties Kildare and Carlow; another more compact one focused on Cork with extension as far as North Cork County; and a third which covers a significant portion of Northern Ireland, focused on Belfast, with cross-border spurs in Dundalk-Newry and Cavan-Enniskillen. The pattern of spatial concentration, particularly in Ireland, indicates the importance of agglomeration economies for the sector with the largest enterprises located in and around the large urban centres and, in particular, Dublin, where many of the larger multinational firms have their operation. Outside of the larger urban centres, many software enterprises are also found in smaller clusters in Limerick, Galway, Waterford and Kilkenny.

Ireland

With its mix of a significant indigenous component and multinational firms the Irish software industry has been identified as a success story. Allowing for the difficulties with the published data, the study has used NACE 62 (computer programming, computer

Figure 13: Ireland software sectoral ecosystem – selected actors



consultancy, computer facilities management and other IT and computer services) and NACE 63 (data processing, hosting and related activities and web portals) to identify the sector. The Forfás Annual Employment Survey for 2013 has over 1,600 enterprises in NACE 62 and 63, employing approximately 66,500 persons on a full time basis. Between them this accounts for almost 25% of agency supported employment and the vast majority of the enterprises and a significant amount of the employment is in the indigenous component of the sector. The sector has seen growth among almost all sub-sectors and, for NACE 62, 95% of the sales of €60 billion are exports.

The growth of the software sector in Ireland can be traced back to the industrial strategy that aimed to attract foreign direct investment.[28] The strongest firms within the sector were successfully targeted in order to create flagship projects which were used to leverage further investment, resulting in some of the world's major software firms locating in Ireland. More recently Ireland has also attracted major 'born on the Internet' firms. However, the influx of multinationals acted as a seed-bed for the development of indigenous enterprises, especially as they were an important source of early stage demand. With over 1,500 enterprises in the sector there is significant heterogeneity in terms of size, growth and growth potential, market orientation, level of innovation and product. Multinational enterprises operating in Ireland range from Microsoft, Apple, SAP, Symantec and Google which are respectively leaders in consumer software, business software, computer security and Internet applications. Indigenous firms range from well known firms like Trintech to new start-up companies who have been supported by a growing provision of equity capital.[29]

The institutional dimension of the sectoral ecosystem comprises the Department of Jobs, Enterprise and Innovation, IDA Ireland, Enterprise Ireland and the Local Enterprise Offices. In the context of developing an all-island sectoral ecosystem, the key role lies with InterTradeIreland. The industry representative bodies (Irish Software Association, Irish Software Innovation Network, ICT Ireland), in addition to their normal lobbying role, also fulfil an important co-ordinating function by encouraging industry interaction and networking. The development of a skilled workforce has been one of the cornerstones of the development of the industry. The key agents in this are the third-level institutes including the institutes of technology with policy by the Department of Education and Skills.

The development of a research base has also been a priority.[30] There are up to twenty research centres, 13 of which had been funded by SFI, most of which involve software development.[31] These include the Irish Software Engineering Research Centre (Lero), based at the University of Limerick (UL), which brings together software development teams based at UL, DCU, Dundalk Institute of Technology, Maynooth University, NUI Galway, Trinity College Dublin, UCC and UCD, and is funded through the SFI CSETS programme. Another important research centre is Waterford IT-based Telecommunications Software and Systems Group (TSSG), which collaborates with Maynooth University, NUI Galway, Trinity College Dublin and UCC. As well as the multinational and indigenous firms and research centres, a fuller depiction in Figure 13 of the Irish software ecosystem makes reference to the industry support agencies as well as Department of Education and Skills and the industry bodies.

