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Assessing Overall Network Structure in Regional Innovation policies: A Case Study of Cluster Policy in the West Midlands in the UK

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ABSTRACT:

Revisiting the theoretical roots of key concepts of 'embeddedness' and 'networks' that underpin many recent regional innovation polices, this paper strives to achieve a more systematic understanding of overall network structure of geographic agglomerations which helps to form a more convincing model of regional development based on learning. This also helps to establish an analysis framework with indicators to assess overall network structure in regional innovation policies. Employing the framework, the examination of cluster policy in the West Midlands highlights its weakness in addressing the overall cluster network structure and the contingent factors influencing the structure. The analysis suggests that there may be similar weakness in other regional innovation policies and theories underpinning them as they share a common weakness in addressing structural characteristics of overall networks.

KEY WORDS: network structure, clusters, regional agglomerations, regional innovation policy

Introduction

The last two decades have witnessed the rising popularity of regional innovation policy (Cooke et al, 2011) with the aim to promote competitiveness and endogenous growth of geographic agglomerations in the global knowledge-based economy. Theoretical rationales of policymaking have been sought from ideas such as industrial district, new industrial space, innovative milieu, learning regions, regional innovation systems and clusters. Over the years these regional innovation models have converged on a few key concepts such as 'network' and 'embeddedness'. Together they represent a focus on "knowledge-based competitiveness and associational approaches, with growing interest in the social and institutional underpinning of the 'economic'" (Lagendijk, 2003, p4).

Recent years, however, have also witnessed the criticism on regional innovation policies and various theoretical frameworks underpinning them (see for example Markusen, 1999; Martin & Sunley, 2003). Particularly apparent is the observation that some key concepts as mentioned above were borrowed externally without critical examination and transferred between regional innovation models and then became the foundation for further theoretical development (Lagendijk, 2003). This has left many regional innovation models 'undertheorised' (Benneworth & Rutten, 2011), which partly accounts for their 'policy distance' (Markusen, 1999).

The purpose of this article is to respond to Benneworth & Rutten's (2011) call to return to the theoretical roots of regional innovation models. However, we are not as

ambitious as to tackle all of their theoretical weaknesses. Instead, we choose to carefully examine one of the core underpinning concepts – 'network' - in order to demonstrate how a return to the theoretical roots of 'network' can contribute to regional innovation models' theoretical development and subsequent policymaking.

The aim of this article is to develop an analysis framework elaborating the overall network structure of geographic agglomerations from which a series of conceptually grounded overall network structure indicators can be developed for policy design and evaluation. The framework is then applied to illustrate how regional innovation policies address overall network structure, using a case study of cluster policy in the West Midlands in the UK.

Our intended contribution is therefore both conceptual and methodological. We hope that our exercise will demonstrate that a careful examination of the theoretical roots of regional innovation models offers clues to establish a more convincing regional development model based on learning. In addition, it will help to resolve the 'policy distance' issue by proposing overall network structure indicators on the basis of which regional innovation policies could be developed and evaluated. As our best knowledge can tell, this article represents the first study to examine overall network structure of regional innovation models and that in regional innovation policies.

The rest of the paper is structured as follows. The next section examines the literature surrounding regional innovation models and network structure, identifying the key issues to be included in the analysis framework. This framework is then outlined and briefly explained with a short discussion of how methodologically it is to be applied

in evaluating overall network structure in regional innovation policies. This is followed by a brief review of the cluster idea and cluster policy development in the West Midlands region. The assessment of overall network structure in the regional cluster policy is detailed in the next section, followed by conclusions highlighting weakness in regional innovation models and policies informed by them with particular reference to network structure.

Geographic Agglomerations, Network Structure and Learning

Most regional innovation models depict a geographic agglomeration as a network of proximate firms and associated institutions, linked by traded interdependence and 'untraded interdependence' (Storper, 1995). The interdisciplinary dialogue between regional innovation models has resulted in a convergence on the concept of 'embeddedness' (Granovetter, 1985, 1992) with enormous emphasis on networks or social relationships in understanding learning in geographic agglomerations and their competitiveness. A geographic agglomeration is therefore a network of internal (those within the critical mass) and external (outside the critical mass) actors and its network relationships could be grouped into internal linkages (linkages between internal actors) and external linkages (linkages between internal actors and external actors).

The initial focus was on the densely connected critical mass within a geographical area where multi-level relationships between individuals and organisations offer a great number of channels through which fine-grained information is transmitted from one end to another (Uzzi, 1997). More recent years have seen increasing recognition

of the fact that geographic agglomerations are embedded in global production or innovation networks through external linkages which play an important role in supporting regional innovation (Bathelt et al., 2004). Some empirical studies, for instance, demonstrate that 'gatekeepers' via their external linkages or 'global pipelines' bringing into the critical mass sources of new knowledge (Giuliani & Bell, 2005; Morrison, 2008). Indeed, it is suggested that there are qualitative differences between local and global linkages (Bathelt et al., 2004; Malmberg & Maskell, 2006). In addition, as the localised and distance learning are complementary, it would be optimal for regional agglomerations to blend these two together (Belussi & Sedita, 2012).

