Measuring Relatedness in a Multi-sectoral Cluster: An Input-Output Approach

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Abstract

The conventional representation of an industrial cluster is that of a self-supporting group of firms with a nest of multi-directional intra-cluster linkages. However, recent research has noted that weak intermediate linkages within clusters do not necessarily imply a weak cluster. Instead, studies in evolutionary economic geography have found that knowledge spillovers, crucial for the development and maintenance of clusters, tend to flow between sectors that are related via similar inputs and/or outputs. Thus, there is a growing body of literature stating that industrial variety within clusters is beneficial for economic growth, whereby local industrial diversity sparks creativity, new ideas and innovations. Within this context, the Irish Maritime and Energy Resource cluster (IMERC) established in 2010 is a diverse, multi-sectoral cluster. Input-Output tables describe the sale and purchase relationships between producers and consumers within an economy. Using an Input Output table this paper examines the intra cluster linkages, as well as the relatedness in terms of inputs and outputs across the four IMERC pillars, Marine Energy, Shipping, Logistics and Transport, Maritime Safety and Security, and Yachting Products and Services. This analysis found that although IMERC has weak intra-cluster linkages, the four pillars share a high number of related inputs and outputs. Based on this analysis, IMERC has the potential to develop into a strong maritime cluster.

Key words: Clusters; Related Variety; Input-Output Analysis; Maritime Activities

1. Introduction

New global opportunities exist in the development of maritime-based products and services (Morrissey et al., 2011; Zhao et al., 2014). Europe has historically had an important maritime

industry with a strong global position in many maritime sub sectors (Viederyte, 2013), including maritime transportation and ship and boat building. However, as globalisation increases competition from lower cost locations like South America and Asia, the question has become how to maintain and strengthen the competitiveness of the European maritime sector. Within this context, many European countries have moved in the direction of having their maritime industries represented by cluster organisations (Viederyte, 2013). The policy focus on cluster development in the maritime sector reflects the insights of research in the early nineties by Porter (1990). Porter (1990; 1998) noted that since many industrial activities are quite `footloose' a high spatial concentration of firms in a particular area indicates that these firms benefit from being part of a spatial concentration or a 'spatial clique' (Gruber and Soci, 2010; Poon et al., 2013). Competitive advantage arises as result of the Marshallian idea that geographic proximity creates the type of collaborations, knowledge spillovers, and positive externalities that companies can use and exploit (Gruber and Soci, 2010; Eriksson, 2011). These externalities are based on the presence of qualified labour, production inputs (for example, support services), and benefits stemming from industrial technological advancement (Gruber and Soci, 2010; Eriksson, 2011; Titze et al., 2011).

Although the importance of colocation is widely acknowledged, there is debate as to whether agglomeration economies arise between firms belonging to either the same or to different industries (van der Panne, 2004; Titze et al., 2011). There is a growing body of literature stating that variety is beneficial for economic growth among collocated industries (Titze et al., 2011; Boschma et al., 2012). The development of clusters with a diverse range of sectors may be more advantageous to clusters than a high degree of sector specialisation. Further studies expand on this notion of diversity and suggest that new industries are more successful when they evolve from the knowledge and resource base of existing industries that are related via similar inputs

and/or outputs of production (Steen and Hansen, 2013; Boschma & Frenken, 2011). However, the extent to which firms are related has an important effect on the actual impact of differing knowledge spillovers and learning within a region. The key argument is that spillovers are more fruitful when they occur between sectors that are neither too cognitive proximate nor too cognitive distant (Nooteboom et al., 2007).

Evolving from its traditional natural resource-based mode of production, the marine sector is increasingly characterised by high-tech, service-based firms that can supply goods and services to a broad range of sectors (Morrissey et al., 2014). The Irish Maritime and Energy Resource Centre (IMERC) is a newly established maritime cluster in the South West of Ireland. Whilst Ireland's share of the global maritime sector is small (Morrissey et al., 2011), IMERC was developed to address the growing global opportunities in four maritime sub-sectors; marine energy; shipping, logistics and transport; maritime safety and security; and yachting goods and services. Referred to as IMERCs four pillars, a foresight study undertaken by Morrissey (2014) estimated substantial output employment and gains for each of these sub-sectors. However, to achieve these outcomes, important questions remain as to whether IMERCs current multi-sectoral approach to cluster development is an appropriate growth strategy for the region. Within this context, this paper wishes to establish the relatedness between the four IMERC pillars in terms of their buyer-seller linkages. From a methodological perspective, this paper also wishes to examine the usefulness of IO tables to provide an initial exploratory analysis on the relatedness within a new maritime cluster in the South West of Ireland.

