The Creation and Growth of ICT Based Industrial Clusters

The New Zealand Case

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Abstract

This paper provides an exploratory review of current global research on industrial clusters, and seeks to identify the key success components of these clusters. It then discusses these attributes in terms of their implication for New Zealand ICT industrial clusters. It is argued that by reviewing the success attributes underpinning industrial clusters a baseline can be established for decision-making in both the commercial activities of industry vertical groups, as well as local/central government economic policy formulation. The paper identifies the key success factors as the presence of large pillar firms that intact with strong local demand via a sophisticated work force, effective catalytic networks across all firms and local research resources, attention to emerging technologies and focus on global markets.

Introduction – What is a Cluster?

Defining a cluster is not easy. Some key elements from numerous descriptions of clusters, suggest that clusters are by nature; (i) usually concentration in small geographic locations, which facilitates close face-to-face communications between the constituents of the cluster; (ii) centred on a particular industry vertical, with close links to related or complementary product, service and research organisations; and (iii) tightly integrated and networked across social, economic and knowledge perspectives.

An important element in these descriptions is that of the geographic proximity, or territorial contiguity, which facilitates interaction and exchanges (Rullani 2001) between cluster constitutes of interconnected companies and institutions in a particular field (Porter 1998), and supports the processes of collective learning and flexible adjustment to changed conditions (Saxenian 1996).

This geographic focus proposes that a cluster is a localised network that uses the territory to provide the means for division of labour and the dissemination of successful ideas (Rullani 2001), and where the richness of the face-to-face human interactions supports the exchange of more subtle forms of information i.e. diffuse and tacit knowledge (Bathelt et al 2002). In contrast, geographic-independent networks (translocal networks) must build collaboration processes, communication systems and

assurance systems to link companies together (Rullani 2001). Implications for the New Zealand ICT industry in both clusters and networks are discussed at the end of this paper.

Key Success Attributes of Hi-Tech Clusters

From an extensive review of extant literature it is argued that the key success components (KSCs) for ICT clusters fall under three categories; **core cluster, emerging innovation and globalisation**. It is proposed that a combination of the all three is required to allow an industrial cluster to form, grow and adapt in dynamic world markets. In subsequent sections this literature is reviewed and an argument presented justifying this proposition. Table 1 lists the components of the core cluster category. These components are discussed in subsequent sections.

Core Cluster

Table 1: Components of the core cluster category

Core Cluster Category	
Success Component	**Literature Reviewed**
Large Pillar Firm Presence)	(Athreye 2001, Bathelt et al 2002, Richards 2001, Dearlove 2001
Local Demand	(Athreye 2001, Saxenian 1994, Rosenfeld et al 2002, Richards 2001, Bathelt et al 2002, Knuckey and Johnston 2002)
Key Agents/Social Networks	(Athreye 2001, Andersen and Teubal 1999, Walshok et al 2002, Rosenfeld et al 2002, Bathelt et al 2002)
Local Company Linkages	(Athreye 2001, Andersen and Teubal 1999, Richards 2001, Dearlove 2001)
Regional Specialisation	(Athreye 2001, Rosenfeld et al 2002, Bathelt et al 2002)
Local Academic Linkages	(Athreye 2001, Bathelt et al 2002, Richards 2001, Dearlove 2001, Rosenfeld et al 2002)
Sophisticated Workforce	(Walshok et al 2002, Rosenfeld et al., 2002, Sommers 2003, Richards 2001)
Management Skills	(Knuckey and Johnston 2002)
Buzz	(Andersen and Teubal 1999, Bathelt et al., 2002, Cooper 1989, Haug 1991, Galbraith 1985, Athreye 2001)
Global Pipelines	(Rosenfeld et al., 2002, Bathelt et al 2002, Richards 2001, Bresnahan et al 2002)

Large Pillar Firms

Silicon Valley had Fairchild Semiconductors (Saxenian 1994), Cambridge had Acorn Computers (Athreye 2001), Oulu, Finland has Nokia (Richards 2001) and Christchurch has Tait Electronics. All of these firms were central to the beginnings of their respective clusters and from their rank and file came the genesis for the myriad of start-ups and support firms that continued to grow around them. All of these firms are also examples of local firms becoming the global players that built the necessary scale to recruit and develop talent, create local funding, and attract the attention of complementers in neighbouring segments (Richards 2001).