It remains unclear, however, 'what an adequate mixture of internal and external linkages would look like' (Brenner et al., 2013: 649). Indeed, network structure of geographic agglomerations remains heavily under-explored in the extant literature (Giuliani & Bell, 2005). An important reason for this is, although scholars pay enormous attention to the relational aspect of 'embeddedness' in understanding network linkages, much less has been given to the structural aspect. A revisit to Granovetter (1992), however, reveals that the original concept of 'embeddedness' emphasises both relational embeddedness and structural embeddedness with the latter referring to the structure of the overall network of relations and the aggregated impact of dyadic relations.

The last few years have seen some efforts in addressing the deficit in understanding network structure of geographic agglomerations. Some studies, for example, explore the role of 'gatekeepers' or 'boundary spanners', because of their advantageous

network position, in acquiring, generating and diffusing knowledge (Giuliani & Bell, 2005; Sapsed et al., 2007; Kauffeld-Monz & Fritsch, 2013). It is further argued that there is unequal distribution of network centrality (the degree to which an actor occupies a central network position) across firms in a geographic agglomeration because of firms' heterogeneous absorptive capabilities and that this explains that knowledge is not diffused evenly within the geographic agglomeration (Ter Wal and Boschma, 2011; Giuliani & Bell, 2005).

Despite this significant progress, the so far limited network structure studies suffer from two major shortcomings. Firstly, most studies focus on dyadic links (Knoben and Oerlemans, 2012; Brenner et al., 2013) but fail to understand the wider network and in particular the overall network of all internal and external linkages where the dyadic links are embedded. As argued in Granovetter (1992), when it comes to structural embeddedness, what matters is the structure of the **overall** network of relations and the **aggregated** impact of dyadic relations. Secondly, most of the extant studies remain static, providing valuable snapshots of network structure and in particular the role of particular actors and advantageous network positions but fail to address how network structure evolves over time (Ter Wal and Boschma, 2009; Buchmann and Pyka, 2013)

As far as our best knowledge can tell, there have not any studies devoting to the structure of the overall network and its evolution. Recognising this gap, the following discussion will elaborate the overall network structure of geographic agglomerations and its evolution, drawing upon literature on economic sociology, economic geography and innovation systems. By doing so, the adequate mixture of internal and

external linkages becomes clearer and so is the role of overall network structure in mediating knowledge flow and innovation and consequently competitiveness of geographic agglomerations..

Overall Network and the Balance between Closure and Range

One of the first steps towards a better understanding of overall network of geographic agglomerations is to recognise that both internal and external linkages are integral parts of the whole innovation system. Therefore examining the overall network of a geographic agglomeration requires investigating the structure of internal and external linkages and the balance between them.

It follows that internal and external networks of a geographic agglomeration have different structural characteristics and therefore different functions and contributions in information transmission and knowledge flow. Because external actors are more likely to be from different geographic places and operate in different social and institutional contexts, it is less likely to find overlapping, multi-level and cohesive relationships in the network of external linkages as in that of internal linkages. This corresponds to the 'closure' (Coleman, 1988) and 'range' (Reagans and McEvily, 2003) arguments in the social network literature. While the former refers to dense networks in which actors are tied to multiple actors who are connected to one another, the latter refers to the extent to which network connections span institutional, organisational, or social boundaries.

It worth emphasising that what matters is not only linkages or relationships per se but also structural patterns of the linkages. Therefore within the internal network of a

given geographic agglomeration, it is the pattern of closure we are likely to observe and it is this network structure that serves efficient information channels, generate trust and norms and provide effective sanctions (Bathelt et al., 2004; Granovetter, 1992). Similarly, within external networks, it is not only the presence of external linkages per se but also their range or diversity that helps to bring in non-redundant and novel information and provides stimulus to prevent the geographic agglomeration from being 'locked-in' (Grabher, 1993).

With regard to the question of the adequate mixture of internal and external linkages, Gargiulo and Rus (2002) contend that the controversy conceals a fundamental difference in the assumption about the type of uncertainty to which closure or range is a solution[1]. The closure perspective implicitly assumes that the primary uncertainty facing actors is how to secure action coordination and joint problem solving. The uncertainty is reduced if actors are embedded in a densely connected network which facilitates fine-grained information exchange and trust generation. The range perspective assumes that the greatest uncertainty is how to economically secure privileged access to relevant knowledge and information. Because network structure with the prevalence of linkages that cross geographic, organisational and social boundaries provides non-redundant information and knowledge, it offers a competitive advantage for actors in the network in pursing their interests.