2. Related Variety

Marshallian agglomeration theory stresses the positive role of localisation on external economies, arguing that the sectoral specialisation of a region is a positive factor because firms

are expected to learn mainly from other local firms in the same industry (Frenken et al., 2007; Gruber and Soci, 2010). Jacobian externalities theory (Jacobs, 1969) suggests that diverse regional economies encourage more knowledge spillovers because firms receive new and better ideas from firms working in many different industries. Much research has focused on whether spillovers occur primarily when a cluster is specialised in a few sectors (localisation economies), or diversified into a large variety of sectors (Jacobs externalities). Recent studies in evolutionary economic geography suggest that new industries are more successful when they evolve from the knowledge and resource base of existing industries that are related via similar inputs and/or outputs of production (Steen and Hansen, 2013; Boschma & Frenken, 2011). Thus, research argues that while Jacobian externalities are important, knowledge spillovers will only be effective among complementary sectors with shared competencies (Frenken et al., 2007). Such complementariness is captured by the notion of related variety (Frenken et al., 2007), where it is argued that industries that are cognitively proximate will gain competitive advantage through shared competencies, innovation and knowledge transfer (Frenken & Boschma, 2007). Related variety is based on the idea that novelty is mostly an outcome of knowledge spillovers between sectors with shared and complementary knowledge bases, rather than a result of specialisation or diversification. Research has found that the more variety across related sectors in a region the more learning opportunities there are for local industries. This will result in more intersectoral knowledge spillovers and enhanced regional performance (Boschma et al., 2012).

However, the extent to which firms are related has an important effect on the actual impact of differing knowledge spillovers and learning within a region. The key argument is that spillovers are more fruitful when they occur between sectors that are neither too cognitive proximate nor too cognitive distant (Nooteboom et al., 2007). That is, some degree of cognitive proximity between two sectors ensures effective communication and common understanding, and some

degree of cognitive distance is needed to avoid cognitive lock-in (Nooteboom et al., 2007; Boschma et al., 2012). It is not only the stock of inputs, such as common technologies, skills, knowledge and purchased goods and services in an economy that affects growth, but also the precise composition of these inputs. A region specialising in a particular composition of complementary sectors will experience higher growth rates than a region specializing in sectors that do not complement each other (Boschma et al., 2012). Thus, it is not regional diversity (which involves too large cognitive distance) or regional specialisation *per se* (resulting in too much cognitive proximity) that stimulates real innovations, but regional specialisation in related variety that is more likely to induce interactive learning and innovation (Asheim et al., 2007). As such, the traditional dichotomy of localization economies and Jacobs' externalities is too simple (Porter, 2003; Asheim et al., 2007).

In the 2000s, the concept of industry relatedness was combined with the empirical observation that knowledge spillovers were often geographically bounded (Boschma et al., 2013). Porter (2003) was one of the first to recognize the importance of spatial externalities across related industries and noted "clusters are important because of the externalities that connect the constituent industries, such as common technologies, skills, knowledge and purchased inputs" (Porter, 2003, p. 562). Porter (2003) argued that it is reasonable to expect that spillovers occur more frequently between close neighbours. Boschma (2005) further noted that geographic proximity is likely to influence the extent to which firms can absorb and use external knowledge from the industry in which the firm operates. While, Eriksson, (2011) notes that geographic proximity reduces the potential communication problems that are associated with being located in a diverse local setting. Section 3 introduces IMERC a newly established multi-sectoral maritime cluster in the South West of Ireland.

3. Maritime Clusters and The Irish Maritime and Energy Resource Cluster (IMERC)

The main objective for developing cluster policies is to improve the business environment, capabilities, and performance of local firms in targeted industries (Doloreux and Shearmur, 2009). From an economic perspective, the maritime sector is multi-sectoral and includes industries both directly (e.g. fishing and oil and gas extraction sectors) and indirectly (e.g. blue biotechnology and offshore logistic computing systems) related to the marine resource (Colgan, 2013; Kildow and McIlgorm, 2010; Morrissey et al., 2011). International research in Ireland (Morrissey et al., 2011), the UK (Pugh, 2008), France (Kalaydjian, 2009), the USA (Kildow and McIlgorm) and China (Zhao et al., 2014) has provided a consistent definition of the subsectors that comprise the maritime economy. Table 1 provides an overview of the subsectors most commonly defined as being part of the marine sector. In theory a maritime cluster has the potential to represent any number or combination of maritime sub-sectors provided in Table 1. However, to date, the majority of maritime clusters have been based on exploiting agglomeration economies between firms belonging to the same maritime subsector, with a particular focus on the transportation sector (de Langan, 2002; Benito et al., 2003; Shinohara, 2010; Brett & Roe, 2010; Chang, 2011; Othman et al., 2011; Morrissey and O'Donoghue, 2013a).

