# 4 Technology Clusters

*"The new industries are brainy industries and so-called knowledge workers tend to like to be near other people who are the same."*

EVAN DAVIS (1962– )

**Chapter contents:**

- Introduction
- Clusters and Knowledge Flows
- Mobility within clusters
- Conclusions

## 4.1 Introduction

Sticky knowledge (Lagendijk, 2000, p. 165) or knowledge accumulations (Florida, 2002; Storper and Venables, 2002), according to Oliver and Porta (2006), constitute the available intellectual capital (IC) sources of a cluster. Sticky knowledge is described as the knowledge embedded in the local industrial milieu which is difficult to copy or transfer to other areas (Oliver and Porta, 2006). Furthermore, sharing knowledge involves firms with a community of workers in a cluster (Harrison, 1991). IC arises from knowledge creation through linkages between firms (knowledge spillovers), firms and institutions, and informal relationships arising from an interaction process in a local skilled labour pool. Knowledge in the cluster is tacit, embedded and transferred within the cluster (Oliver and Porta, 2006).

For the transfer of knowledge within a cluster three mechanisms identified by Keeble and Wilkinson (1999) include new firms, spin-offs from firms, universities and public sector research laboratories, interactions between the makers and users of capital equipment, interactions between customers and suppliers, and inter-firm mobility of the labour in the cluster. The relationships and mechanisms create flows within the cluster and the knowledge transfer processes result in cumulative know-how that is external to firms remaining internal to the cluster (Oliver and Porta, 2006). Empirical evidence has shown how knowledge sustainability (expenditure on education), regional economic outputs (earnings and labour productivity), knowledge capital (patents and R&D) and human capital (high tech employment) components have influenced regional competitiveness (Porter, 1990). Economic productive activities are enabled by tacit knowledge, the contribution of local businesses and infrastructures such as research institutes and universities, by employee exchange and the mobilisation of human capital resources (Oliver and Porta, 2006). According to the resource-based view of the firm (Penrose, 1959; Peteraf, 1993) the competitive advantage of companies arises from the core competences or knowledge of firms.

The community of people is an important element of a cluster (Harrison, 1991). Indeed, Porter's (1990) model included the skilled labour pool involving territorial human resources specialisation in clusters. Representing a cluster resource, the skilled labour pool is available to cluster firms (people educated on specific cluster university courses and trained through educational programmes in cluster requirements) (Oliver and Porta, 2006). In addition to training and education there are the social capital aspects associated with tacit knowledge and information flows attributable to directors, managers and workers in cluster companies (Uzzi, 1996). It has been reported by Dahl and Pedersen (2004) that in clusters knowledge flows take place through informal contacts. The local labour pool will contain the available pool of entrepreneurship, competences, education and traditional crafts (Oliver and Porta, 2006). But absorptive capacity is needed to capture, use and disseminate knowledge within the cluster (Zahra and George, 2002).

The movement of labour in technology-based clusters is investigated in this chapter. Labour mobility and knowledge spillovers in clusters are interrelated phenomena with knowledge embodied in entrepreneurs and specialised workers spilling over from one enterprise to another through labour mobility and direct revelation (Guarino and Tedeschi, 2006). The mobility rate of labour in clusters is considered with reference to the growth of clusters. Through the study of the mobility of labour the value of intellectual capital (IC) in the cluster can be considered (Oliver and Porta, 2006).