Yet geographic agglomerations and firms may face both uncertainties. For a given geographic agglomeration, the appropriate network structure would then be a function

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1 Gargiulo and Rus (2002) however do not use the term of range. Rather they talk about diverse networks rich in structural holes, which can be viewed as range.

of the criticality of these two distinct uncertainties. When there is little difficulty in accessing the right knowledge and information but coordination is crucial, closure of internal linkages will provide the mechanism to overcome the problem. On the contrary, when access to the necessary information and knowledge appears to be critical, then range of external linkages will be the solution.

Contingent Factors of the Balance between Closure and Range

It is therefore important to identify the contingent factors of network structure of geographic agglomerations that determine the relative importance of closure and range. Literature suggests that network structure and the balance between closure and range are contingent on 'technological regimes' (Nelson and Winter, 1982) of geographic agglomerations and their life stages which dictate the uncertainties in knowledge access and action coordination and therefore warrant different mixes of closure and range to facilitate development of geographic agglomerations.

Technological regime. According to Winter (1984), firms' innovative performance and industrial development are determined by the technological regime in which they operate, namely the character and functioning of the underlying system of knowledge sources such as sources of technology opportunities, efficiency of patent protection, and extent of difficulty of imitation[2].

The idea is captured in the literature of Sectoral Systems of Innovation (SSI, see Breschi and Malerba, 1997; Malerba, 2002), which further specifies some key

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[2] In their recent work Cooke et al (2011) refer technological regime to 'the norms, institutions, organisations and rules that tend to sustain the dominant technological paradigm' (p1).

dimensions of the knowledge base and learning process related to the notion of technological regimes. These include opportunity, appropriability and cumulativeness. Technology opportunity reflects the likelihood of gaining knowledge that is external to firms. Cumulativeness refers to the degree by which new knowledge builds upon current knowledge or the possibility of innovating along specific trajectories. Appropriability of innovation reflects the possibility of profiting from innovative activities by constraining imitation and other opportunistic behaviour (Malerba, 2002). It is argued that these specificities of knowledge and technological regimes "provide a powerful restriction on the patterns of firms' learning, competencies, behaviours and organisation of innovative and production activities in a sectoral system" (ibid, p.254).

Following a similar vein of argument, one could propose that the specificities of technological regimes condition the environment within which geographic agglomerations and firms operate. Therefore geographic agglomerations, as systems of innovation, could also be seen as being governed by specific conditions of technological opportunity, appropriability of innovation, and knowledge cumulativeness. These specificities of knowledge and technological regimes set the parameters of specific uncertainties in knowledge access and action coordination. The implication is that a geographic agglomeration may be better off with a distinct mix of range and closure but not others.

For example, for a geographic agglomeration characterised by high levels of technological opportunity, knowledge is relatively easy to obtain and the primary uncertainty is in how to secure action coordination. Hence, the geographic agglomeration and firms should endeavour to establish the necessary coordination

mechanism to exploit knowledge. As discussed before, this calls for closure of internal linkages. For a geographic agglomeration characterised by opportunistic behaviour and low level of appropriability of innovation, closure will help to establish norms, common rules, regulations and other institutions, which provide the necessary protection and reduce the uncertainty in action coordination. For a geographic agglomeration with low level of cumulativeness, the possibility of innovating along existing trajectories is low and knowledge critical to the development of the geographic agglomeration is more likely to be found outside the critical mass. The primary uncertainty is in how to get access to relevant knowledge. Therefore the geographic agglomeration would benefit more from range of external linkages, which provide the critical new and novel information from many different alternatives.

Life stage of geographic agglomerations. As market, technology and network relationships all change over time, the criticality of uncertainty in knowledge access and action coordination also varies with time. It is therefore important to consider the time dimension of the development of geographic agglomerations and the evolving match between their network structures and uncertainties they are facing at different times.

The importance of the evolutional dynamics of geographic agglomerations has been picked up by some recent contributions. For example, cluster life cycles were discussed in Bergman (2008) and Menzel & Fornahl (2010) while Belussi & Sedita (2009) examined life cycles in industrial districts. In 2011, Regional Studies even devoted a special issue to studies of cluster life cycle.

Our focus, however, is not cluster life cycle per se, but the application of evolutionary concepts in a network context that emerged only recently. In particular, we echo Ter Wal and Boschma (2011) linking industrial life cycle to network dynamics. Our unique contribution lies with the illustration of how a geographic agglomeration's overall network structure co-evolves with its life cycles.

In line with earlier studies, it is proposed here that geographic agglomerations evolve through three stages: origination, convergence, and reorientation or decline. We contend that each stage represents a unique, strategic context with particular uncertainties in knowledge accession and action coordination, which should be matched by appropriate network structure for a geographic agglomeration to successfully survive and grow.

The origination stage concerns the emergence of the core or anchor firms as the result of successful initial entrepreneurial efforts and the follow up of a few similar firms and suppliers in the same location. As the critical mass has not been achieved, there is no closure yet and therefore no geographic agglomeration in real sense.