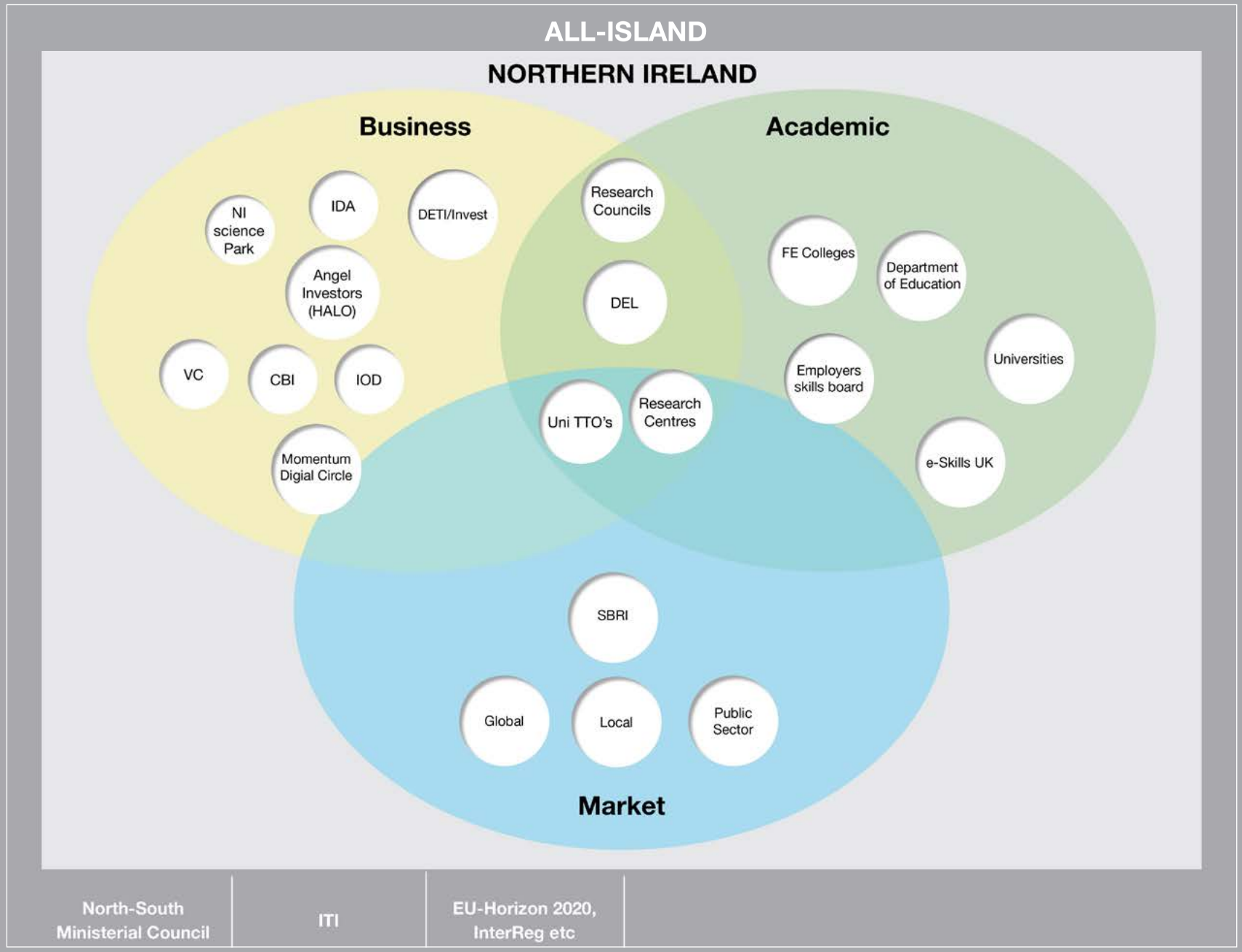
[28] See F. Barry and B. Topa, 'The Irish Software-Venture Capital Cluster in Comparative Perspective', paper presented to the 1st Research Conference on Entrepreneurship in Emerging Regions, Indian School of Business, Hyderabat, (December 2006); M. Crone, 'The Irish Indigenous Software Industry: Explaining the Development of a Knowledge-intensive Industry Cluster in a Less Favoured Region', paper presented at the 42nd Congress of the European Science Association (August 2002).

[29] See Barry and Topa, 'The Irish Software-Venture Capital Cluster'.

[30] Forfás, *National Research Prioritisation Exercise (2011)*.

[31] Department of Jobs, Enterprise and Innovation, *Directory of Research Centres and Technology Centres 2015*.

