Knowledge Clusters and Knowledge Hubs: Designing Epistemic Landscapes for Development

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1. Introduction: The Devaluation of Space and the End of Industrial Agglomeration?

With globalization and knowledge-based production, firms now cooperate on a global scale, outsource parts of their administrative or productive units and negate location altogether. Geographical space has been theoretically downgraded and proximity or distance devalued (Brown and Duguid 2002). In fact rapid advances in ICT have enabled the emergence of global production networks (Coe et al. 2004), outsourcing, just-in-time production, high-level manpower migration (Fallick, Fleischman and Rebitzer 2006) and global "head hunting" for managers and engineers.

Globalization theorists, like Saskia Sassen (Sassen 1991) have proclaimed the existence of a "global city", consisting of CBDs (central business districts) in major cities worldwide, amalgamated into on huge global city welded together by intense electronic communication, sharing a common language and a common corporate culture of a capitalist world economy. The extremely low transaction costs of data, information and knowledge seem to invalidate the theory of agglomeration and the spatial clustering of firms (James 2005), going back to the classical work by Alfred Weber and Alfred Marshall, who emphasized the microeconomic benefits of industrial collocation (Weber 1909).

Despite this compelling theoretical argument, empirical reality shows a different picture. Industries well versed in ICT, outsourcing and cooperation via the internet still tend to cluster and form industrial agglomerations. "Contrary to the views of some economists, most categories of knowledge and information are not a ubiquitously available public good. Rather, they display large spatial disparities which show a remarkable historical persistence" (Meusburger 2000:352). More recently, Carillo, Erkazakis and others have emphasized the concentration of knowledge intensive institutions in urban areas and coined the concept of the

"knowledge city" (Carrillo 2006; Ergakakis et al. 2006), a concept which according to Carillo, is still in a "pre-paradigmatic stage" in need of further refinement (Carrillo 2004:33). Proximity increases a company's innovative capacity when firms can share ideas, products, and services. Examples are the Silicon Valley, the Hyderabad IT cluster, the Munich high-tech zone and the ABC (Aachen-Bonn-Cologne) cluster in Germany, the MSC in Malaysia, Biopolis and adjacent areas in Singapore and many others. In short, it is exactly innovative non-material production, applied research and knowledge-based manufacturing that tend to cluster in specific locations. Was Durkheim wrong when he asserted that "the truths of science are independent of any local context" (Durkheim 1972:88)? In a modern global context the question then arises, why do knowledge-based industries form clusters rather than making use of ICT to connect diverse locations world- wide?

Following the recent trend in recognizing knowledge as a factor of production, cluster research has increasingly turned away from an emphasis on agglomeration economics and the minimization of transaction cost.

Michael Porter in his well known study *The Competitive Advantage of Nations* produced a "diamond of advantage" to explain why clusters developed (Porter 1990).

This diamond consisted of the following elements:

• *Factor conditions* – a region's endowment of factors of production, including human, physical, knowledge, capital resources, and infrastructure, which make it more conducive to success in a given industry

• *Demand conditions* – the nature of home demand for a given product or service, which can pressure local firms to innovate faster

• *Related and supporting industries* – networks of buyers and suppliers transacting in close proximity to foster active information exchange, collective learning, and supply-chain innovation

• *Firm strategy, structure, and rivalry* – a climate that combines both intense competition among localized producers, with cooperation and collective action on shared needs, making it fertile for innovation and regional competitive advantage (Porter 2000; Porter 1990).

His widely accepted view was recently challenged by Henry and Pinch. They argued that more important are "the competitive advantages secured by firms through gaining rapid

access to knowledge concerning the innovations, techniques and strategies of competitor firms" (Henry and Pinch 2006:114). In view of the high ICT capabilities of high-tech firms, this argument reveals only half the truth. Why is rapid access to knowledge not gained through video conferencing, networking with other technical staff through the world-wide-web, through accessing data banks that could be located anywhere on the globe, via chat rooms on the internet or just using old-fashioned telephone connections? All these modern means of communications are used to negate geographical distance by allowing ad-hoc communication within seconds. Still, high-tech firms and knowledge-based industries show an avid tendency to cluster in geographical space. Why should this be the case?