## 4.2 Clusters and Knowledge Flows

How embedded knowledge flows through labour mobility in regional clusters in Denmark was investigated by Dahl (2002, p. 3) who defined a cluster as "a geographically concentrated group of firms active in similar or closely connected technologies and industries with a degree of both horizontal and vertical linkages". He goes on to note that firms are inter-connected through the formation of a local labour market and that this is for a particular kind of labour. Furthermore, with regard to knowledge clusters and the specialisation of technological and economic activities resulting from agglomeration economies, the local labour force is specialised (Marshall, 1890; Piore and Sable, 1984; Krugman 1991(a); (b); Arthur, 1994; Saxenian, 1994; Porter 1998). In the area of the market suited to the companies in the cluster the growth of the cluster creates an increased demand for labour (Dahl, 2002). Feldman (2000) notes that job moves by workers between companies in an industry is influenced by ideas that are embedded in individuals' minds. Such moves allow the accumulated knowledge of the workers during their careers with companies to be taken advantage of by employers. As a result knowledge flows through the movement of workers between companies, and when start ups offer jobs (Dahl, 2002).

Accumulated experiences from parent companies allows start ups to have knowledge diffusion which has been shown to be important in a number of industries (Franco and Filson, 2000; Klepper, 2002). Reasons why workers move within a cluster include existing social ties and risk aversion (Breschi and Lissoni, 2001). Similar companies in a cluster offer workers wider employment prospects and companies will pay higher salaries for needed knowledge from a previous employee of a similar company. The social and institutional context is important (Breshi and Lissoni, 2001). Employee mobility needs to be supported by the innovation culture involving not only the company but the community (Angel, 1991). Knowledge flows between companies will be greater where the culture and institutional setting of the cluster promote mobility (Dahl, 2002).

In order to climb the occupational ladder through job mobility requires a change of employer. Hall and Kasten (1976) show that for most job changes there is a move to a higher occupational category involving higher pay. The work of Saxenian (1990; 1994) includes many examples of mobility and inter-firm knowledge flows. But there is only indirect evidence on the link between employee mobility and knowledge flows from the literature (Rosenkopf and Almeida, 2001). One of the first empirical studies to delve further into knowledge spillovers was Zucker and Darby (1996) who found that workers had the skills and knowledge for technological development through the embodiment of ideas. In biotechnology case studies the star scientists (who had made major breakthroughs) drew on their intellectual capital in the innovation process. The knowledge on breakthrough techniques was held by these scientists.

It was found by Zucker, Darby and Brewer (1998) that there were clear linkages between the start-up of biotech firms and star scientists. Further investigation of these aspects was undertaken by Alemeida and Kogut (1997) who used patent data to track the inter-firm moves of the star engineering scientists to trace knowledge and idea diffusion in the semiconductor industry and showed that inter firm mobility enabled the transfer of ideas between companies with subsequent new patents through the star scientists. Franco and Filson (2000) focused on the mobility of employees creating spin offs which diffused knowledge. Patent citation analysis of the semiconductor industry was used by Rosenkopf and Almeida (2001) to study the way in which the search for new knowledge in companies through mobility and alliances was undertaken. They found clear evidence that companies used mobility to fill holes in knowledge (Rosenkopf and Almeida, 2001) which clearly supports inter firm mobility of workers facilitating inter company knowledge flow.

In the latter period of cluster development it was reported by Dahl (2002) that there was entry by multinational firms. Lorenzen and Mahnke (2002) found acquisition of small firms by multinationals resulting in the local business environment changing. It was also found that social networking was discouraged by multinationals which focused on inter company networks (Lorenzen and Mahnke, 2002). This resulted in knowledge diffusion through networks and co-operation decreasing and knowledge diffusion through worker movement subsiding (Dahl, 2002).

Dahl (2002) noted that there can be mobile and non mobile engineers. It was found that mobile engineers were paid more for their acquisition of knowledge and in job learning than non mobile employees. New companies paid them more than they earned at previous companies because of the knowledge they brought. It has also been found that there is a positive impact of education since a longer education increases the ability to learn and absorb knowledge (Dahl, 2002). Furthermore, mobility appears to have a positive effect on earnings growth. Whether an employee has a degree, masters or PhD affects annual earnings (Dahl, 2002).

