TRANSFORMATIVE TECHNOLOGY AND THE CALGARY WIRELESS CLUSTER: AN OPEN SYSTEMS PERSPECTIVE.

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Abstract
The Calgary wireless cluster is defined by its thick labour market and specialized expertise in high technology engineering and design. It is involved in "transformative technologies" (Langford et al., 2002). That is, technologies that are created out of a global knowledge base and integrated on a local scale. This depiction of the Calgary wireless cluster challenges the much-favoured 'Porterian' diamond (1990) model which suggests that encouraging competition in a local industry between members in similar and related industries will improve national competitive advantage. In the local context, innovation is not driven by competition. Rather, local collaboration and mobility within the labour force facilitates innovation in niche markets to encourage global competition.

This paper compares attributes of the Calgary wireless cluster in the case study with traditional models in the literature. Dominant thinking about clusters suggests that they operate in a closed system, that is, that clusters are driven locally and operate in relation to a local context and a set of political and economic circumstances. This model is incomplete for clusters involved in transformative technologies since inputs and outputs flow globally. This paper proposes that clusters involved in global high technology need to be studied as open systems affected by several interacting factors. An appropriate model for this purpose is Phillip's (2002) "knowledge entrepot model." If the term cluster is to be useful to policy makers then an analysis that includes an understanding for how knowledge is used and disseminated in global industries is crucial.

Key Words: Open clusters, Transformative technology, Knowledge flows

Background

This paper stems from thesis research conducted on the Calgary wireless cluster as part of the Innovation Systems Research Network (ISRN) major collaborative research initiative.[1] The Calgary wireless cluster study prepares a body of work that clearly captures a regional and local condition that can be further utilized in comparing other regional studies within the ISRN project (Wood, 2004). Seventy interviews were conducted and analyzed using qualitative data analysis and grounded theory methodology. This research was performed in conjunction with the Masters degree requirements of the participating ISRN graduate student. Selected findings and discussions are presented here as they relate to and build on data analysis in the graduate student thesis.

Introduction

The depiction of the Calgary wireless cluster challenges the much-favoured Porterian (1990) diamond approach which suggests that encouraging competition in a local industry between members in similar and related industries will improve national competitive advantage. Porter argues that firms that are "geographically localised" or "clustered" can contribute to the overall economic success of a nation if they focus on four key factors of competition (firm strategy; structure and rivalry; factor input conditions; demand conditions; and related and supporting industries). By defining clusters in terms of firms and local economic dynamics, Porter sets up specific boundaries for examining clusters. These boundaries preserve the cluster as a regionally

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[1] More details on the ISRN network, its members, and the current cluster studies can be found at: http://www.utoronto.ca/isrn.

closed system. That is, it is an entity which may be planned and driven by an internal dynamic (Hughes, 1983). National and regional economic dynamics however are insufficient for studying clusters with transformative technologies that hinge on global interaction, local integration and innovation.

This paper explains the term cluster as defined in mainstream scholarly models and contrasts it with evidence from research on the Calgary wireless cluster. This paper argues that in an emerging industry social networks rather than firm-to-firm competition can drive the innovative capacity of a cluster. These networks function as open systems that link stakeholders outside of regional boundaries. The networks are tightly knit at the local level which help disseminate knowledge and information and encourage innovation. Regional or national borders do not confine high technology industries.

Based on the research from the Calgary wireless cluster this paper proposes that clusters involved in global high technology need to be studied as open systems affected by several interacting factors and subject to change. An appropriate model for this purpose is Phillip's (2002) "knowledge entrepot model." Phillips' contends that rather than studying the cluster in terms of localized impacts, high technology clusters can be studied similar to that of a traditional trade entrepot model where most of the inputs are imported; there is local value added; and semi-finished products are exported into a world market. As such, Phillips is less concerned with regional geographic borders and economics and highlights that clusters can be defined by following knowledge, talent, products and services that flow in and out of a local base.

If the term cluster is to be useful to policy makers then an analysis that includes an understanding for how clusters are differentiated, particularly those involved in global high technology, is crucial.

Clusters

Clusters are phenomena of study contested in the literature. Michael Porter (1990) spurred several debates in this area after the introduction of his text *The Competitive Advantage of Nations* where he argued that national innovation strategies should be devised through a regional or cluster approach and discussed in terms of factors important to competition. Porter's (1990) diamond approach has likely been the most influential in discussions of clusters and competitive advantage. Porter maintains that firms in clusters can contribute to the overall economic success of a nation by focusing of four factors of competition; firm strategy, structure and rivalry, input conditions such as key suppliers, demand conditions such as demanding customers and related and supporting industries. Porter (1998) maintains that the factors in the diamond approach are mutually influential and occur in a local context that encourages local competition and appropriate forms of investment and upgrading.