Table 1 Maritime Industries

From a partner's perspective, cluster development means a shift in focus from the firm to productive systems and understanding competitiveness as a collective result rather than the outcome of individual processes (Fingleton et al., 2005). Within this context, although cooperation between linked companies may occur spontaneously, policy provision and support for clusters is traditionally seen as a governmental role. However, rather than a top down governmental approach, other types of institutional interventions, such as universities, research

centres, local authorities and private businesses, may facilitate cooperation (Cooke and Morgan, 1998; Calzonetti et al., 2012). Porter (1990; 1998) emphasises the importance of university led clusters, as an optimal manner in which R&D and innovation can be rapidly shared among cluster participants. With regard to the maritime sector, research in Canada found that clustered maritime firms tend to be more innovative and more frequently involved in R&D and employee training, make more use of informational input from research institutes and universities, and collaborate more intensively with local partners than maritime firms in general (Deloreux and Melançon, 2008). Further research on the Malaysian maritime cluster (Othman, 2011) also stresses the key role of universities and research centres in the success of the maritime-based clusters, particularly in disseminating knowledge. The Irish Maritime and Energy Resource Cluster (IMERC) established in 2010, is a multi-sectoral cluster developed across University College Cork (UCC), Cork Institute of Technology (CIT) and the Irish Naval Service (INS). Whilst Ireland's share of the global maritime sector is small (Morrissey et al., 2011), IMERC was developed to address the growing global opportunities in four maritime sub-sectors; marine energy; shipping, logistics and transport; maritime safety and security; and yachting goods and services.

IMERC encompasses a mix of established sectors such as the maritime transport and emerging sectors such the marine renewable energy sector (Morrissey et al., 2011). Globally the oil and gas exploration sector is a mature sector, marine renewable energy is an embryonic sector with Ireland seen as having the best wave resources. Regarding the shipping, logistics and transport pillar, maritime transportation is a mature industry both in Ireland and internationally. However, large growth potential in services area (EU, 2012), around high tech services to shipping companies, particularly in the development of high tech logistics equipment. The EU's Blue Growth Study, *Blue Growth – Scenarios and drivers for Sustainable Growth from the Oceans,*

Seas and Coasts (2012) identifies the maritime safety and security as a key new sector within the marine economy. In terms of the yachting products and services, the design and building of luxury yachts is a burgeoning sector internationally and one can classify this sector as an emerging sector in Ireland, with high international growth potential. Table 2 gives an on overview of the GDP, employment and life course classification according to the EU's Blue Growth Strategy (EU, 2012) for each of IMERCs pillars. Using macro level measures, gross domestic product (GDP) and employment figures for 2010 as a benchmark, Morrissey (2014) undertook a foresight exercise to assess the additional GDP and employment (Full Time Equivalents, FTEs) creation of the IMERC cluster to 2025. Using a production-oriented approach, the foresight exercise estimated a low scenario and high scenario outcome. The low scenario analysis estimated that IMERC can facilitate the delivery of 2,990 new jobs by 2025 and generate an additional €970 million in annual GDP in the Cork region. Placing a strong emphasis on IMERC's potential to attract significant investment from multi-national corporations to the Cork region; the high scenario analysis estimated that IMERC partners could facilitate the delivery of 4,400 jobs new jobs and generate an additional €1.2 billion in annual GDP by 2025 in the Cork region. Using the high scenario forecast, it was envisioned that the IMERC could provide up to 33% (Morrissey, 2014) of the 2.4% additional ocean-related GDP target outlined in the Government's Integrated Marine Plan for Ireland (Marine Institute, 2012).

The role of IMERC from an institutional perspective is therefore one that explores and exploits the complementariness of the four pillars in terms of knowledge, labour skills and related demand and supplier costs. This requires stimulating the development of networks, knowledge flows and social capital to link upstream and downstream firms, as well as other organisations, to form a productive and innovative system generating vertical and horizontal spillovers (Viederyte, 2013). In assessing the future impact of the cluster, it is important that IMERC

partners have access to appropriate methods to evaluate the relative strengths of the cluster from its onset. As outline above, studies suggest that clusters are more successful when they are related via similar inputs and/or outputs of production (Steen and Hansen, 2013; Boschma & Frenken, 2011) rather than multi-directional intra-cluster linkages. Given the multi-sectoral profile of IMERC, it is important that a method for analysing the interlinkages or the 'relatedness' between each of the four pillars; Marine Energy, Shipping, Logistics and Transport, Maritime Safety and Security, and Yachting Products and Services is available. The next section introduces Input-Output based analysis as a method to examine the level of relatedness among the IMERC sub-sectors.