Figure 14: Northern Ireland software sectoral ecosystem – selected actors



Northern Ireland

Mirroring the software sector in Ireland, estimates vary of its size and scope. Invest NI estimate that the ICT sector in Northern Ireland employs approximately 15,000 workers in 900 ICT companies. Momentum, the digital industry representative body, uses a broader definition incorporating software development, data communications and infrastructure, IT services, and creative media, along with various other forms of technology provision, to estimate 30,000 employed in the sector with a contribution of c.£1.5bn to the economy. The sector has been successful in attracting inward investment to Northern Ireland with 71% of the 12,000 new jobs created through FDI in 2006-2011 in software and IT, business and professional services and financial services. This trend has continued since 2011 with new investments in ICT and software-related sectors, such as financial services technology investments. Prominent companies in the sector include LibertyIT, NYSE, Citi, Allstate and CME.

Invest NI divides the ICT sector into four main categories, three of which are closely aligned to software development: (i) Mobile/Wireless with over 50 companies (including OpenWave and Bytemobile) and hundreds of developers; (ii) Cloud Computing with firms such as Kana Software, Singularity, Kainos, SAP, Aepona, SQS; and (iii) Financial services technology with 24 companies employing 3,300 people or 40% of employment in the overall ICT sector including for example Liberty IT, First Derivatives and Fidessa. The ownership profile of the sector appears somewhat similar to that in Ireland with a large number of very small micro enterprises involved in applications development, consultancy or service provision. A number of spin-outs from the universities (e.g. Kainos and Lagan Technologies) and other indigenous businesses have achieved significant scale, although many have gone on to be acquired. Finally, the VC market is relatively immature in Northern Ireland with the needs of firms at times being too small for the Dublin or London-based investors.

The research base has been important to software development as a provider of skilled software engineers for FDI projects and local firms, and as the source of a number of spin-out companies from both universities. The key research centres include: the Institute of Electronics, Communications and Information Technology (ECIT) in Queen's University with three centres of excellence on space technologies, secure information technologies and capital markets; the Centre for Secure Information Technologies (CSIT) – part of ECIT – which has become recognised as a leading international centre for cyber security; the Computer Science Research Institute (CSRI) in Ulster University; and SAP's Campus-based Engineering Centre (CEC) in Belfast, now the research centre of SAP (UK) Ltd. As well as the multinational and indigenous firms and research centres, a fuller depiction in Figure 14 of the software ecosystem in Northern Ireland makes reference to the industry support agencies, equity capital providers and the industry bodies. The Department of Employment and Learning and the skills/training bodies are also key as the issue of skills, as illustrated below, is a key challenge for software businesses.

Opportunities for increased all-island co-operation

The potential for all-island co-operation and co-ordination of the software ecosystem and the benefits which could flow from this, are explored in the rest of this section. The five areas in which potential benefit could occur that have been identified by the analytical framework of this project are presented in Table 3. Education & Training and Research, Technology and Development offer the best areas for opportunities.

TABLE 3
Relative level of benefit related to different areas of an all-island software ecosystem

	CURRENT LEVEL OF ALL-ISLAND CO-ORDINATION	POTENTIAL BENEFITS OF FURTHER CO-ORDINATION
Labour Market	Medium	Small
Education & Training	Small	Medium
Infrastructure	Medium	Small
Product & service markets	Small	Small
Institutional support	Small	Medium
Research, Technology and Innovation	Medium	Large

OPPORTUNITY 8: Developing an all-island internship scheme

A young skilled workforce has been a key strength of the island in relation to the software industry, but strong growth requires an expansion of the labour force with the required skills and a key concern of the sector on an all-island level is to attract sufficiently qualified staff. Furthermore, alongside the need for industry-specific skills is an increasing need for managerial, marketing, sales, customer relationship and language skills.[32]