Since Porter, there have been several studies on clusters and several are underway to try and determine what factors are important for economic growth in clusters. Five major themes emerged from a review of the literature: competitive advantage (discussed above); regionalism and boundaries; knowledge flows, labour and learning; culture; and path dependence and policy.

The boundaries of a cluster are seen as important factors in determining cluster activities however ascertaining the boundaries of a cluster is a major problem for scholars in cluster research. Gulbrandsen (1997) suggests looking at administrative borders to define a region in terms of relations to university and infrastructure. This approach allows the study of clusters from a triple helix perspective where university-government-industry interactions define the search space. Porter (1990) and others have suggested that defining boundaries is important for facilitating local collaborations that could lead to new innovations.

Clusters have also been discussed as playing a role in knowledge transfer and creation (Wolfe, 2002). Some of the main ideas coming out of this theme are that knowledge is created out of collaborative activities, rivalry, and the mobility and informal relations among individuals (Malmberg & Power, 2003).

In recent years there has been a focus on the role of culture in clusters. Saxenian's (1994) research and analysis of the Silicon Valley and Route 128 technology clusters points out that differences between regional economies must be understood by viewing firms as an integral part of the institutions and social structures from which they arise. She contends that it is the informal and cultural relations that exist in these social structures that are the key to collective learning and communication (Ibid.). Likewise, Richard Florida (2000) maintains that cultural norms, values and processes in clusters play a role in defining a

regional economy through the attraction of people. A high quality of life and a diverse cultural scene have been discussed as key factors in the development of a given milieu.

Lastly, clusters have been discussed in terms of path dependence such that historical events shape the context of a given cluster. The historical roots from which clusters emerge are an important aspect in defining a given trajectory and localization of a cluster (Malmberg & Maskell 2001). Government decisions can play a role in defining that trajectory via policies and initiatives that can impact the favourability (or otherwise) of a cluster (Phillips, 2002). Porter (1998) asserts that governments have perhaps the greatest stake in regional developments since they are ultimately responsible for improving and promoting the well being of citizens and productivity particularly in given geographic regions. The government must come to understand what sort of role is required in certain areas. For example a minimalist government might be required in some areas such as trade barriers and pricing, while in other areas the government might be required to play a more active role such as in education and training etc. (Ibid.). The decisions a government makes with respect to cluster development will ultimately impact cluster trajectory.

Transformative clusters: open versus closed systems

While the five major themes outlined above are important for cluster maintenance and growth, a local thematic analysis is insufficient for studying clusters involved in transformative technology where inputs and outputs flow globally. Traditional models suggest that clusters operate in what Hughes (1983) calls a "closed system". That is,

systems that may be planned and driven by an internal dynamic. He states, "some systems are planned to their full extent, while others grow by increments and by confluence with other systems over time" (1983, p. 6). Hughes suggests that closed systems tend to be governed by some mechanism of control in order to achieve a desired output. The output is therefore driven by a variety of technical, scientific, economic, political, and social forces that are likely manageable.

Relating Hughes notion of closed systems to clusters would indicate that clusters are driven and managed locally and operate in relation to a local set of political and economic circumstances. While it is true that clusters will be affected and influenced by local conditions, they are not necessarily controlled or managed at the local level. Empirical research by Nadvi (1995) for example points out that the role of government in cluster development will be varied and that government intervention in order to create clusters is unlikely (p.3).[2] That is, clusters will emerge out of their own independent geographic and social specificities. It is unlikely that a government or other initiative to build clusters will result in favourable outcomes (Ibid.).

In the case of high technology or transformative clusters that operate in a global sphere factors for cluster growth must be considered in terms of an "open system" (Hughes, 1984). That is, to think of the cluster as a system that can be affected by multiple environments and several interacting factors that are subject to change resulting from

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[2] Nadvi gives an in depth comparison of five cluster studies conducted for the United Nations Industrial Development Organization (UNIDO); The Brazilian shoe cluster in Sinos Valley; The Mexican shoe cluster in Guadalajara and Leon; The Indian cotton knitwear cluster in Tiruppur; the Indian high technology industrial networks in Bangalore; and the South Korean Chaebol networks.

global market forces. An appropriate model for this purpose is Phillip's (2002) "knowledge entrepot model." Phillips' contends that rather than studying the cluster in terms of localized impacts, high technology clusters can be studied similar to that of a traditional trade entrepot model where most of the inputs are imported; there is local value added; and semi-finished products are exported into a world market.