4. Methods

A cluster is composed of several inter and intra-linked elements: the firms, their collective infrastructure, their respective suppliers and buyers and their research and development (Learmoth et al., 2003). As with individual firms, clusters rely on firms both within and outside their cluster to purchase inputs for their production process, while simultaneously selling output to sectors (sales) to generate profit. A sector's linkage through its direct and indirect purchases is called its backward linkage. As opposed to backward linkage, a sector is forward linked to other sectors through its direct and indirect sales to them. As noted in Section 2, research in evolutionary economics has found that an important dimension of cluster interconnectedness is the nature of buyer–supplier links. Purchasing and sales linkages provide one means for transmitting both codified and tacit knowledge between firms, in terms of technology, skills, products or new management ideas (Midmore et al., 2006). Thus, tighter buyer-supplier linkages may provide agglomeration externalities (Steen and Hansen, 2013; Boschma & Frenken, 2011) within clusters. Considering the complexity of these inter-linked elements, it would be an

enormous task to trace and measure the backward and forward links between each of the firms, as well as their external connections within a cluster (Cai and Lueng, 2002).

Developed by the economist Wassily Leontief, IO tables detail the sales and purchases for each sector within an economy for a given year (Learmoth et al., 2003). IO tables can therefore be used to quantify the size, importance and character of a cluster by identifying the scales of input and outputs to other cluster sectors and external cluster sectors (Learmoth et al., 2003; Titze et al., 2011). However, within the IO framework there are a number of approaches that may be used to measure relatedness (Titze et al., 2011). These include a qualitative input-output analysis (Titze et al., 2011), an eigenvector method (Midmore et al., 2006) and a principal components factor analysis. However, as with most quantitative analysis the method one can use is often based on the data one has to hand. To examine the inter-sectoral linkages between the marine sector in Ireland, Morrissey and O'Donoghue (2013b) augmented the Irish IO table to contain the relevant input and output data for ten marine subsectors. For a detailed description of the marine augmented IO table for Ireland please see Morrissey and O'Donoghue (2013b). Using this augmented IO table, the analysis presented here is similar to the direct flow analysis proposed by Bijnen (1973) and focuses on quantifying the strength of both backward and forward linkages within and across IMERC.

However, it is important to note the limitations of both the data this paper proposes to use and the IO framework more widely with regard to examining relatedness among sectors. First, the augmented marine IO table uses data from 2010 and is therefore somewhat out of date. However, it is important to note that IMERC was established in 2010. Thus, the use of 2010 date to provide an ex-ante evaluation of the relatedness between the four pillars is still relevant.

Second, although the augmented IO table developed by Morrissey and O'Donoghue (2013b) includes ten additional marine sub sectors, an immediate problem encountered is that one cannot map the cluster as defined for policy purposes to the augmented IO table. Table 3 presents the mapping of each of the four IMERC pillars onto its respective marine augmented IO sector. This difficulty occurs because there is a lack of congruence between the cluster designation and sectors as defined under the NACE system of classification. For example, marine energy, which refers to both hydrocarbon and renewable marine energy, is represented by oil and gas extraction. A renewable energy sector does not exist within the augmented marine IO table. In contrast, the shipping, logistics and transport may be divided into water transport services (shipping activities) and auxiliary water transport services, which include port activities, stevedoring, etc.

Maritime safety and security is linked to public administration and defence as a means of representing the naval service activities within the cluster, whilst yacht products and services are represented by the boat building sector. Third, only monetary based linkages can be measured with the IO table (Learmoth et al., 2003). This means that many important features of the cluster particularly knowledge spillovers are ignored. Knowledge spillovers are crucial to innovation, but it is unclear on how knowledge spillovers are made and happen (Steen and Hansen, 2013; Boschma and Frenken, 2011). Examining a number of Scottish clusters, Learmoth et al., (2005) state that if the flows of education, innovation and labour knowledge is linked to the flows of goods and services between sectors, the IO table is not as restricted in terms of non monetary flows as originally assumed. Further, research by evolutionary economic geographers (Boschma & Frenken, 2006, 2011; Neffke et al., 2011) has found that knowledge tends to flow between sectors that are related via similar inputs and/or outputs of production. Thus, while

this paper focuses on quantifying the tangible linkages between the IMERC pillars, one can argue that the flow of inputs and outputs within a cluster may also be seen as a rudimentary proxy for knowledge flows.