2. Types of Knowledge: A revised Nonaka thesis

To answer this question we have to go back to the basics of knowledge management.
In his much cited work Nonaka and Takeuchi distinguish between tacit and explicit knowledge (Nonaka and Takeuchi 1995). Tacit knowledge is basically experience gained through action and explicit knowledge refers to knowledge stored and made available in books, databanks or other media. Maintaining competence within an organization despite a high turnover of employees, either through retirement or retrenchment poses a major management challenge, as tacit knowledge is lost. Michel Polanyi in an earlier work emphasized that tacit knowledge is based primarily on doing rather than cognition. A person can therefore "do" more than he or she "knows" (Polanyi 1967). In fact, Botkin and Seeley estimate that eighty percent of knowledge is tacit (Botkin and Seeley 2001). One of the most difficult tasks of knowledge management is therefore to facilitate the transfer of tacit knowledge into explicit knowledge or to transfer personal into organizational knowledge, i.e. turning a firm or government agency into an intelligent learning organization.

The conversion of tacit to explicit knowledge is difficult and provides an essential challenge to the practice of knowledge management. The best way to transmit tacit knowledge or experience is still by observation, by face-to-face contacts and learning from doing. Routine work can easily be outsourced, but innovative, knowledge-based work needs team work and the existence of communities of practice, frequent social interaction and capacity building by direct face-to-face learning. This line of argument eventually leads to the hypothesis that

"the transfer of tacit knowledge is a major factor in the emergence of knowledge clusters. The more important tacit knowledge is for production the more localised production is likely to be" (knowledge transfer hypothesis).

There is, up to now, only some empirical evidence to support our "knowledge transfer hypothesis", but the fact remains that clusters are still emerging and keep going by banking on their competitive advantage. We believe that our hypothesis holds both for pre-industrial handicraft manufacturing as well as for modern research and development work and knowledge based production. Pre-modern handicraft production tended to be clustered in special quarters or streets (Enright 2003:100). The craftsmen quarters in European medieval cities or the Hang (merchandise) streets in the Hoan Kiem district of Hanoi are, indeed, knowledge clusters driven by the transfer of expertise and experience of master craftsmen to apprentices as well as through keen observation of the practices in neighboring shops. Imitation of successful competitors and early access to crucial information is conducive to clustering (Meusburger 2000:259). Observations of the practices of competitors rather than blind market forces of supply and demand appear to be the most salient factors driving economic processes in this context. This insight has also been used to argue for a sociological theory of markets and prices (Evers and Gerke 2007; Fligstein 2002; White 1981).

By now a fair number of relevant studies provide empirical evidence that proximity and face-to-face interaction indeed facilitate the transfer of tacit knowledge and form a decisive asset in the emergence of knowledge hubs. As Zook argues "Marshallian interaction and observation retain their relevance even within the decidedly global financial and internet industries" (Zook 2004). A study in modern Italy e.g. examines the approaches used in determining communication and innovation in technological districts in Italy to identify their distinctive features and provide a framework for empirical analysis (Antonelli 2000). The study found that clusters cannot rely solely on agglomeration for their success but develop differently due to different knowledge sharing and research and development chances.

This view is contested by Håkanson, who raises doubts that privileged access to "tacit knowledge" alone provides competitive advantages that cause the growth and development of both firms and regions (Håkanson 2005). His point is acceptable in so far as indeed tacit knowledge is always embedded in cultural and social contexts that need to be taken into account together with market conditions.

Menkhoff et al studied knowledge in science parks and found that intense ethnic based interaction played a decisive role in the dynamics of knowledge hubs (Menkhoff et al. 2005). Similarly close interaction in socially diverse communities of practice were more productive than homogeneous knowledge hubs (Menkhoff et al. 2008).

A study on rural areas in the US emphasizes the importance of local actors and argues that "rural knowledge clusters are specialized networks of innovative, interrelated firms …, deriving competitive advantages primarily through accumulated, embedded, and imported knowledge among local actors about highly specific technologies, processes, and markets" (Munnich, Schrock and Cook 2002). Another US wide study concludes that tacit knowledge is an important factor in creating innovation (Audretsch and Feldman 1996).