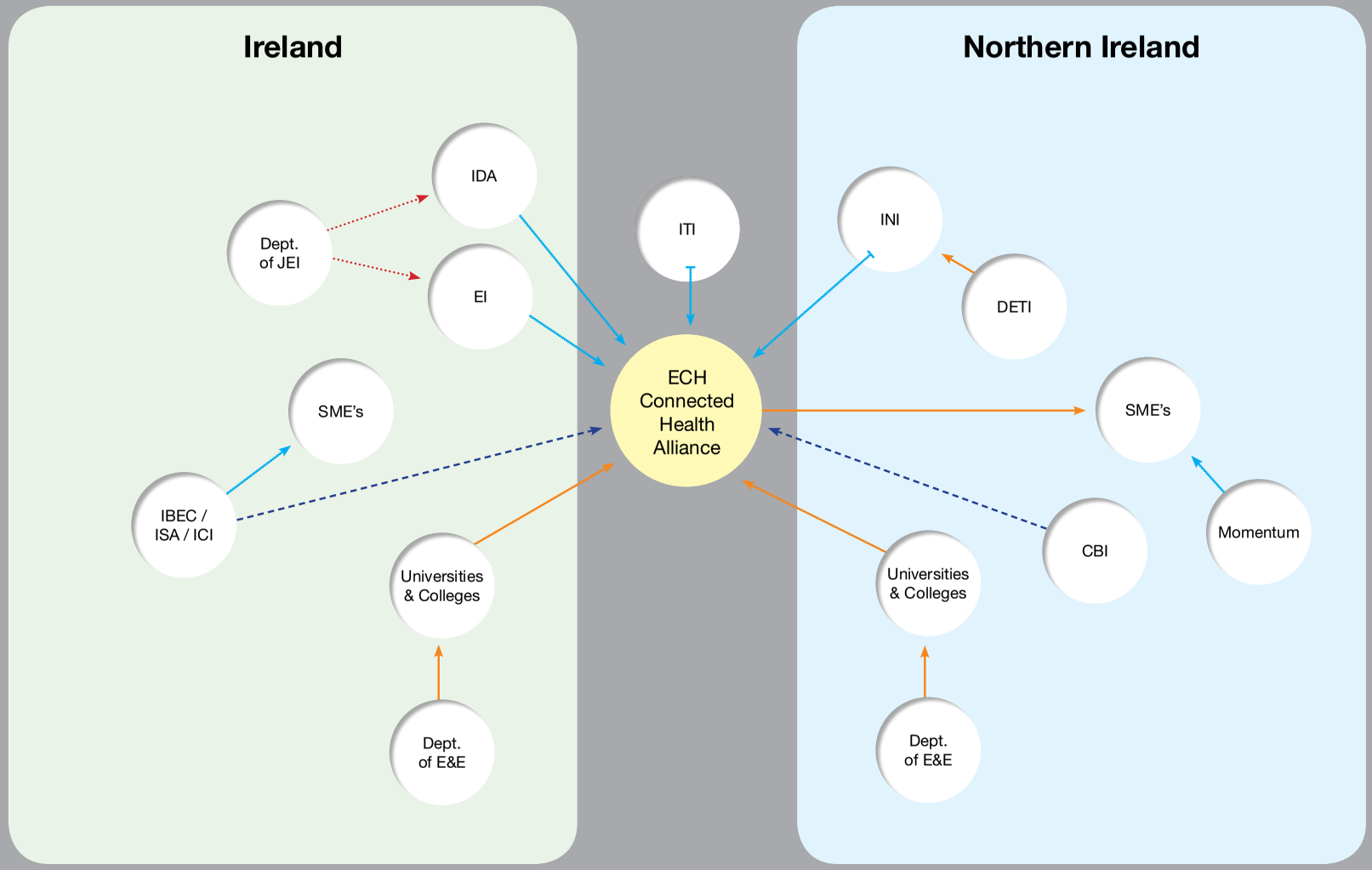
The supply of skilled workers appears to be less of a problem for large multinational firms whose brand names, opportunities for career advancement and more job security help in attracting the skills they need. Larger enterprises have established internship programmes that help in screening and attracting graduate candidates and fulfil an educational role as they help develop on-the-job experience for students. These operate with a small number of third-level institutes and help build networks that can be used to attract further staff.