Other researchers (Bathelt et al, 2002; Dearlove 2001) also support the important role of these 'pillar' companies in the establishment of clusters. However, in the case of the Scandinavian Wireless Cluster, Dearlove (2001) proposes that companies such as Nokia and Ericsson are not products of the Scandinavian clusters; rather they were established before the mobile/wireless cluster formed.

However, it is proposed that a fundamental success component in the development of any cluster is the presence of large pillar firms focusing on the emerging technologies and supported by strong local market (Richards 2001). Whether they are the initial companies of the new cluster, or established companies in a different market that then reposition themselves into the emerging industry vertical (Nokia from rubber to mobile technologies), the result is the same.

Local Demand

Before a company can execute on a global basis, it must be able to 'interact' with local demand. This interaction provides the basis for translating technical innovation into commercial success, and it is often easier to interact with demand if it is local (Richards 2001).

Using the New Zealand example, Tait Electronics was supported by the large local demand for radio-based communications due to geographic distances in a largely agrarian economy. In the Nordic Wireless cluster the initial success of both Ericsson and Nokia was boosted by the European Union decision to standardise the vendor agnostic mobile standard of GSM. This gave them access to and interaction with the large and growing demand pools of the GSM wireless market in Europe in the 1990s and drove widespread local deployment of wireless technology in Europe (Richards 2001). This continued in-depth interaction by large firms with the local market provides the basis for continued product innovation and creates a "virtuous cycle" of funding, innovation, and global marketplace success that is characterizes a mature cluster (Richards 2001, Andersen and Teubal 1999).

An antithesis to this impact of local demand is the Cambridge cluster and Acorn Computers. Starting with strong local (UK) demand for personal computers, Acorn and the Cambridge cluster grew dramatically, but then slowed and declined due to reduced local demand through an atrophied

industrial base (UK) and poor standards of living (Saxenian 1988). All of these factors eventually lead to the Cambridge computer cluster being swamped by larger US based PC companies exporting from their strong local US markets of the US (Athreye 2001).

Key Agents, Social Networks and Local Company Linkages

Across all the research a strong link was found between the emergence of successful clusters and the activities of a few entrepreneurs and industry 'personalities'. Typically these individuals came from the large pillar firms at the heart of the cluster, or from various research or academic institutions closely connected with these firms via educational and consulting activities.

In the 1986 study of the Cambridge Cluster by Segal, Quince and Wicksteed (SQW), approximately two thirds of the hi-tech businesses (244 out of a known 355 firms) were interconnected, with an overwhelmingly large proportion of founders of new firms coming from local firms (Athreye 2001). Walshok et al (2002) also noted one of three critical success factors seen in a study of the San Diego hi-technology cluster was the character and extent of 'catalytic' business and financial networks, with the individuals in these networks being responsible for starting up new ventures, providing advice and mentoring to other company owners and creating venture capital funds (Athreye 2001, Saxenian 1994). Notably, these individuals are generally few in numbers, but highly visible to the large majority of cluster stakeholders and are catalyst for regional powerhouses (Dearlove 2001).

Regional Specialisation

This combination of large firms, local demand and catalytic networks of key agents operating within a geographic territory gives rise to regional specialisation. This is significant to the role of central government in cluster development as the goal of cluster strategy is not to have communities compete for the same types of clusters ie an electronics cluster in Canterbury, Wellington and Auckland. Rather, it is to determine which clusters make sense for which communities (or regions) (Rosenfeld et al., 2002).