Finally, research by Neffke et al. (2011) indicates that industries have different agglomeration needs over different stages of their life cycles. This is because their mode of competition, innovation intensity, and learning opportunities change over time. Classifying industries as young, intermediate, or mature, Neffke et al., (2011) found that Marshallian externalities steadily increase with the maturity of industries. However in contrast the effects of local diversity (Jacobs' externalities) are positive for young industries, but decline and even become negative for more mature industries. Given the cross sectional nature of the data used, this paper is unable to produce a dynamic perspective regarding IMERCs life-course. However, a simple classification of each of IMERCs four pillars as either traditional or emerging sectors (Morrissey et al., 2011; EU, 2012) in terms of their economic development, Table 2 demonstrates that IMERC is typified by mostly young industries. While the IO methodology has clear limitations, the simplicity of using an IO table for linkage analysis and the availability of a marine augmented IO table for Ireland means that the method is an interesting starting point for measuring relatedness within IMERC. Using the augmented IO table (Morrissey and O'Donoghue, 2013) the next section quantifies both inter and intra linkages across IMERC.

Table 3 Map of each of the four IMERC pillars onto its respective marine augmented IO sector

5. Results

The four IMERC pillars and the wider economy

This section demonstrates how the augmented IO table can be used to (a) quantify the linkages between the cluster and the wider economy and (b) intra cluster linkages in terms of shared inputs and outputs among the four IMERC pillars. To quantify the linkages between IMERC and the wider economy, Table 4 presents the overall backward linkages for each of the IMERC pillars. Of the IMERC pillars, maritime transportation has the highest (109) and boat building the second highest backward linkage (73). Previous research using the marine augmented IO table by Morrissey and O'Donoghue, (2013b) found that the maritime transportation has the third highest backward linkage (1.09) within the wider Irish economy. This implies that for every €1 produced within the water transportation sector, €0.09 is backward linked to its direct and indirect upstream suppliers. A backward linkage of greater than one implies that the sector is an important input supplier to other downstream sectors. Table 4 indicates that of the IMERC pillars, maritime transportation (120) and auxiliary maritime transport services (95) have the highest forward linkage and second highest linkages respectively. Previous research by Morrissey and O'Donoghue, (2013b) found that the maritime transportation sector had the seventh highest forward linkage within the Irish economy with a value of 1.20 in 2007. This implies that every €1 produced by the maritime transportation sector is forward linked to €0.20 to the production of the sectors direct and indirect downstream demanders. The high forward linkage of the maritime transportation sector reflects the fact that the service provided by the sector is primarily consumed as part of the intermediate production process by consuming industries. It is important to note that the small forward linkages for the boat building sector and public administration & defence reflect the fact that the goods produced for this sector are sold for final consumption.

Table 4 Overall Backward and Forward Linkages for each of the IMERC Pillars

Relatedness among the IMERC pillars

More central to this paper and demonstrating the effectiveness of IO tables as a cluster analysis tool, Table 5 presents the top five sectors in terms of purchases (backward linkages) for each of the IMERC pillars. For the marine energy sector (NACE, oil and gas sector), one can see that 25% of its backward linkages (sectors that they buy their goods and services from) are associated with financial intermediation services, 11% with electricity and gas, 9% with both other business services and land transport services respectively and 7% with the computer and related services industry. With regard to the yachting products and services sector (NACE: boat building), 19% of its backward linkages are associated with the insurance sector, 11% with the financial intermediation sector, 8% with the construction sector, 7% with hotels and accommodation and 7% with medical, precision and optical instruments. Examining the shipping, logistics and transport sector (NACE: water transportation sector), linkages are highest with the water transportation sector itself 43%, auxiliary transport services (17%), computer and related services, 7%, financial intermediation services and auxiliary marine transportation services 4%, respectively.

Table 5 Top 5 Backward linkages of each of the IMERC Pillars disaggregated by NACE Code

In terms of auxiliary maritime transportation services (NACE: auxiliary marine transportation services), Table 4 indicates that this sector has the strongest backward linkages with other business services, computer and related services and auxiliary transport services, 13%; water transport, 11% and the financial intermediation sector 7%. Finally, for the maritime safety and security (NACE: public administration and defence), the sector has the highest backward linkages with the construction (17%), other business services (13%), real estate (12%), computer and related services and post and telecommunications sector (7%). From Table 4, it can be seen

that the 4 pillars within IMERC (represented as five sectors for the purpose of this research) have relatively weak intra-cluster links, with the closest links between the maritime transportation sector and auxiliary maritime transportation service sector.