Smaller firms do not run these graduate recruitment campaigns or internships, though they are more challenged in attracting talented staff than the larger blue chip companies. Developing an all-island internship programme aimed at indigenous SMEs would offer firms an opportunity to connect with potential employees, give students a chance to select an internship from a set of very diverse companies and encourage closer relationships between SMEs and third-level institutes. A cross-border internship programme would benefit both parts of the island, given that the smaller scale and scope of the industry in Northern Ireland provides fewer opportunities for students to gain experience in a range of subsectors, but Northern Ireland also has expertise that does not exist in Ireland.

Such an all-island internship scheme would require support and co-ordination, beyond that which SMEs could provide. Organisation of a cross-border internship programme might require the involvement of the enterprise agencies Enterprise Ireland, Invest NI and InterTradeIreland. Figure 15 shows the possible distribution of responsibilities of the key players that could organise an all-island software sector internship programme.

[32] ICT Ireland and Irish Software Association, *The Global Technology Hub: How Ireland Enables Success for International and Indigenous Technology Companies* (2014); Enterprise Ireland, *Best Connected - Software from Ireland: A Strategy for Development of the Indigenous Software industry 2009 – 2013* (2009).

Figure 15: Organisation of an all-island software sector internship programme



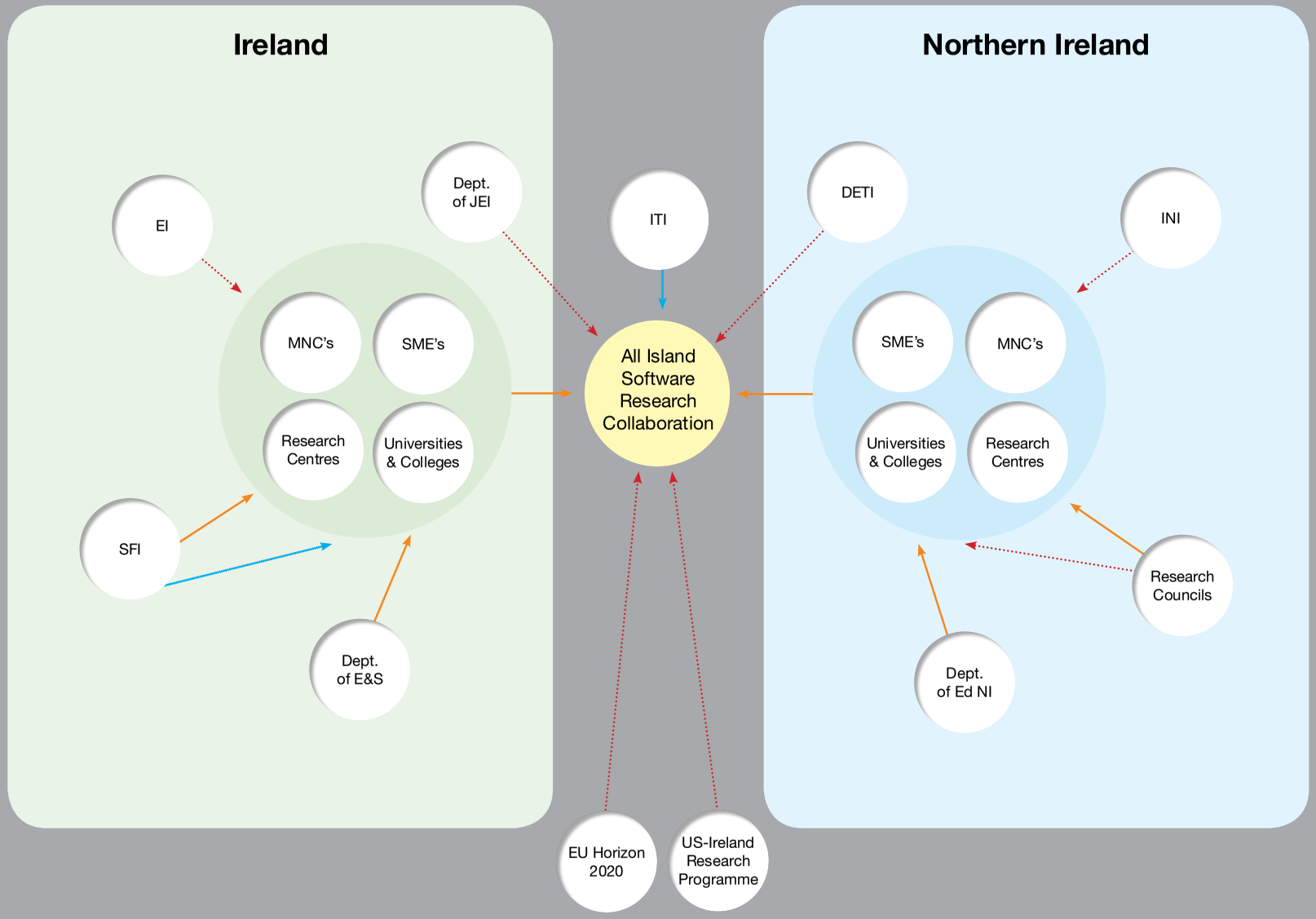
OPPORTUNITY 9: Increased research collaboration