Therefore, when reviewing which industries should be considered by a local or central government for cluster facilitation, research should be undertaken on the basis of local demand, which larger pillar firms are already present and the strength of the catalytic networks of industry personalities and entrepreneurs are. This may require more refined market segmentation within a region to obtain an appropriate differentiation, or vertical industry mass, for example, multimedia and creative digital arts in Wellington, and electronics/software operating systems in Canterbury. By creating an appropriate differentiation, these clusters of firms can develop knowledge far beyond the reach of any single member of that group, and create a demand for specialized services and support (Bathelt et al., 2002)

Academic Linkages

Another core success factor in these regional clusters is the presence, and more importantly, the close linkages, between academic institutions and successful clusters firms. However, it should be noted that it is the research centre of activities and specialised educational programmes designed to meet the needs of the local cluster, that have the most impact, rather than links to general University administrations and standard degree programmes (Saxenian 1994).

For example, in the Cambridge cluster there has been a prominent growth of industry-university linkages and in particular the involvement of Cambridge College alumni and the establishment of specific research centres or institutions (Athreye 2001). These linkages have also provided frequent interaction between Cambridge University and local firms via collaborative projects and University staff acting as consultants to local firms (Athreye 2001). Silicon Valley also benefited from close ties between local industry and Stanford University and the University of California at Berkley, both of which developed industry-focused training programmes and research collaboration. In contrast, Boston's Route 128 electronics cluster and MIT were much slower to develop programmes of these types. Resulting in both Stanford and Berkley training close to twice as many doctoral degrees students as MIT by the mid 1970's (Saxenian 1994).

Sophisticated Work Force

This tight integration between the regional specialisation, its training and educational requirements and a responsive academic institution gives rise to the organic growth of a deep and highly skilled local workforce. In the case of the San Diego hi-technology cluster one of three critical success factors was the breadth and depth of the advanced skills and knowledge of the human capital (Walshok et al., 2002). Numerous studies have demonstrated that technology-based businesses do well in states (regions) with education systems that stress science and engineering at all levels, resulting in a strong and technologically sophisticated work force (Sommers 2003). An important consideration in the development of this sophisticated workforce is the availability of customised and specialized educations and training that produces and upgrades skills and knowledge (Rosenfeld et al., 2002).

This requires that academics integrate into the catalytic networks of company founders and business builders within the cluster, and become intimately involved with both the large pillar firms, as well as the myriad of cluster start-ups. As in the case of Silicon Valley, the success of these large firms also created both the funding and local skilled labour (technical and managerial) for the emergence of entrepreneurial culture and start-ups (Richards 2001)

Management Skills

New Zealand based research such as the ICT Taskforce report and *Firm Foundations: A Study of New Zealand Business Practices and Performance* (Knuckey and Johnston 2002), point to the lack of both management and commercialisation skills within the ICT sector. In the ICT Taskforce report, lack of management and internationalisation skills was identified as a key roadblock to growth in the New Zealand economy, while *Firm Foundations* proposed that the focus of New Zealand firms is short-to medium term, which appears to be related to the scale of most enterprises and reliance on one or a few people to both lead and manage the business (Knuckey and Johnston 2002).

In contrast, Nokia success in the wireless space attests to their possessing significant managerial experience and global networks (from their rubber production operations) which may have provided a more stable base with which to enter the new wireless market. They had the managerial talent required to grow Nokia into a successful businesses on world markets by successfully executing old-fashioned firm-building and business unit strategy, focusing on emergent markets and allocating resources necessary to become global leaders in their chosen space (Richards 2001)

'Buzz'

Ultimately the concentration in a geographic region of all these core success factors (large pillar firm presence, local demand, key agents/social networks, local company linkages, regional, specialization, local academic linkages, sophisticated work force and management skills) leads to the development of 'industrial atmosphere', (Marshall 1927), or 'Buzz' (Bathelt 2002), defined as being something that is 'in the air', limited to the people within a particular region or place.