Table 5 indicates that a number of the IMERC pillars share the same inputs to production. These include financial Intermediation services (linked to 4 of the 5 IMERC pillars), computer and related services (linked to 4 of the 5 IMERC pillars) and other business services (linked to 3 of the 5 IMERC pillars) sectors. The shipping, logistic and transport sector, broken into shipping operations and auxiliary maritime transport services for the purpose of this research, as noted above are closely backward linked and also share similar input suppliers across sectors. As a whole, one notes that the 4 pillars of IMERC have the strongest backward links with service-based sectors, particularly high value added sectors such as the financial and computer sectors.

While there is no indication in the literature on what kind of numbers indicates a high level of relatedness within a cluster, these results are important qualitatively. These results are important qualitatively. As noted by Frencken et al., (2007) the underlying qualitative nature of economic development, e.g. in terms of the variety of sectors in a region or a cluster, have been rarely addressed. This means that not only the stock of inputs affects growth, but also the precise composition in a qualitative sense (Frencken et al., (2007). Thus, the aim of this is to example the buyer-seller linkages within IMERC from a compositional perspective. Furthermore, while the marine sector is often seen as a 'traditional' primary production oriented sector, these results indicate that the marine sectors within IMERC have the strongest linkages with service-based sectors. In terms of knowledge spillovers based on shared inputs to the process of production, the analysis demonstrates the strong input links between each of the IMERC pillars that may be exploited from increased cluster based cooperation.

Continuing the analysis, Table 6 provides the five sectors with the highest sales (forward linkages) for each of IMERC's pillars. For the marine energy sector, one can see that 23% of its forward linkages (sectors that they sell their goods and services to) are associated with construction, 8%, basic metals (23%), electricity and gas (13%), petroleum and other manufacturing products (8%) and wholesale trade (3%). With regard to the yachting products and services sector, forward linkages are highest with other transport equipment sector (39%), boat building itself (10%), air transport (5%), Recreation (1%) and Water Based Activities (less than 1%). Examining the shipping, logistics and transport sector; its forward linkages are highest with the auxiliary maritime transport sector (39%), wholesale trade (13%), post and telecommunications (8%), auxiliary transport services (5%) and water transport itself (5%). Table 6 indicates that the auxiliary maritime transportation services sector has the strongest forward linkages with wholesale trade (25%), water transport (17%), auxiliary transport services (9%), construction (5%), and post and telecommunications (4%). Finally, the maritime safety and security sector has the highest forward linkages with the construction sector (27%), Housing and Social Welfare (9%), Other Business Services (9%), Real Estate (9%) and Land transport (9%). With regard to relatedness and outputs, Table 6 indicates that a number of IMERC sectors deliver outputs to the same sectors. These include wholesale trade (linked to 3 of the 5 IMERC pillars), construction (linked to 3 of the 5 IMERC pillars) and post and communications (linked to 2 of the 5 IMERC pillars) sectors. Whilst, it is important to note once again that the small input linkages for the boatbuilding and public administration & defence reflect the fact that the goods produced for these sector are sold for final consumption.

Table 6 Top 5 forward linkages of each of the IMERC Pillars disaggregated by NACE Code

6. Discussion

Agglomeration and clustering are seen as fundamental causes of an enhanced level of local economic development, creating externalities that cause firms to grow faster and larger than they otherwise would (Fingleton et al., 2005). This is evident from the remarkable ability of some regions to sustain above-average economic performance. However, the processes underlying the success of clusters including Silicon Valley or the Biomedical cluster in Galway Ireland, are still largely unknown and subject to debate (van der Panne, 2005). Competitive advantage within clusters arises as result of the Marshallian idea that geographic proximity creates the type of collaborations, knowledge spillovers, and positive externalities that companies can use and exploit (Gruber and Soci, 2010; Eriksson, 2011). However, an important debate remains as to whether agglomeration economies arise between firms belonging to either the same or to different industries (van der Panne, 2004; Titze et al., 2011). Previous research has found that regional policies based on supporting related variety reduce the risk of selecting wrong activities because one takes existing regional competences as building blocks to broaden the economic base of the region.