With only a small number of examples of cross-border cooperation, such as that between the Computer Science Research Institute (CSRI) at the University of Ulster, the Biomedical Diagnostics Institute at Dublin City University, and Trinity College Dublin's Institute of Neuroscience or collaboration between CSRI and Dundalk Institute of Technology, there is significant scope for enhanced cross border interaction. For example, of the almost 300 projects funded under the EU 7th Framework Programme for ICT with Irish partners just seven had a partner from Northern Ireland, despite the fact that the majority had a UK partner involved.

In both parts of the island there appear to be strong links between third-level institutions, research centres, business, industry bodies and government. Research centres appear to have a national orientation, initially seeking partners within the country and then outside partners internationally, with no specific focus on partners across the border. This is probably because the research funding system is largely nationally focused, with the exception of the EU Horizon 2020 and the US/Ireland R&D programmes. That said, most research institutes now need to seek additional funding outside the national funding schemes. For example, while Lero receives substantial SFI funding currently 47% of its funding comes from non-SFI sources. An added incentive for cross-border collaboration, particularly with respect to EU Horizon 2020 funding, is that having a partner from the other part of Ireland helps satisfy the criterion to have partners from another EU country. The relative geographic proximity of research institutes on the island of Ireland compared to that of institutes in Great Britain or other EU member states should facilitate stronger relationships between partners.

Linking the research base up might be a good way of strengthening the overall system as this would allow for both scale and scope economies both within the software sector but also on a cross-sectoral basis. Scale economies arise in areas where both Ireland and Northern Ireland have an existing research strength while scope economies arise out of differences in research strength and the different industrial structures in the two parts of the island (see Figure 16).

Figure 16: Closer all-island software sector research collaboration



SECTION

4

SUMMARY AND CONCLUSIONS

Summary and Conclusions

This study aims to identify the potential for all-island sectoral ecosystems. An analytical framework for the benefits of cross border sectoral ecosystems was derived with reference to a number of strands of the academic literature. This framework distinguishes six areas in which potential benefits could theoretically occur:

- Labour market;
- Education and training;
- Infrastructure;
- Goods and services markets;
- Research, technology and innovation;
- Institutional support infrastructure.

The benefits in each of these areas are expected to arise out of scale or scope economies. Regarding scale economies for example, a cross-border ecosystem would typically encompass a larger labour market than one restricted to either Northern Ireland or Ireland. A larger cross-border ecosystem would also be able to justify and utilise more fully specialised infrastructure. Scope economies are closely related to scale economies in that greater scale also implies the possibility for greater variety. For example, given the scale of universities in either part of the island, the variety of research centres in a particular sector is limited. Adding universities through the development of an all-island sectoral ecosystem increases that variety.

An important aspect in the emergence and development of ecosystems is the degree of interaction between the various stakeholders which itself has a natural spatial dimension as interaction with geographically proximate actors arises more readily.

To overcome the limitations of existing measures of industrial concentrations in the spatial dimension of sectoral ecosystems this study develops a new measure to map industry concentrations. This measure improves on existing ones by incorporating both employment scale and the number of enterprises. The measure also uses labour fields based on commuting data to identify the extent of concentrations rather than administrative units. The new measure was applied to a combined all-island dataset. Unfortunately, the nature of the data that was made available for Northern Ireland did not allow for as tight a delineation of concentrations for Northern Ireland as in Ireland.