Buzz, and its existence has been proposed as a major contributor to cluster growth and success, and by its very nature, is regionally based not national. Indeed it is the cluster environment that creates the buzz. To quote Bathelt (2002):

> *Buzz refers to the information and information ecology created by face-to-face contacts, co-presence and co-location of people and firms within the same industry and place or region … The nature of buzz is spontaneous and fluid, as co-presence within the same economic and social context generates manifold opportunities for personal meetings and communications … It is argued that the coexistence of high levels of 'buzz' and the many pipelines may provide firms located in outward looking and lively clusters with a string of particular advantages not available to outsiders …*

Global Pipelines

In their work on a Community College Approach to Cluster-Based Workforce Development Rosenfeld et al, suggested that one of the key principles underlying successful cluster programs is to act collaboratively and connect externally (Rosenfeld et al., 2002).

Bathelt et al (2002) also argued that the coexistence of high levels of 'buzz' and many pipelines may provide firms located in outward looking and lively clusters with a string of particular advantages not available to outsiders. These 'global pipelines' between the regional cluster and other relevant hot spots around the globe (Bathelt et al. 2002) provide the means of speeding up the process of turning new technological innovations into competitive products (Richards 2001).

Owen-Smith and Powell (2002) use the term 'pipeline' to refer to the channel used in distant interactions. They have shown in the case of the Boston biotechnology industry that access to new knowledge does not just result from local and regional interaction but is often acquired through strategic partnerships and inter-regional and international reach. Boston's biotechnology firms are thus not only embedded in regional innovation networks but also in social networks that are not defined geographically (Bathelt et al, 2002) Another example of global pipelines is both Nokia and Ericsson establishing R&D centres in key US wireless locations to bring their R&D teams closer to the pools of large local demand.

These global connections between firms and individuals from a particular cluster also has a feedback benefit to the cluster as a whole as the more developed the pipelines between clusters and distant sites of knowledge become, the higher quality (and value) of local buzz benefiting all forms in the local cluster. This is why a firm will learn more if its neighbouring firms in the cluster are globally well connected instead of being more in-ward looking and insular in their orientation (Bathelt et al., 2002). These global pipelines are impacted significantly by the functionality of collaboration and communication technologies, suggesting the rising impact of translocal networks in both assisting and competing with regional clusters.

The second core category is emerging innovation. The components of the category are listed in Table 2 and each is subsequently discussed in more detail.

Emerging Innovation

Table 2: Components of the emerging innovation category

Emerging Innovation	
Success Component	**Literature Reviewed**
Emerging Technology and Standards	(Athreye 2001, Bresnahan et al 2002, Richards 2001, Knuckey and Johnston 2002, Terziovski et al 2001)
Innovation, Research and Development	(Sommers 2003, Walshok t al 2002, Athreye 2001, Knuckey and Johnston 2002, Dearlove 2001, Richards 2001)
Venture Capital	(Sommers 2003, Athreye 2001)

Emerging Technology and Standards

The existence of a new technology or standards can also have dramatic effects on the sustained growth and adaptability of a cluster, as it can thrive by focusing on niches that are not covered by leaders (Richards 2001). The establishment of new technologies can be driven by policy initiatives of central governments and this should be considered when formulating strategies for the development of ICT clusters. For example, the EU using public policy to define standards (GSM) that produced European winners of Nokia and Ericsson in 3G technologies (Richards 2001).

However, public policy alone cannot produce standards or clusters. As Richards (2001) points out the critical point of the GSM standard that produced the Scandinavian success was the presence of multiple competitors and the fact that the GSM standard was not defined with the technological bets of any particular incumbent in mind (Richards 2001) This position of policy also points towards a success component of implementing an industry niche focus, to obtain differentiation, rather than a broad ICT grouping. In the New Zealand case we should carefully consider the respective 'niche' plays of our regions ie electronics in Christchurch, creative in Wellington, before establishing any broad based ICT cluster in Auckland.

Innovation, Research and Development

The continued success of industrial clusters is closely coupled with emerging technologies, start-up firms and the presence of cutting-edge research facilities and top educational institutions that provide a basis for innovation (Dearlove 2001). Numerous studies have demonstrated that technology-based businesses do well in regions with dynamic research programs yielding commercialisable technology ideas (Sommers 2003), and as these industry clusters continue to grow the role of the research

institutions will deepen and broaden to encompass workforce development and training as well as technology transfer (Walshok et al., 2002).