## 4.3 Mobility within clusters

The mobility of highly qualified labour in a cluster is an important vehicle for knowledge flow and indicators of the movement that takes place can help the investigation of important linkages. Mobility indicators can be used to determine the effects of the movement of labour on the development of the cluster. A parameter that can be used as an indicator of the potential in a knowledge based cluster is the stock of knowledge and the rate of mobility of labour can be used to indicate innovation potential. Information investigated includes gender, age, education and employment at a particular time and can be used to compare the stock of labour with different types of education across a cluster and describe the flow of labour between companies within the cluster. Higher education institutions (HEIs) and research institutes play an important role in the education and development of the workforce within a cluster. The mobility of highly educated labour is probably the most apparent mechanism of knowledge transfer. Mobility may take place without knowledge transfer and similarly knowledge transfer can take place without the mobility of labour. For example, information and communication technology (ICT) enables knowledge transfer without the physical movement of labour. In addition to the mobility of labour other knowledge transfer mechanisms include buyer-supplier relationships, co-operations, networks, R&D collaborations, staff placements and temporary staff exchange. Further indicators are the number of co-operations and external contacts, joint patents and citations and co-authorships. There is particular interest in the importance of senior labour as a vehicle for knowledge transfer. It has been found that PhD mobility appears to be a weak knowledge transfer mechanism (Stenberg et al, 1996).

The mobility of senior labour between companies indicates the basic assumption of knowledge transfer. This depends on the ability and opportunity of the labour to learn from the company in which they are employed and on their education and time in employment which are variables that are available for analysis. Also, the occupation and position of senior labour within an organisation influences their learning. Mobility can be considered to be a change of workplace, organisation or company. Knowledge exists in a number of forms including codified knowledge, competencies, formal knowledge, skills and tacit knowledge. The indicator that has been taken to denote the level of knowledge has been formal education. Formal education has advantages over indicators of other forms of knowledge which have data that are difficult to collect and collate. Although the highest level of formal education achieved has limitations as a knowledge indicator it is the most appropriate available. Senior staff will tend to be highly educated (including those with research degrees) with a high degree of specialisation. Here indicators of formal knowledge should be an acceptable knowledge indicator.

Mobility of senior staff will involve both permanent employment and the temporary exchange of labour. There will also be higher and lower mobility exhibited by companies involving both 'movers' and 'stayers' (Graversen et al, 2002). Mobility will arise due to takeovers and acquisitions and it will also result from the entry and exit of companies into a cluster and where firms go out of business or are restructured they will change their identity. This impacts on the definition of mobility in terms of what is 'real' mobility and what is 'artificial' or 'false' mobility caused by change of company ownership in the cluster. As well as change in employment as a focus for knowledge transfer, involving labour transferring knowledge from their previous to their current workplace, there is also the turnover of labour in firms arising from employees leaving and retiring resulting in the employment of new staff from other companies, the unemployed or recent graduates. These employees will contribute to the renewal and flow of knowledge through new knowledge being brought into the company.

The senior labour's field with formal education will be of interest due to potential innovation power – this assumes that labour with high education have a higher level of innovative knowledge than those with intermediate or low education levels. The exchange of labour not only brings new knowledge into companies but also results in the loss of knowledge and the right balance is a major challenge for human resource departments in companies.

It is apparent for companies that 'job to job' mobility involves 'in flows' and 'out flows'. Those workers who have accumulated experience for one company may be viewed as valuable labour for another and will be considered to be experienced workers. If they change employers frequently they can be considered to be 'experienced nomads' (Graversen et al, 2002). On the other hand, inexperienced workers who have a tendency to move are 'inexperienced nomads' and will be recently educated seeking appropriate employment (Graversen et al, 2002). The loss of experienced workers will be considered to be more serious than the loss of those recently employed. Furthermore, senior labour that stays with the same employer will be considered to be stable workers. It has been found that the share of stable workers increases with age and the share of mobile workers decreases with age (Graversen et al, 2002).