General conclusions

The mapping analysis identifies 4 categories of spatial concentrations on the island of Ireland with sectors distributed as in Table 4 below.

TABLE 4
Sectoral Categorisation

CATEGORY	SECTOR
1. Dispersed significant concentration	Manufacturing of Beverages
	Manufacturing of Medical Devices
	Information service activities
	Motion picture, video and television programme production, sound recording and music publishing activities
	Printing and reproduction of recorded media
	Manufacture of chemicals and chemical products

CATEGORY	SECTOR
2. Concentrations with a cross-border element	Manufacturing of wearing apparel
	Manufacturing of textiles
	Manufacture of paper and paper products
	Publishing activities
	Manufacture of basic pharmaceutical products and pharmaceutical preparations
	Manufacture of rubber and plastic products
	Computer programme, consultancy and related activities [Software]
3. Ubiquitous across the island	Manufacturing of food products
	Manufacture of other non-metallic mineral products
	Manufacture of furniture
	Manufacture of fabricated metal products, except machinery and equipment
	Manufacturing of wood and wood products, except furniture
4. Ubiquitous in Northern Ireland with significant concentrations elsewhere	Manufacture of electrical equipment
	Office administration, office support and other business support activities
	Financial services activities, except insurance and pension funding
	Activities of head offices; management consultancy activities
	Architectural and engineering activities; technical testing and analysis
	Manufacture of motor vehicles, trailers and semi-trailers
	Repair and installation of machinery and equipment

While the data analysis and mapping identifies the spatial dimension of the ecosystems, it does not encompass the six factors of the conceptual framework in which benefits are likely to emerge. In order to investigate the salience of these, a more detailed case study analysis at the sectoral level was carried out with a focus on three sectors, namely: medical devices; pharmaceuticals; and software.

The case studies demonstrate that the potential for, and advantages of, developing all-island sectoral ecosystems are different from sector to sector. Importantly, the case studies suggest that there is great potential for developing all-island sectoral ecosystems. However, different areas offer different levels of potential and benefit. At the same time it is possible to distil a number of general conclusions pertaining to all-island sectoral ecosystems.

The case studies suggest that the benefits from the further integration of all-island labour markets are likely to be limited. There are few barriers to labour movement and currently, the pharmaceutical, medical devices and software industries are characterised by medium or high levels of labour market integration. This implies that the potential for further labour market integration is limited, although there is potential to develop croos-border initiatives that could alleviate skills shortages in certain sectors. There is little to suggest that this situation will be much different in other sectors. It is however worth noting that salary differentials are attracting workers from Northern Ireland to Ireland.

The area of sector-specific infrastructure does not offer great potential either. Although the current level of all-island integration is low, this is generally not perceived as a problem and the potential benefits of further co-ordination are considered small. It is

possible though that other sectors may have sector-specific infrastructural requirements that can be more efficiently provided though greater levels of all-island co-ordination. It is also notable from the spatial mapping exercise in Section 2 that there are less significant concentrations along the North West a factor which may be due to a relative infrastructure deficit.

The areas offering the greatest potential benefit across the three sectors include research, technology & innovation and education & training. In all three case studies the current level of all-island co-ordination is relatively low and the potential benefits of further co-ordination are perceived to be large.

Research, technology and innovation offers rich potential for further collaboration, which currently is quite limited. Targeted sectoral collaboration is likely to stimulate innovation as opposed to all-island initiatives to promote innovation on its own. Potential in emerging areas, such as cloud computing and data analytics, highlights the importance of strengthening research capability in these areas. There is also scope to further align universities and industry through funding, research centre governance structures and other cross-border collaboration which should translate to further innovation activity and commercialisation into the business sector.