In his case study Phillips argues that the canola biotechnology cluster in Saskatoon is a "regional entrepot" where basic knowledge and proprietary technologies are imported, combined with new crop variations (add value), which are then exported globally (p. 32). As such, Phillips is less concerned with regional geographic borders and highlights that cluster boundaries can be defined by following knowledge, talent, products and services that flow in and out of the local base. [3]

Phillip's claims that knowledge and talent flows via extensive networks linking firms to collaborators, competitors, private companies, and government research institutions both locally and globally. These linkages facilitate talent and resource exploitation via local value added tacit knowledge flows. Phillips notes that local resources such as talent and knowledge (tacit or codified) add value to the creation of intermediate products which are then exported to a global market (Ibid.). In addition, his work underscores ideas of path dependence and local and global flows of talent and knowledge in clusters.

In transformative clusters local analysis is insufficient. Current developments and the future for wireless in Calgary hinge on global knowledge integration and reconfiguration

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[3] See also Langford, Wood and Phillips, (2002).

since inputs and outputs flow globally. Malmberg & Power's (2003) strategy to identify particular attributes of clusters in order to understand what kinds of interactions are at play is useful here. Some of the attributes of the Calgary wireless cluster are outlined below. By studying attribute data using Phillips model an open systems approach to examining clusters emerges.

The Calgary wireless cluster: an open system

The Calgary wireless cluster is defined by its thick labour market and specialized expertise in high technology engineering and design. It is involved in "transformative technologies" (Langford et al., 2002). That is, technologies that are created out of a global knowledge base and integrated on a local scale. Innovation trajectories are defined by access to this knowledge base through extensive social networks linking research institutions, government infrastructure, and industry. In the local context, innovation is not driven by competition. Rather, local collaboration and mobility within the labour force facilitates innovation in niche markets to encourage global competition. Success hinges on access to a global knowledge base, integration of that knowledge at the local level, and its redistribution in different and or new forms. The local cluster is an access point for knowledge and communication in an open global network of knowledge flow (Wood, 2004).

Without a doubt the talent in the cluster, identified as a skilled pool of expertise, is a fundamental attribute and driver in Calgary's development. Interviewees were unanimous in the view that the key attractor in Calgary is the presence of a talent pool in wireless

technologies. In all aspects of the research (i.e. organization background; strategy; networking, relationships with suppliers, customers and competitors; location and infrastructural factors; the role of research institutions and technology transfer centres; local cluster characteristics and social capital; and future perceptions), the talent pool was the main topic of discussion. Richard Florida (2000) suggests that factors involved in attracting and maintaining a regional talent base depend on a certain acceptance of diversity within a region in addition to a thick job market and a high quality of life. Certainly the character of the Calgary cluster resembles Florida's depiction. An interviewee pointed out that people do not move to this region for "a" particular job but for the availability of multiple jobs in their field. This finding is consistent with contemporary research by Glaeser (2000) who points out that access to a skilled labour market is a primary factor in holding together a "regional agglomeration" (p. 85). When firms were asked why they chose to locate in Calgary and what advantages Calgary held in terms of running a business, the first response was that Calgary has a highly skilled talent pool and a high quality of life.

The talent pool is identified as the primary factor for innovation in the Calgary wireless cluster working as a mobile force to encourage innovation through the exploitation of informal networks. These features are traceable through interpersonal networks where social relations tend towards the informal. An emerging cluster shows how personal networks and informal business communication may lead to formal business partnerships, strategic relationships and mentoring (Langford et al., 2003). Furthermore, the role of the research institutions and infrastructure has come to play a critical role in

the Calgary wireless cluster. Perhaps their greatest contribution to the cluster's growth has been the continuous output and supply of talented graduates.

Malmberg and Maskell (2000) point out that often clusters localize as a result of a historical development. This is surely the case for Calgary where the wireless cluster developed out of the mature oil and gas industry. Strong firms backed by the government played an active role in recruiting talent early on and key events such as the NovAtel divestiture in the early 1990's led to the dispersion of that talent throughout the city and was ultimately a key factor in spinning out new business ventures (Langford et al., 2003). The Calgary scene became a highly differentiated market space with several small start-ups and medium sized firms competing for a different niche.

At the firm level, Calgary is seen as a favourable business location with low overall costs and a positive political climate for business. Thus, what has emerged is a constellation of firms enjoying rich knowledge flows, largely mediated "on foot" or in conversation among close associates, that permits efficient import of technology and science from the global knowledge system, its efficient configuration to create new knowledge (Gibbons et al., 1994: Mode 2) and add value, then successful export of product to a world market.