At the convergence stage, an agglomeration of firms begins to emerge. A critical mass comes into being and is continually growing. The dense network relationships lead to a high level of information exchange among internal actors of the geographic agglomeration (Bathelt et al., 2004; Maskell, 2001). Face-to-face interaction, the intimacy involved in interaction and the similar 'mental models' (Pouder and St. John, 1996) make the information being exchanged highly interpretable. In addition, the knowledge base of innovative activities is evolving towards a dominant design

(Malerba, 2002; Ter Wal and Boschma, 2011). In other words, knowledge is rather cumulative in the geographic agglomeration and requires little access to new and diverse sources of knowledge (Neffke et al., 2011). Based on past successful experience, "current innovative firms are more likely to innovate in the future in specific technologies and along specific trajectories" (Malerba and Orsennigo, 2000, p.302). In summary, the convergence stage is characterised by high knowledge opportunity and cumulativeness. The prominent uncertainty facing the geographic agglomeration at this stage is how to secure coordination among members to exploit the opportunities derived from the available knowledge, which requires facilitation of closure.

After "long time spans of incremental change and adaptation which elaborate structure, systems, controls, and resources toward increased coalignment" (Tushman and Romanelli, 1985, p.215, in Pouder and St. John, 1996, p.1205), the geographic agglomeration enters into the reorientation or decline stage. The velocity of information exchange among internal actors is still high. However, "as innovation process changes to involve the development of more complex technologies, the production of these technologies requires the support of sophisticated organisational networks that provide key elements or components of the overall technology […] [and] increasingly the components of these networks are situated across a wide array of locations" (Wolfe and Gertler, 2004, p.1077). Therefore, at this stage, closure or the critical mass is neither large nor heterogeneous enough to provide the necessary knowledge and resources for more complex innovation and production. In other words, the level of self-sufficiency or cumulativeness of knowledge is in decline in the geographic agglomeration. In addition, as internal actors tend to stick to

established norms, institutions and 'mental models' (Pouder and St. John, 1996), they become more homogeneous and less sensitive to external stimulus. This would effectively reduce technology opportunities – the likelihood for firms to gain external knowledge becomes lower. In summary, at the reorientation or decline stage, knowledge becomes less cumulative and technology opportunities become fewer in the geographic agglomeration. The main uncertainty therefore shifts to how to secure necessary information and knowledge. The way for geographic agglomerations to rise 'like phoenix from the ashes' is to have a network structure leaning more towards range.

Therefore we propose that network structure co-evolves with the development of geographic agglomerations and the changing uncertainties in knowledge accession and action coordination. As geographic agglomerations move from the origination stage to the convergence stage, they need to strengthen closure to reduce uncertainty in coordination and exploit rich information circulated within the network. As they become matured and show signs of decline, they need to pay special attention to range and diversity of external linkages, in order to get access to relevant knowledge to restructure themselves.

An Analysis Framework of Overall Network Structure in Regional Innovation Policies

The above discussion points to the importance of analysing the overall network structure of geographic agglomerations. The policy implications are: firstly, policies enlightened by regional innovation models need to address structural characteristics of both internal and external linkages and therefore to help geographic agglomerations

nurture closure and range; secondly, policies need to consider structural characteristics of the overall network of geographic agglomerations and in particular strike a balance between closure and range; thirdly, policies need to address how contingent factors such as technological regime and life stages of geographic agglomerations impact on their overall network structure.

It follows that these should also be included in the analysis and evaluation of regional innovation policies. This suggests three levels of overall network structure indicators. The first level would be the consideration of closure and range in policies. The second level concerns whether policies address the balance between closure and range. The third level examines contingent factors of the balance between closure and range, i.e. technological regime and life stages.

These three levels of overall network structure indicators could be examined at each of the major stages of the policy development process which, as Jenkins (1978) suggested, involves initiation, information, decision, implementation and evaluation. An analysis framework of network structure in regional innovation polices could therefore be established as shown in the following table:

Table 1 here

The following discussion will apply the analysis framework to investigate to what extent overall network structure is addressed in one of most popular regional innovation policies - cluster policy. This is explored through a case study of cluster policy in the West Midlands region in the UK with a particular focus on the cluster strategies for the ICT, automotive, and the medical technologies industries.

These three clusters were chosen because together they represent the profile of the industrial base of the West Midlands region. In addition, they are different from each other with regard to their innovation patterns and development stages. This provides an opportunity to examine whether overall network structure was differently addressed in their cluster strategies as the analysis framework suggests.

 The discussion seeks evidence from original policy documents as well as interviews with policy makers and stakeholders. Interview data is taken from the first author's PhD work which examines cluster policy development in the West Midlands with a particular focus on the three industries mentioned earlier. 45 interviews were conducted in the period from the end of 2004 to the autumn of 2005.