From an economic perspective, the maritime sector is multi-sectoral and includes industries both directly (e.g. fishing and oil and gas extraction sectors) and indirectly (e.g. blue biotechnology and offshore logistic computing systems) related to the marine resource (Colgan, 2013; Kildow and McIlgorm, 2010; Morrissey et al., 2011). Co-located in the Lower Cork Harbour, IMERC is a mix of established marine sectors such as the offshore exploitation and production of oil and gas and the maritime transportation sector and emerging sectors such as

marine renewable energy and sensing technology. These sectors bring together a highly heterogeneous set of actors with skills and capabilities ranging from engineering and construction to advanced computer modelling and technical design to navigating vessels at sea. The conventional representation of a cluster is a self-supporting group of firms with a nest of multi-directional intra-cluster linkages (Learmoth et al., 2003). The IO analysis presented in this paper found that the 4 pillars within IMERC (represented as five sectors for the purpose of this research) have relatively weak intra-cluster links, with the closest links between the maritime transportation sector and auxiliary maritime transportation service sector. However, work on clusters note that weak intermediate linkages in input and outputs within clusters do not necessarily imply a weak cluster (Learmoth et al., 2003). Recent research by evolutionary economic geographers (Boschma & Frenken, 2006, 2011; Neffke et al., 2011) has found that knowledge tends to flow between sectors that are related via similar inputs and/or outputs. New industries are more successful when they evolve from the knowledge and resource base of existing industries that are related via similar inputs and/or outputs of production (Neffke et al., 2011; Boschma & Frenken, 2011; Steen and Hansen, 2013).

The IO analysis found that a number of the IMERC pillars share the same buyer-seller links. With regard to input/backward linkages these include financial Intermediation services (linked to 4 of the 5 IMERC pillars), computer and related services (linked to 4 of the 5 IMERC pillars) and other business services (linked to 3 of the 5 IMERC pillars) sectors. The IO analysis also found that a number of IMERC sectors deliver outputs to the same sectors. These include wholesale trade (linked to 3 of the 5 IMERC pillars), construction (linked to 3 of the 5 IMERC pillars) and post and communications (linked to 2 of the 5 IMERC pillars) sectors. With regard to how these findings relate to the future of IMERC and Irish regional development, previous research in Spain on the

impact of related variety on regional development found that related variety enhances employment growth (Boschma et al., 2012). Relatedness was found to be high between the IMERC pillars, particularly among high knowledge, high added value sectors such as financial intermediation and computer and related services. This result indicates that the heterogeneous mix of sectors within IMERC should aid Morrissey (2014) employment forecasts for the cluster to 2025.

Research by Neffke et al. (2011) indicates that industries have different agglomeration needs in different stages of their life cycles because their mode of competition, innovation intensity, and learning opportunities change over time. Placing these findings in an industrial lifecycle classification, this paper found that the four IMERC pillars are predominately young industries, anchored by one mature sector, the shipping sector. Neffke et al., (2011) found that Marshallian externalities steadily increase with the maturity of industries. However in contrast the effects of local diversity (Jacobs' externalities) are positive for young industries. Thus, given the predominately young nature of each of IMERCs pillars a heterogeneous rather than specialised cluster should have a positive impact on the economic development of the cluster.

As a small open economy, Irish economic prospects are primarily determined by world economic activity (Duffy and Timoney, 2013). The impact of the global economic recession was severe on the economy of Ireland (Duffy and Timoney, 2013), particularly the construction and financial services sectors (Duffy and Timoney, 2013; Morrissey, forthcoming). IMERC has the potential to increase economic activity and employment in sectors that were hardest hit by the economic recession in regions outside Dublin. From a methodological perspective, no single analytical method has been deemed appropriate to analysis the level of relatedness within a

cluster. The analysis found that linkage analysis based on the IO framework is a relatively simple and useful tool that can be used to quantify the linkages between sectors in a cluster. With regard to the usefulness of IO tables in capturing non-monetary flows in a cluster, particularly information, this paper argues that similar to Learmoth (2003) that if the flows of non market linkages within a cluster are linked to the flows of goods and services between sectors, the IO table is not as restricted in terms of non monetary flows as originally assumed. The results of this paper also provide an initial map of knowledge linkages based on shared inputs and outputs within IMERC that may be integrated within further research on knowledge flows within clusters. The outcomes presented in this paper require further research, both empirically and methodologically. Similar to Boschma et al., (2012) this paper argues that there is a need to further explore the source of agglomeration externalities. There is some evidence that labour flows between related industries are of particular importance (Boschma et al. 2009), but more systematic evidence is needed. This paper argues that a more qualitative research methodology such as the qualitative input-output approach used by Titze et al., (2011), combined with employment data may be a suitable starting point.

Finally, it is also important to link these findings within the context of previous research on maritime clusters in Ireland. Research by O'Donoghue and Morrissey (2013a) and Brett and Roe (2010) found that there is potential for a maritime cluster within the Dublin region. However, these findings do not conflict with the research found here. The cluster proposed in the Dublin area focuses solely on the sectors directly related to the maritime transportation sector and exploiting the natural comparative advantage of the Dublin port infrastructure. However, more recent studies on agglomeration and clusters have increasing noted that different industries agglomerate for different reasons (Ellison et al., 2010; Faggio et al., 2014). For instance, in some

industries knowledge spillovers are important. Other industries are driven by labour market pooling or input sharing. Within this context, IMERC is situating the maritime transportation sector within the wider marine economy in the South West region. Thus, while a maritime cluster in the Dublin region would seem to prosper by focusing on maritime transport activities alone, similar to Marshall's specialisation theory of cluster organisation, IMERC proposes to create comparative advantage based on the notion of related variety within clusters (Frenken et al., 2007).