In a different social arena in high-tech research laboratories empirical studies by Karin Knorr-Cetina have shown that face-to-face interaction between scientists inside and outside the laboratory have a decisive impact on the "manufacture" of knowledge (Knorr Cetina 1981). Knowledge production is always a social process that requires interaction. This may take place to a certain extend in cyber space, but innovation and discovery are also driven by emotions, by fun and anger, excitement and frustration which are projected at persons in direct interaction. Emotions are a less studied, but nevertheless important enabler (or hindrance) of knowledge sharing (Chay et al. 2005).

From these studies we can conclude that whereas industrial clusters gained their competitive advantage primarily from a reduction of transaction costs (Iammarino and McCann 2006), knowledge clusters emerge primarily through a direct transfer of tacit knowledge.

3. Knowledge Architecture

The marshalling of tacit knowledge and the use of proximity (Boschma 2005) for competitive gains needs a specific institutional frame, a specific "knowledge architecture" (Evers, Kaiser and Müller 2003). In a social science context Fligstein uses the term "architecture" to describe the interrelation between markets and governments (Fligstein 2002). In ICT research the term architecture "typically describes how the system or program is constructed, how it fits

together, and the protocols and interfaces used for communication and cooperation among modules or components of the system" (www.courts.state.ny.us/ad4/LIB/gloss.html). "IT architecture is a design for the arrangement and interoperation of technical components that together provide an organization of its information and communication infrastructure" (http://www.ichnet.org/glossary.htm). The ICT architecture is by now the backbone of knowledge clusters in knowledge based societies, but the impact of different architectures or ICT regimes on knowledge flows is not known, except for the fact that ICT speeds up communication. "Thus, clusters are made up not only of physical flows of inputs and outputs, but also include the intense exchange of business information, know-how, and technological expertise, both in traded and un-traded forms" (Sölvell 2009:15).

Pinch and others have drawn attention to the fact that "agglomerations may develop a cluster-specific form of architectural knowledge that facilitates the rapid dissemination of knowledge throughout the cluster by increasing the learning capacity of proximate firms and thereby conferring cluster-specific competitive advantages" (Pinch et al. 2003:373). In line with this argument we define the *knowledge architecture* of a knowledge cluster as

> *the institutions of communication and the type and intensity of knowledge flows (knowledge sharing), based on the formal and informal interaction between persons and organizations.*

Steven Pinch has described the characteristics of architectural knowledge, which "tends to be specific to, or embedded in, particular organizations within which it evolves endogenously over time in a complex trajectory…architectural knowledge is highly path dependent…and tacit in character…Crucially, architectural knowledge is also essential in determining the capacity of organizations to acquire, assimilate and adopt new knowledge" (Henry and Pinch 2006). What holds true for individual organizations can also be applied to a knowledge hub within a large corporation or a knowledge hub, consisting of several smaller organizations. In short, the knowledge architecture is a crucial determinant for the innovative capacity of firms, knowledge hubs and, indeed, the whole knowledge cluster.

As the knowledge architecture is basically "tacit" in character, tacit knowledge transfer is an essential factor in the emergence of knowledge hubs, as we have argued in the "knowledge transfer hypothesis" above. A knowledge architecture emerges on the basis of knowledge (Chay et al. 2005; Chay et al. 2007). Knowledge about the knowledge architecture within a

cluster or within a firm provides a competitive advantage for persons in the know as well as for intelligent firms in comparison to organizations outside a cluster. Architectural knowledge must be distinguished from “component knowledge”, which is “normally tied to the technology of the industry, is relatively coherent and definable, and is usually acontextual” (Tallman et al. 2004:264). Component knowledge can easily be shared with experts in the same field or transmitted to organizations. Architectural knowledge, like organizational or managerial processes is, however, more difficult to pass on, as it evolves as an inseparable part of a firm and is therefore contextualized (Tallman et al. 2004:265).

Knowledge flows and knowledge depositories constitute the knowledge architecture of an organization or a cluster of organizations. “Knowledge architecture” is therefore a property of an organization or cluster. This argument may be supported from the vantage point of sociological systems theory (Luhmann 1984). As Helmut Willke has argued, the intelligence of an organization is more than the sum of knowledge of its members. The knowledge of organizations is, indeed, different from personal knowledge, because “organisational or institutional knowledge resides in de-personalized, anonymous rule systems” (Willke 2007:113) and, we would argue, its knowledge architecture. In a modern knowledge society, Willke argues, large organizations tend to be more knowledgeable, more intelligent than individuals. No single individual is capable of building a modern airplane (Willke 2007:114). It needs organizational intelligence to accomplish this task and, we would add, industrial clusters and knowledge hubs as well.