Although cluster policy making in the West Midlands and indeed, in England, does not exist anymore, an evaluation of West Midlands cluster policy, as will become apparent towards the end of the paper, clearly demonstrates problems of policy design and implementation based on undertheorised concepts and models which still represents a significant risk for many regional innovation models (Benneworth and Rutten, 2011)

Interestingly, despite the burgeoning literature on cluster policy evaluation (see Schmiedeberg, 2010 for a review of cluster policy evaluation and its methodology) and the increasing recognition of clusters as systems composed of networks, little research has been carried out to evaluate cluster network structures and relations (see, however, Bellandi & Caloffi, 2010 and Pickernell et al., 2009, for two exceptions). In

addition, there still lacks a 'conceptually grounded and easily replicable set of indicators for gauging the current state and future prospects of cluster development' (Arthus et. al., 2009: p265). The danger is that, without sufficient attention paid to the conceptual ground of cluster policy and in particular its 'networking' core, much of the assessment of the impact of clustering or networking can be misleading because of the possible misalignment between the original policy intention and what is assessed.

To address this deficit, the following discussion will slightly modify the overall network structure analysis framework developed earlier and then employ it to evaluate elements of overall network structure in the regional cluster policy in the West Midlands. The modification is regarding the policy process in order to allow the analysis to cover major steps in a cluster policy cycle as some previous cluster policy process analyses suggest (Benneworth and Charles, 2001; Raines, 2000). This is presented in the following table:

Table 2 here

Cluster Policy Development in the West Midlands

Cluster policy was made popular in the English regions by the last Labour government, which, promoting a 'new regionalism' approach to regional development, asked Regional Development Agencies (RDAs) in England to produce a Regional Economic Strategy (RES) for their own regions. In 1998, the Department of Trade and Industry (DTI) advocated the development of clusters to meet the challenges in the knowledge-based economy. In response, AWM, the RDA for the West Midlands

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region in England, published in 2001 its *Agenda for Action (AfA)* - the action plan for its RES - and outlined its cluster policy. Alongside AWM, many other RDAs also took the opportunity to embark on the 'cluster' train and developed their own version of cluster policy. However, the concept of 'clusters', as a fashionable idea, seems to have faded only after a few years of being promoted to the RDAs. AWM, in fact, appeared to be the only RDA that still kept 'clusters' as a key word in its strategy until 2008. All these are in history now as the RDAs were ordered to wound up by the current coalition government that went into power in 2010 and since then no policy making at the regional level in England.

AWM's AfA identified ten clusters on a region-wide basis and grouped them into established clusters, growing clusters and embryonic or aspirational clusters. Subsequently, a range of cluster mapping projects and cluster business needs analyses were conducted and published in 2002. In addition, AWM tried to form a Cluster Opportunity Group (COG) for each of the ten clusters. These were supposed to be business-led groups which bring together 15-20 strong key public and private sector representatives to take forward the cluster agenda. The idea was that, as AWM acts as 'catalyst for change', the strategy responsibility was delegated to the COGs to ensure 'demand-led' and cluster-tailored strategy and action.

In 2004, AWM requested all the COGs to prepare their cluster strategies for the period 2005-2008 which were published in April 2005. The Agency then pledged to spend £50 million on cluster development during 2005-08, supplemented by £13.5 million European Regional Development Fund (AWM, 2005a).

Overall Network Structure in the West Midlands Cluster Policy

Guided by the analysis framework in table 2, the following discussion will examine elements of overall network structure in four important aspects of policymaking including policy objectives, cluster definition, cluster analysis and policy instruments. However, policy evaluation is excluded from the analysis because, at the time of undertaking the field work, evaluation of the regional cluster policy had not been carried out.

Overall Network Structure in Policy Objectives

The then Labour government proposed clusters as a new approach to regional development "putting greater emphasis on growth **within** all regions and strengthening the building blocks for economic success by boosting regional capacity for innovation, enterprise and skills development" (DTI and DfEE, 2001, para.3.3, emphasis added). It was made clear that the focus was to "build on **indigenous** strengths" and "exploit the **indigenous** strengths in each area and region" (HMT and DTI, 2001: p.55-56, emphasis added).

Within the West Midlands, AWM summarised the objective of business clusters as:

> *"To grow the competitive advantage and reputation of the regions in key markets and industries in order to increase our long-term wealth creation capacity. To do this by facilitating businesses in each of our priority clusters to **collaborate ("cluster")** in exploiting strategic opportunities. Also to identify a small number of long-term changes which are necessary for growth in these areas, and to implement projects and initiatives which begin to deliver these changes." (AWM, 2004a, p.68, emphasis added)*

Elements of closure and range. The aim of West Midlands cluster policy was

therefore to promote regional competitiveness by developing regional clusters via networking. However, as clusters were defined as 'regional' (this will be discussed in more detail later), networking and collaboration only referred to those within the region. A senior AWM manager argued that close engagement within the region is what clustering is about and the whole purpose of cluster policy (personal interview). To use the social network language, the regional cluster policy focused on closure within regional clusters.