Tacit knowledge flows between institutions, industry and government in the region defined by socio-cultural norms and values give rise to the creation of innovative ideas that are traced through a highly mobile talent pool and various company spin outs.[4] More

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[4] See Langford et al., (2003) and Wood (2004) for detailed relationship maps on the Calgary wireless cluster.

importantly, the firms and institutions that work collaboratively recruit ideas and talent from a worldwide knowledge base. This global reach allows for the introduction of new ideas into a local system. Knowledge flows are therefore difficult to track but by following people and studying the cluster as a system, tacit knowledge is identified flowing among people, universities, government industries, organizations and other cluster members. The outcome is a localized core with global reach.

The Calgary wireless cluster currently resembles Phillips' (2002) knowledge entrepot model where the boundaries are defined by following talent, products, inputs, and knowledge flows. The Calgary wireless cluster is characterized as a local industry with extensive global reach. Home-grown expertise fostered by extensive education, training programs, and mentorship between individuals is key to the sustainability of the region. However knowledge and talent for the industry are also imported from a no less than global base. Calgary imports basic science and technology and important players function as "system integrators" who add value and then market products worldwide.

Discussion

This depiction of the Calgary wireless cluster is different from the dominant Porter (1990) diamond model of clusters that emphasizes geographic proximity to input and demand conditions as important to competitive advantage. The Calgary wireless cluster deviates from this model in three important ways. First, local competition is not a factor in cluster growth due to a highly differentiated market. Little local rivalry and competition were found in the Calgary wireless cluster. Instead, informal friendly networks and collaboration characterize local activity. In fact most participants had

trouble identifying local competition but referred to collaborative activities such as "co-opetition" where stakeholders tend to partner for technological developments and then exploit those developments within different niche markets. Competitive advantage does not stem from intense local rivalry and competition as in the Porter model, but rather from informal and friendly networks that lend themselves to easy communication between different market segments. Tacit knowledge flows between these groups encourages communication in a differentiated environment (Mode 2: Gibbons et al., 1994) and is therefore more similar to Phillip's (2002) knowledge entrepot model.

Second, collaborative rather than strong demanding local customers were identified as important to innovation. Likewise relations with suppliers are important. Cooperative relationships play a key role in fostering new ideas and developing new products and services however customer and supplier location is not a critical factor in sustaining business in a global market.

Third, Porter (1990) and others have suggested that defining boundaries is important for facilitating local collaborations that could lead to new innovations. The boundaries of the Calgary wireless cluster are open. There is plenty of local collaboration however global input is fundamental in the innovation process. Rather than defining geographic or administrative borders, the Calgary cluster pushes borders back such that international collaborations, granted via social networks, can lead to knowledge diffusion and innovation.

The cluster is therefore similar to the knowledge entrepot model and is defined by following talent, knowledge flows, inputs, and outputs. This group of expertise is highly mobile and industry knowledge is transferred via "interlocking" or interpersonal social networks. New knowledge is brought into the cluster via network actors with diverse connections outside the local base. These network actors function as "weak links" in niche local and global markets.

Conclusions

Research on the Calgary cluster indicates that in an emerging industry attributes such as social networks knowledge flow, collaboration and access to a global knowledge base is what drives the innovative capacity of a cluster. These networks function as open systems that link outside of regional boundaries. They are tightly knit at the local level which helps disseminate information and encourage innovation. The ability of social networks to drive innovative capacity depends on the successful importation of new ideas and the ability to transform those ideas into marketable products and processes.

Informal communication patterns are the main form of social interaction in the Calgary wireless cluster. The innovative capacity of a cluster is therefore dependent on communication in social networks needed to diffuse new knowledge. This fact is only part of the innovative dimension. As has been shown, innovation also hinges on the complexities of a social, economic, political, cultural and technical system. These features are mutually and recursively connected and therefore cannot be studied independently.

By studying attribute data and using Phillip's knowledge entrepot model for interrogating cluster activity we are able to redefine the borders of high technology clusters and the conditions for innovation. Given that high technology clusters are based on innovation and change we recognize that these clusters may not be controlled or managed locally. By following the talent, social networks and collaborative activity, the Calgary wireless cluster challenges dominant thinking of the closed localized cluster and places emerging technology clusters in an open and global context. Research on the Calgary wireless cluster refutes some of the mainstream claims made about innovation in clusters and conforms more towards Phillips notions of the knowledge entrepot model. Calgary imports basic science and technology and important players function as "system integrators" who add value and then market products worldwide.

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