As proposed in 'Local Demand' above, the close interaction with local markets can drive a "virtuous cycle" of funding and innovation. For example, one of Nokia's key strengths has been the ability to rapidly turn technological progress into rapid product innovation – and in particular products that are met with immediate and widespread consumer adoption (Richards 2001)

However, in the case of New Zealand, innovation and its supporting R&D processes, appear to be less emphasized as a strategy (Knuckey and Johnston 2002). This may be due to the large number of smaller (less sophisticated) firms in the markets, or the result of limited local demand for the products produced due to the absolute size of the New Zealand market place. In either case it is the close linkage between emerging technologies, local demand and tight integration between individual firm and research facilities, or members of social networks connected with the research institution e.g. Alumni from Cambridge Colleges (Athreye 2001) that drive firms to more sophisticated innovation processes.

In the author's opinion, New Zealand should focus on innovations in niche markets that have local demand, and then extend these niche markets overseas. In fact, Knuckey and Johnston (2002) propose that more sophisticated strategies are needed for New Zealand firms to be internationally competitive (whether competing in New Zealand or overseas) and it would be desirable to see more New Zealand businesses incorporating innovation and flexibility into their strategies.

Venture Capital

The combination of vertical industry mass, strong local demand, knowledge linkages to local research facilities and strong catalytic social networks due to very close geographic proximity, creates a gravity around the cluster that continues to attract more industry organisations, associated input suppliers (such as venture capital and support services organisations) and skilled workers to a geographic region.

Numerous studies have demonstrated that technology-based businesses do well in states (regions) with a history of entrepreneurialism and financial capacity to support technology start-ups (Sommers 2003).

In the case of Silicon Valley, many of the initial entrepreneurs from Fairchild and Intel went on to set up specific venture capital funds within the cluster (Saxenian 1994). A notable feature of the Cambridge Cluster was the involvement of employees from Cambridge firms, and sometimes entrepreneurs from earlier generations in managing venture capital funds that have flowed into Cambridge (Athreye).

The third core category is globalisation. The components of the category are listed in Table 3 and each is subsequently discussed in more detail.

Globalisation

Table 3: Components of the globalisation category

Globalisation	
Success Component	**Literature Reviewed**
Clustering Policies and Programmes	(Andersen and Teubal 1999, Athreye 2001, Bresnahan et al 2002, Walshok et al 2002, Rosenfeld et al 2002, Wallsten 2001, Andersen and Teubal 1999, Richards 2001)
International Expansion	(Athreye 2001, Richards 2001)

Clustering Policies and Programmes

In their work on *Cluster Formation in the New Silicon Valley*, Bresnahan et al (2002) propose that the forces underlying the emergence of a cluster differ from those needed to insure its continued growth. They suggest that while increasing returns and external effects can keep a cluster going, the initial spark is more difficult to obtain and more risky to pursue, and requires significant efforts by the "pioneers" of the cluster to promote organizational and technological capabilities of various sorts and create new firms and institutions.

Andersen and Teubal (1999) also suggest that there are key differences in requirements between Cluster Creation or Emergence, Cluster Operation and Cluster Reconfiguration and propose that continued success of a cluster is also dependant on its ability to 'reconfigure' or restructure itself based on response to environmental factors and competition. This requires not only initiatives from the initial innovators and entrepreneurs (advanced firms), but also effort from the wider cluster firms and supporting suppliers and service providers. Despite strong capabilities these advanced firms cannot complete their (cluster) restructuring without the help of a technology infrastructure (housed in a newly created technology centre). Therefore, these advanced firms will put pressure on government and help to plan the creation of such a centre (Andersen and Teubal 1999).

An alternative to the concept of a technology centre is that of the endogenous emergence of a key sector which may emerge from vertical disintegration and innovation (which exploits an innovation from an advanced firm), and which in turn is stimulated by the generic nature of the new technologies (Andersen and Teubal 1999).