## 4.4 Conclusions

With a local technology cluster a local production network exists around companies. An extensive knowledge network will be built around the firms facilitated by senior staff movement between them. Competition within the group is intense and formal collaboration rare, and international concerns and relationships are of importance resulting in well developed global production facilities, suppliers, customers, partners and competitors, and contradictions exist between perceptions of members and the reality of linkages within the cluster. A cluster may be local to a region but part of a wider international industry cluster with simultaneous importance of local cluster effects and extensive international links. In the early days of a local technology cluster, most firms may be associated with a particular technology, but as the industry matures all of the major players can employ a range of technologies in their products. As a consequence of maturity the focus shifts from technical development to marketing and distribution of the product.

### Recommended Reading

Stam, E., Garnsey, E. and Thomas, B. (2009) Competence creation in the Cambridge Inkjet Printing Industry, *25th EGOS Colloquium, Passion for creativity and innovation*, ESADE Business School, Barcelona, July 2–4, 166.

Garnsey, E., Thomas, B. and Stam, E. (2009) *The Emergence and Development of the Cambridge Ink Jet Printing Industry*, Centre for Technology Management Working Paper, No. 2009/4, Institute for Manufacturing, University of Cambridge, pp. 1–30.

Garnsey, E., Stam, E. and Thomas, B. (2010) The emergence and development of the Cambridge ink jet printing industry, in Fornahl, D., Henn, S. and Menzel, M-P. (eds.) *Chapter 11, Emerging Clusters: Theoretical, Empirical and Political Perspectives on the Initial Stage of Cluster Evolution*, Cheltenham: Edward Elgar, pp. 265–291.

## References

Almeida, P. and Kogut, B. (1997) The Exploration of Technological Diversity and the Geographic Localization of Innovation, *Small Business Economics*, 9, pp. 21–31.

Angel, D.P. (1991) High Technology Agglomeration and the Labour Market: The Case of Silicon Valley, *Environment Planning*, 23, pp. 1501–1516.

Arthur, W.B. (1994) *Increasing Returns and Path Dependence in the Economy*, University of Michigan Press, Stanford.

Breschi, S. and Lissoni, F. (2001) Knowledge Spillovers and Local Innovation Systems: A Critical Survey, *Industrial and Corporate Change*, 19(4), pp. 975–1005.

Dahl, M.S. (2002) Embedded Knowledge Flows through Labour Mobility in Regional Clusters in Denmark, Paper presented at the *DRIUD Summer Conference on "Industrial Dynamics of the New and Old Economy – who is embracing whom?"*, Copenhagen/Elsinore 6–8 June.

Dahl, M.S. and Pedersen, C.O.R. (2004) Knowledge flows through informal contacts in industrial clusters: myth or reality? *Research Policy*, 33, pp. 1637–1686.

Feldman, M.P. (2000) Location and Innovation: The New Economic Georgraphy of Innovation, Spillovers and Agglomeration, in Clark, G.L., Feldman, M.P. and Gertler, M.S. (eds.) *The Oxford Handbook of Economic Geography*, Oxford University Press, Oxford.

Florida, R. (2002) *The Rise of the Creative Class*, Basic Books, New York, NY.

Franco, A.M. and Filson, D. (2000) Knowledge Diffusion through Employee Mobility, Research Department staff Report, No. 272, Federal Reserve Bank of Minneapolis, Minneapolis.

Graversen, E.K., Nas, S.O., Ekeland, A., Bugge, M.M., Svanfeldt, C. and Akerblom, M., *Knowledge transfer by labour mobility in the Nordic countries*, Working Paper 2002/1, The Danish Institute for Studies in Research and Research Policy, Aahus, Denmark.

Guarino, A. and Tedeschi, P. (2006) *Endogenous Knowledge Spillovers and Labour Mobility in Industrial Clusters*, Department of Economics and ELSE, University College, London.

Hall, R. and Karsten, R. (1976) Occupational Mobility and the Distribution of Occupational Success Among Young Men, *American Economic Review*, 66(2), pp. 309–315.