7. References

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Table 1 Marine Industries

Ship Owners & Shipping Operators	Seaweed
Auxiliary Maritime Transportation services	Oil & Gas
Marine Tourism	Renewable Energy
International Cruise	Boat Building
High Tech Maritime Services	Marine Construction
Marine Commerce	Marine Engineering
Other Maritime Services	Other Marine Manufacturing
Fisheries	Naval Services
Aquaculture	Maritime Education
Seafood Processing	

Table 2 Output, employment and life course classification for the 4 IMERC pillars (Morrissey, 2014)

IMERC Pillar	**Life Course Classification**	**Output 2010 (GDP)**	**Employment 2010 (FTE)**
Marine Energy Oil & Gas Extraction Marine Renewable Energy	 Mature Emerging	€200m	1000 FTE
Shipping, Logistics and Transport Ship owners and operators Services to Shipping, Logistics and Transport	 Mature Emerging	€741 m	1836 FTE
Maritime Safety and Security	Emerging	€5m -€10m	75 - 150 FTE
Yachting Products and Services	Emerging	€10m	200 FTE

Table 3 Map of each of the four IMERC pillars onto its respective marine augmented IO sector

IMERC Pillar	**NACE Name**
Marine Energy	Oil & Gas Extraction
Shipping, Logistics and Transport	Water Transport Auxiliary Services to Water Transport
Maritime Safety and Security	Public Administration & Defence
Yachting Products and Services	Boat Building

Table 4 Overall Backward and Forward Linkages for each of the IMERC Pillars

IMERC Pillar	**IO Sector**	**Multiplier**
Backward Linkages for each of the IMERC Pillars		
Marine Energy	Oil & Gas Extraction	44
Shipping	Water transport services	109
Shipping Logistics & Transport	Auxiliary Maritime Transport Services	44
Maritime Safety and Security	Public Administration & Defence	52
Yachting Products & Services	Boat Building	73
Forward Linkages for each of the IMERC Pillars		
Marine Energy	Oil & Gas Extraction	62
Shipping	Water transport services	120
Shipping Logistics and Transport	Auxiliary Maritime Transport Services	95
Maritime Safety and Security	Public Administration & Defence	11
Yachting Products and Services	Boat Building	1

Table 5 Top 5 Backward linkages of each of the IMERC Pillars disaggregated by NACE Code

Oil & Gas Extraction	
Computer and related services	7%
Land transport services	9%
Other business services	9%
Electricity and gas	11%
Financial intermediation services	25%
Boat Building	
Medical, Precision and Optical Instruments	7%
Hotel and restaurant services	7%
Construction work	8%
Financial intermediation services	11%
Insurance and pension services	19%
Maritime Transportation	
Auxiliary Maritime Transport Services	3.7%
Financial intermediation services	3.7%
Computer and related services	7.3%
Auxiliary transport services & travel agencies	16%
Maritime Transportation	43%
Auxiliary Maritime Transport Services	
Financial intermediation services	7%
Maritime Transportation	11%
Auxiliary transport services & **travel agencies**	13%
Computer and related services	14%
Other business services	14%
Public Administration & Defence	
Post and Telecommunications	9.6%
Computer and related services	10%
Real estate services	12%
Other business services	13%
Construction work	17%

Table 6 Top 5 forward linkages of each of the IMERC Pillars disaggregated by NACE Code

Oil & Gas Extraction	
Wholesale trade	3%
Petroleum & Other manufacturing products	8%
Electricity and gas	13%
Basic metals	23%
Construction work	23%
Boat Building	
Water Based Activities	Less 1%
Recreation	1%
Air transport services	5%
Boat Building	10%
Other transport equipment	39%
Water transport services	
Construction work	5%
Auxiliary transport services & travel agencies	5%
Post and telecommunication services	8%
Wholesale trade	13%
Auxiliary Maritime Transport Services	39%
Auxiliary Maritime Transport Services	
Post and telecommunication services	4%
Construction work	5%
Auxiliary transport services & travel agencies	9%
Water transport services	17%
Wholesale trade	25%
Public Administration & Defence	
Land transport services	9%
Real estate services	9%
Other business services	9%
Health and social work services	9%
Construction work	27%