Guided by this principle of intra-regional networking, various approaches were undertaken in the three case study cluster strategies. It was hoped that through these various techniques, a cohesive regional cluster community or closure, would be established, which would generate 'strategic opportunities'. The objective of developing closure was explicit, for example, in the automotive cluster strategy:

> "Embedding OEMs and Tier 1 companies **within** the region;
> […]
> Promoting **regional cohesion** within the sector;
> Building relationships with key companies **within** the region" (AWM, 2005c, p.9. emphasis added)

In contrast to the focus on internal linkages and things within the region, little attention was paid to external linkages. Certainly AWM did not mention external linkages at all in its declared cluster policy objective; neither did it show any appreciation of range or structural characteristics of external linkages.

Some policy makers ascribed the reason for the lack of emphasis on external linkages to the embryonic status of the ICT cluster in the region, but that hardly explains the case for the automotive cluster which is mature and has long been embedded in the global value chain. It is indeed surprising to see the automotive cluster strategy

concentrated so much on internal linkages but so little on external linkages.

The overall network structure and the balance between closure and range. Apart from insufficient appreciation of the strategic importance of external linkages and range, there are further questions concerning network structure in the regional cluster policy. In particular, it seems that policy makers did not give thorough consideration to the structural characteristics of the overall cluster network. Because of the lack of recognition that internal and external linkages have different roles and functions in knowledge creation and diffusion, there was little appreciation among policy makers of the necessity of striking a balance between internal and external linkages or more specifically between closure and range.

Interviews with AWM managers revealed that they were not sure how to address cluster network structure. Partly because of this, the Agency left the question of networking with the COGs. However, there is little evidence that the automotive, ICT and medical technologies cluster strategies addressed overall network structure of clusters. Many COG members admitted that the structure issue was not in their mind when they developed their strategies which focused on internal linkages. The majority of them admitted that they did not consider the structure of cluster networks when they developed cluster strategies.

Elements of Contingent Factors. With regard to the contingent factors of overall network structure, i.e. technological regime and cluster life stage, it was difficult to discuss these with policy makers, as the majority of them did not even start to consider the structure of internal and external linkages and their balance. However, there was some general understanding of the difference between clusters and the fact that they have different development stages. AWM stated that "different degrees of support, groups of organisations and approaches will be needed for each cluster" (AWM, 2001, p.13). Probably this is the reason that the agency categorised priority clusters into three different groups: established, growing and embryonic. However, as policy makers failed to examine clusters from the network structure perspective, it was not possible for them to consider the contingent factors for cluster network structure. Indeed, the authors found few signs that policy makers dealt with issues such as the impact of technological regime and cluster life stages on cluster network structure and the implication for cluster dynamics.

Overall Network Structure in Cluster Definition

It is clear that cluster policies in the UK were highly influenced by the work of Michael Porter. The early research commissioned by the DTI to guide cluster development in English regions, for example, all firmly adopted Porter's definition of regional clusters:

> "(clusters are) geographic concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries, and associated institutions (for example universities, standards agencies, and trade associations) in particular fields that compete but also co-operate." (Ecotec, 2003, p.4; Trends Business Research, 2001, p.6)

Apparently, the reason that policy makers adopted the regional cluster view corresponds to the objectives of cluster policy. As discussed before, cluster policy was

adopted as a tool to boost regional capacity in order to realise their growth potential and therefore contribute to national competitiveness.

Once national policy makers adopted the regional cluster view, there was not much RDAs could do but follow. AWM, for example, followed the same Poterian definition of clusters as mentioned above. In its original RES, AWM said clusters are "groups of companies and organisations in related industries that have economic links because they buy and sell from each other, or because they use the same skills and infrastructure in a local area" (AWM, 1999, p.8). The agency stated that, "the essence of a cluster is some linkage and togetherness between the firms and a sense in which the cluster is firmly located in a place" (AWM, 2001, p.12). Obviously what AWM emphasised is geographic proximity and linkages 'in a local area'. The geographic proximity was later extended as regional wide and AWM, in various policy documents, tried to persuade people that clusters were not restricted to specific sub-regions but could be region-wide and therefore to provide rationale for its regional clusters (AWM, 2001, 2004b).

As a result, clusters were defined as regional wide, drawing upon actors across the region that did not necessarily have strong linkages between them. This indicates that policy makers overlooked the nature of networking linkages between cluster actors and their importance to cluster development. Thus, very often various firms and organisations were grouped together and defined as a cluster while the quality and structure of the linkages between them were neglected. Without appreciation of cluster network structure, the regional cluster policy was not able to address some of

the important issues of cluster development such as external linkages, range and the balance between closure and range.

Indeed, what is implicit in AWM's cluster definition is the exclusive emphasis of geographic proximity and internal linkages (in the sense of being in the same region). This indicates that promoting closure within the region was the focus of the regional cluster policy, while external linkages were not in AWM's consideration. In fact, the Porter definition of clusters that AWM adopted does not mention external linkages at all. Neither does it reflect any understanding of the balance between closure and range and the contingent factors. This had a knock-on effect on the subsequent cluster analyses, in which external linkages were almost completely absent.