Harrison, B. (1991) Industrial districts: old wine in new bottles? *Regional Studies*, 26, pp. 469–483.

Keeble, D. and Wilkinson, F. (1999) Collective learning and knowledge development in the evolution of regional clusters of high technology SMEs in Europe, *Regional Studies*, 33, pp. 295–303.

Klepper, S. (2002) The Evolution of the U.S. Automobile Industry and Detroit as its Capital, paper presented at the *DRUID Winter Conference*, 17–19 January, Rebild, Aalborg, Denmark.

Krugman, P. (1991a) *Geography and Trade*, MIT Press, Cambridge, Massachusetts.

Krugman, P. (1991b) Increasing Returns and Economic Geography, *Journal of Political Economy*, 99(3), pp. 483–499.

Lagendijk, A. (2000) Learning in non-core regions: towards intelligent clusters. Addressing business and regional needs, in Boekema, F., Morgan, K., Bakkers, S. and Rutten, R. (eds.) Knowledge, *Innovation and Economic Growth: The Theory and Practice of Learning Regions*, Edward Elgar, Cheltenham, pp. 165–191.

Lindgren, U. and Eriksson, R. (2007) Cluster Mobility – Impacts of Inter-Firm Labour Mobility on Firm Performance, Paper presented at the *Regional Studies Association International Conference: Regions in Focus?*, Lisbon, Portugal, 2–5 April.

Lorenzen, M. and Mahnke, V. (2002) *Global strategy and the acquisition of local knowledge: how MNCs enter regional knowledge systems*, Copenhagen Business School, Copenhagen.

Marshall, A. (1890) *Principles of Economics*, Macmillan, London.

Oliver, J.L.H. and Porta, J.I.D. (2006) How to measure IC in clusters: empirical evidence, *Journal of Intellectual Capital*, 7(3), pp. 354–380.

Penrose, E. (1959) *The Theory of Growth of the Firm*, John Wiley & Sons, New York, NY.

Peteraf, M. (1993) The cornerstones of competitive advantage: a resource-based view, *Strategic Management Journal*, 14, pp. 179–191.

Piore, M. and Sabel, C. (1984) *The Second Industrial Divide*, Basic Books, New York.

Porter, M.E. (1990) *The Competitive Advantage of Nations*, The Free Press, New York, NY.

Porter, M.E. (1998) *On Competition*, Harvard Business School Press, Boston.

Rosenkopf, L. and Almeida, P. (2001) *Overcoming Local Search through Alliances and Mobility*, University of Pennsylvania and Georgetown University, Georgetown, Pennsylvania.

Saxenian, A. (1990) Regional Networks and the Resurgence of Silicon Valley, California *Management Review*, 33(1), pp. 39–112.

Saxenian, A. (1994) *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Harvard University Press, Cambridge, MA.

Stenberg, L., Gustafsson, E. and Marklund, G. (1996) Use of human resource data for analysis of the structure and dynamics of the Swedish innovation system, *Research Evaluation*, 6(2), pp. 121–132.

Storper, M. and Venables, F. (2002) Buzz: the economic force of the city, paper presented at the *Druid Summer Conference*, Copenhagen, 6–8 June.

Uzzi, B. (1996) The sources and consequences of embeddedness for the economic performance of organizations, *American Sociological Review*, 61, pp. 974–998.

Zahra, L.G. and George, G. (2002) Absorptive capacity: a review, re-conceptualization and extension, *Academy of Management Review*, 27, pp. 185–203.

Zucker, L.G. and Darby, M.R. (1996) Star Scientists and Institutional Transformation: Patterns of Invention and Innovation in the Formation of the Biotechnology Industry, *Proceedings of the National Academy of Science of the United States of America*, 93, Nov. 12, pp. 709–716.

Zucker, L.G., Darby, M.R. and Brewer, M.B. (1998) Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises, *American Economic Review*, 88(1), pp. 290–306.