In relation to education and training, all three case studies identify a very low level of all-island co-ordination of the education system. Links across the third-level institutions are currently relatively weak. However, both Northern Ireland and Ireland are experiencing demand for graduates in similar sectors. For example the number and quality of graduates entering the software industry has been identified as a key issue by industry representatives in Ireland and Northern Ireland. There is also significant scope for deeper collaboration particularly with respect to post-graduate courses. Furthermore, introducing a vocational element via an all-island programme of internships in SMEs, would help these businesses connect with potential employees and would also help in developing skills and the diffusion of knowledge from the universities to enterprises.

The area of product and services markets can offer equally great potential benefits, but not for all sectors. In many industries the Ireland and Northern Ireland markets for end-products are already strongly integrated and/or unimportant for the sector. However, the pharmaceutical sector case study shows that, in this industry the current level of integration is relatively low and there are substantial benefits to be gained from the further co-ordination of the vendor markets. This opportunity may be relevant to other (non-case study) sectors.

Part of the area of institutional support infrastructure cuts across the three sectors and, indeed other sectors. As discussed in the case studies, all initiatives involve the co-ordination of the institutional support system. Some elements are sector-specific but the policy framework and enterprise support system is relevant to all sectors and is included as a cross-sectoral, general framework, area. The current level of co-ordination of the enterprise support systems in Northern Ireland and Ireland is low. The potential benefits of developing closer cooperation is, however, considered medium, partly because the limited feasibility of important elements of such a co-ordinated system.

Specific opportunities

A more granular case study analysis of three sectors, Pharmaceuticals, Medical Devices and Software identifies more specific opportunities, summarised in the box on following page, that will enhance the development of all-island sectoral ecosystems to mutual advantage.

Opportunities To Enhance Development of All-Island Sectoral Ecosystems

Pharmaceuticals

Opportunity 1 – strengthen the cross-border co-ordination of research centres, institutes and networks

Opportunity 2 – all-island interoperable clinical trials co-ordination network

Opportunity 3 – further integration and development of vendor sector

Opportunity 4 – greater co-ordination of education and training

Medical Devices

Opportunity 5 – increase cross-border cooperation in the health information and data analytics sector

Opportunity 6 – enhance cross-border co-ordination of training in medical device commercialisation

Opportunity 7 – cross-border cooperation in health information innovation

Software

Opportunity 8 – develop an all-island internship scheme

Opportunity 9 – increase research collaboration

Realising these opportunities is not without its challenges but the interviews carried out as part of the case studies indicate that there is considerable enthusiasm among key actors and many have offered to be involved as core actors and champions for the various initiatives identified in Section 3 and summarised briefly in the box above.

Looking further ahead a more integrated all-island pharmaceutical sectoral ecosystem will comprise three or four industry concentrations. The Dublin and cross-border groupings are likely to merge creating a very strong, research-based, biopharmaceuticals cluster that will account for well over half of all pharmaceutical employment on the island and seven universities with relevant research groups. The regional groupings will continue to benefit from pooled markets of skilled workers. These benefits will, to an extent, continue to be regionally bounded. However, the greater all-Island co-ordination of advanced education and training will provide additional pooling benefits operating at an all-island scale. An integrated all-island sectoral ecosystem will provide benefits of scale and scope to the vendor sector which, in turn, will translate into benefits to the pharmaceutical companies, irrespective of their location on the island. Similarly, the enhanced technology spillovers, derived from integrated research centres and networks and clinical trials systems will operate at an all-island scale and benefit companies irrespective of their location on the island.

The analysis in Section 3 suggests that spillovers in the medical devices sector are not particularly spatially bounded, but are related to complementarities across differently specialised industry concentrations. In this context pursuing the opportunities to develop an all-island sectoral ecosystem for the Medical Devices sector is expected to benefit the industry in general, which in turn would benefit the significant concentrations identified in Ireland and could lead to the emergence of a very significant concentration in this sector in Northern Ireland.

The software sector is currently characterised by four significant industry concentrations, with the Belfast-centred concentration comprising a cross-border element. While there are all-island spillovers in this sector, the scale and scope economies due to agglomeration are important drivers in the sector. Thus, developing an all-island software sector ecosystem will benefit the entire sector but particularly the existing concentrations. Given the current geography of the sector, such developments are likely to lead to a merging of the Belfast and Dublin centred concentrations, which together would constitute an internationally significant industry agglomeration.

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