Overall Network Structure in Cluster Analysis

Given the priority on closure, it would not be surprising to observe that the cluster analysis concentrated on what was happening within the region but not much on that outside. This is evident, for example, in the Medical Technologies cluster mapping study which tried to profile the medical technology cluster only drawing upon companies within the region without any companies outside the region being included. The study also included a Porterian analysis of the medical technology cluster 'in the region', applying Porter's diamond model and examining factor conditions, firm strategy, structure and rivalry, demand conditions, related and supporting industries and government policy. However, the Porterian analysis was again confined to what the region hosted and what happened within the region. For example, in its analysis of factor conditions, the study reviewed the research capability of the universities and

NHS as well as supply of skilled labour within the region. It also analysed supporting industries in the region such as professional services, specialist materials and precision engineering. In contrast, there was no similar review of the support that the cluster could obtain from outside the region.

The study did have a section dedicated to cluster dynamics and linkages and found out that medical firms in the region interacted more with hospitals and the NHS outside the region than with those in the region. However, these external linkages were not considered as components of the cluster network. Therefore in the study there was no assessment of the overall cluster network and in particular external linkages, for example their nature, quality and structure.

The ICT cluster analysis also focused on things within the West Midlands region:

> "Key to this (cluster) concept is the positive 'spill-over' effects companies confer on others when they operate **in an area**, leading to the view that clustering leads to industry competitiveness and economic growth **within a locality**." (SQW, 2003, p.10, emphasis added)

Clearly what the report emphasised was the positive effect arising from geographic proximity, while the effects of linkages with distant actors in unlocking clusters from the 'lock-in' situation and in providing novel knowledge were overlooked. In addition, the cluster behaviour being analysed focused on networking activity between regional actors. For example, in the medical and ICT cluster analyses, firms were surveyed to rate the importance or strength of their links with universities, competitors, customers and suppliers outside the region. However, there were no attempts to investigate, at the cluster level, the nature and structure of these external linkages, their geographic spread and diversity and their role in knowledge creation and diffusion in the cluster.

The same regional focus could be found in the automotive cluster analysis (MacNeill et al., 2004). This report also applied Porter's 'diamond model' as an analysis framework. However, similar to the Medical Technologies cluster mapping study, the SWOT (strengths, weaknesses, opportunities and threats) exercise in the automotive cluster analysis also concentrated on things within the region and therefore provides an inventory of major automotive assemblers, producers in each of the main component groups in the region, capital resources and skilled labour the region hosts, and knowledge resources with regard to research infrastructure in universities and other research organisations that the region accommodates. Again, those external to the region including competitors, suppliers, capital resources, skills and universities and research organisations, were absent from the analysis. One of the few exceptions was the mentioning of several national government initiatives.

Looking across the three cluster analyses, a common feature is their predominant focus on what happens within the region while external linkages were treated as peripheral at best. In particular, there lacked critical assessment of external linkages. Thus, range, or the structure of external linkages, was not addressed by the three cluster analyses. Without adequate information of external linkages and range, the overall cluster network structure, the balance between closure and range, and the contingent factors to the structure were absent from the investigation.

Overall Network Structure in Policy Instruments

As mentioned earlier, there was no explicit overall regional cluster strategy in the West Midlands as AWM left the development of cluster policy to the individual

COGs. The analysis here therefore focuses on policy instruments in the automotive, medical technologies and ICT cluster plans but also includes some actions AWM itself had planned that were pertinent to the ten individual cluster strategies.

Adapting Raines' (2002) typology, we categorise all the cluster policy instruments into four types for thorough examination:

community-building: which is to encourage interaction between cluster members, engender common interest, and develop the cluster's identity and image;

projects and linkages: which target specific groups of firms and organisations networked for common purposes;

common resources: where the policy provides common services or shared facilities;

external linkages building: unlike the three types above which targets the internal cluster community, this type of instruments is to establish linkages with external actors for innovation, knowledge transfer, trade and inward investment.

The fourth type, external linkages building, is added to Raines' (2002) typology because, although the focus of the regional cluster policy was on promoting internal linkages, some elements of external linkages did exist. Most previous cluster policy analyses tend to overlook external linkages (He, 2007). They are however, at the core of the inquiry of this paper.

Elements of closure and range. Previous analysis has demonstrated the focus on closure and internal linkages in the policy objective, cluster definition and cluster analysis. It is hardly surprising that policy instruments also concentrated on encouraging closure and intra-regional networking. Therefore, projects for community building meant to build the community of regional clusters; projects for common resources referred to resource sharing among regional actors; specific linkages and

projects aimed at collaboration between regional actors. In other words, support for networking was exclusive to actors within the West Midlands region.