Considering the rising importance of both local catalytic and translocal networks it is proposed that cluster programmes should be focused on providing the 'glue' that connects both advanced firms, start ups, wider cluster firms and supporting suppliers and service providers, with research and development centres, as well as providing specific 'processes' for linking academic institutions into these firms to better understand any skills shortages and training requirements. This process should be highly responsive and focused on measurable outcomes that benefit the wider regional cluster, not just specific firms or institutions. Hiscocks (2004) also refers to this linking process and uses the term "join-ed-ness" to describe Cambridge Enterprises' role and strategy in the Cambridge Cluster.

However, cluster policies should include more explicit institutional components, than network creation polices; and changes in the systems of governance of non-business institutions and organisations. Neither incentives nor new institutions can, at first glance, be dispensed with; the role of incentives is not to promote a particular activity but rather to learn about such an activity (Andersen and Teubal 1999).

International Expansion

While trends towards globalisation of industries and companies might appear to reduce the importance and distinctiveness of (sub-national) regions, a tendency towards localisation of certain industries and economic activities appears to do exactly the opposite (Enright & Roberts 2001). The ICT industry in particular is impacted by these changes as product can be transmitted around the global at literally the speed of light.

Therefore, unless New Zealand firms compete in the world markets, they will face competition from the world (????!!!), and due to the absolute size of the New Zealand markets this focus must be in niche vertical market applications that show strong local demand and innovation. As proposed by Porter (year, p.) "Paradoxically, the enduring competitive advantage in a global economy lies increasingly in local things - knowledge, relationships, and motivation that distant rivals cannot match".

India and Ireland have had mixed success – on the one hand building strong services and localization capabilities yet on the other hand less successful in building globally branded firms capable of capturing significant producer rents (revenues) (Richards 2001). Similarly, Cambridge did not 'globalise' to the same degree as Silicon Valley, due to the inability of Cambridge firms to capture global markets in any one product or technology space due to their in ability to cope with competition from the USA (which had a strong local demand) and also a lack of good marketing and management skills (Athreye 2001)

Implications for New Zealand

A cluster is a territorial contiguity, which facilitates interaction and exchanges across interconnected companies and institutions in a particular field and supports the processes of collective learning and flexible adjustment to changing market conditions. In contrast, geographic-independent networks (translocal networks) must build collaboration processes, communication systems and assurance systems to link companies together (Rullani 2001).

By this very dependence on technology, translocal networks lose some of the ability to provide the solid foundation for innovation and stability in dynamic markets that is created by constant face-to-face contacts, co-presence and co-location of people and firms within the same territory (Bathelt et al 2002). However, as the richness of these 'collaboration' technologies increases global competition between clusters and networks will also increase, as translocal networks have the advantage of being able to multiply the frequency and opportunities of experience by linking different locations and cultures (Rullani 2001). The ramifications for New Zealand are significant, as it is the clusters of small-to-medium ICT enterprises in the Auckland, Wellington and Christchurch regions that provide a basis for world class innovation, but it may be the establishment of translocal networks with other relevant groups globally that will provide a means to overcome the challenges of the "tyranny of distance" prevalent in the New Zealand situation.

The first step has been taken in this paper to understand the success components, the next is to build these differentiated regional clusters around pillar firms with strong local demand, and to ensure the establishment of personal linkages (catalytic networks) between individuals in the firms of the clusters with the individuals in the regional research institutions, business building programmes, service providers and funding operators. This process is not about building new programmes, rather it is the continual focus on the acts of communication and collaboration to glue together, or 'join-up-ness' cluster constitutes.

New Zealand may well face increased competition from off-shore clusters and networks and research should be undertaken that investigates the impact of these translocal networks on regional clusters. Therefore, we need to understand how the impact of increasing sophisticated models of management for networked, or virtual organizations, coupled with the use of rich collaboration technologies, can provide the means for New Zealand clusters of 'territorial contiguity' to connect to the world markets.

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