The West Mildlands ICT Hub project in the ICT cluster strategy illustrates this well. The project was designed to help participants of six existing cluster programmes to work closer together and to develop 'a single point of reference for information on ICT in the West Midlands' (AWM, 2005b). This could be seen as an effort to join existing sub-regional groups together who are not connected previously and therefore to build a wider regional ICT community, i.e. an ICT closure in the region. The MidTech project in the Medical Technologies cluster strategy is another example. The project was to expand the remit and capacity of MidTech, one of the regional innovation hubs established by the Department of Health to identify and commercialise innovative ideas within the NHS, to act as the regional signposting agency for NHS innovation and to act synergistically with Medilink West Midlands, a life science industry association in the region, to provide a single regional point of contact for NHS related enquiries. It is therefore effectively a common resource shared by companies in the region who are interested in NHS innovation. Again it is an effort of building a regional medical technologies closure by linking regional companies with the NHS in the region.

As the principle of the regional cluster policy was to build closure of regional clusters, actors outside the West Midlands region were excluded from the networking initiatives funded by AWM. Therefore, an automotive component supplier on the border with the East Midlands region would not be treated as a community member if it were not in the West Midlands, even if it was very close to the region and the

majority of its customers were in the West Midlands. It would therefore be excluded from the projects that facilitated resource sharing and collaboration between regional actors.

Obviously external linkages were not given sufficient weight in the regional cluster policy. However, it appears that some elements of external linkages did exist. AWM, for example, had plans to develop a cluster-geared regional inward investment strategy and international trade cluster plans that aimed to link the regional firms with the global business. In addition, the Agency had collaboration with South East, East of England and the East Midlands on the motor sport development, and with the East Midlands on the aerospace sector. Moreover, the automotive cluster strategy was to build a Midlands strategic collaboration, which reflected the need to engage some actors in the East Midlands such as Toyota and its supply chain and Loughborough University.

Despite a few projects of forging external linkages mentioned above, there was little effort in the regional cluster policy in building range, while the social network literature suggests that forming external linkages per se is not the point, but building range that crosses geographic, organisational and social boundaries.

Indeed, the scope and depth of building external linkages was rather limited in the regional cluster policy. We only managed to find a few policy instruments that had some connection with external linkages and most of them were not operational at the time of the case study. Moreover, most of these external linkage projects were about trade and investment. In contrast, little was said about how to encourage R&D

collaboration with relevant firms or research organisations outside the region, neither how to exploit knowledge resources in universities in other regions, nor how to acquire the skills the region may not be able to offer.

Elements of network structure and contingent factors. Previous discussion has confirmed the lack of recognition among policy makers of the fact that internal and external linkages have different roles and functions in knowledge creation and diffusion. It has also illustrated the absence of appreciation of the importance for cluster policy to address overall network structure and contingent factors. These have been reflected in the policy objectives and the definition of clusters as well as cluster analyses in the development of West Midlands cluster policy. Not surprisingly, little evidence was found in the policy instruments that addresses the overall cluster network structure and its contingent factors.

Conclusions

Drawing upon a wide literature, this paper develops an analysis framework which identifies a series of indicators in order to assess overall network structure in regional innovation policies. Applying the analysis framework to the West Midlands, it shows that the regional cluster policy has a huge deficit in addressing overall network structure which is summarised in the following table:

Table 3 here

To some extent, this deficit is striking, as there was a good part of literature emphasising external linkages. In addition, cluster policy had been pursued in other parts of the world for some years and, presumably, some lessons had been learned. Moreover, some policy makers seemed to understand the importance of forging external linkages to the development of the regional automotive, ICT, and medical technological industries, although the degree of urgency might be different. Furthermore, if embryonic status is the reason for the ICT and medical cluster strategies to be constrained to an intra-regional focus, it cannot explain why the automotive cluster strategy was also weak in addressing external linkages and range, as the industry is mature and global and needs external knowledge input.

All these beg the question as to why there was such a network structure deficit in the regional cluster policy. Burfitt & MacNeill (2008) indicate that applying a 'fuzzy' concept such as cluster is inevitably problematic in the 'congested state' with multi-level and multi-actor governance frameworks. What is highlighted in this paper is the weakness in the theoretical underpinnings of policy making particularly regarding overall network structure.

We suspect this was, to a large extent, also the case with other regional innovation policies in many other regions as regional innovation models, despite their differences, share a common weakness in addressing overall network and its structural characteristics. The contributions of this article are twofold. Theoretically, it establishes a more systematic understanding of network structure of geographic agglomerations by revisiting the theoretical roots of the key concepts of 'embeddedness' and 'networks'. Emphasising the study of overall network structure

of geographic agglomerations, this paper points to the importance of range – the structure of external linkages, the balance between closure and range, and the co-evolution between the overall network structure and geographic agglomerations' technological regimes and life stages. Methodologically this article contributes to the evaluation of regional innovation policies by developing an analysis framework of overall network structure. Overall, this article highlights the need for more grounded theory and more conceptually grounded policy making in regional economic development.

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