4. K-Clusters and K-hubs

Most of the current literature does not draw a distinction between knowledge clusters and knowledge hubs. Policy statements in particular use both term arbitrarily. We feel that turning these terms into different analytical concepts would enhance our understanding of spatial processes. The most general concept would be “agglomeration”, i.e. clusters are agglomerations with ”proximity” as a crucial variable. Henry and Pinch use the term agglomeration and cluster synonymously “to refer to geographical groupings of firms (both large and small but often SMEs), broadly in the same sector, but extending beyond to incorporate greater parts of the value chain” (Henry and Pinch 2006:117). This definition is in line with the definition used by the Cluster Mapping project of the Harvard Center for

Strategy and Competitiveness: “Clusters are geographically concentrated groups of interconnected companies, universities, and related institutions that arise out of linkages or externalities across industries” (https://secure.hbs.edu/isc/index.jsp).

The cluster concept emphasizes the organizational aspect of agglomerations, while the term hub refers to the knowledge sharing and dissemination aspect. A more precise definition reads as follows.

> *Knowledge clusters are agglomerations of organizations that are production-oriented. Their production is primarily directed to knowledge as output or input. Knowledge clusters have the organizational capability to drive innovations and create new industries. They are central places within an epistemic landscape, i.e. in a wider structure of knowledge production and dissemination. Examples for organizations in knowledge clusters are universities and colleges, research institutions, think tanks, government research agencies and knowledge-intensive firms.*

Knowledge hubs may exist in the same locations as knowledge clusters and may be nested within them.

> *Knowledge hubs are local innovation systems that are nodes in networks of knowledge production and knowledge sharing. They are characterized by high connectedness and high internal and external networking and knowledge sharing capabilities. As meeting points of communities of knowledge and interest, knowledge hubs fulfill three major functions: to generate knowledge, to transfer knowledge to sites of application; and to transmit knowledge to other people through education and training. .*

Knowledge hubs are always nodes in networks of knowledge dissemination and knowledge sharing within and beyond clusters. Their knowledge architecture shows specific characteristics that can be made apparent in empirical studies. As a study of the wine industry in Italy and Chile has shown, firms with a strong knowledge base are more likely to exchange innovation-related knowledge with other firms. However, this is considered to occur only among firms whose cognitive distance is not too high. “This may explain the formation of

densely connected cohesive subgroups and the emergence of local knowledge communities" (Giuliani 2007:163), in our terminology to the formation of knowledge hubs.

With the development of the World Wide Web, a new architecture was introduced by leaving core resources of the internet in a "commons". "This commons was built into the very architecture of the original network" and was decisive for he innovation and creativity that was spurned by the internet (Lessig 2004:227-228). Despite the wide use of common knowledge in the internet communication is still concentrated within organizations and knowledge hubs (see table 1). E-mail communication is supplemented by attendance of formal meetings, discussion groups und informal chats in coffee rooms or canteens, mostly within an organization, but occasionally also at conferences. It is characteristic of knowledge hubs that other knowledge hubs are also accessed and knowledge is shared throughout a knowledge network. In fact the resilience and strength of a knowledge hub seems to rest in its connectivity, based on strong internal and external ties. As one always needs knowledge to acquire and use new knowledge, organizations with a low level of knowledge assets would seek consultancy services elsewhere, rather than joining an emerging knowledge hub and engage in knowledge sharing.

To visualize a complex matter in simple terms we may say that clusters are most visible as an agglomeration of organizations and buildings and hubs as a community of knowledge sharing and knowledge producing people.

The concepts discussed above are summarized in the following table.

Table 1 Concepts

Concept	Short Definition	Measurement (examples)
k-cluster	agglomerations of organisations emphasizing knowledge as output or input	number of organisations per location
K-hub	local innovation systems that are nodes in networks of knowledge production and knowledge sharing	number of knowledge workers and their products (patents, papers, software)
k-architecture	the structures and institutions of communication and the related type and intensity of knowledge flows	ICT governance regimes, regular meetings, k-sharing incentives
Epistemic landscape	areas of high or low knowledge intensity	Regional R&D expenditure, location of k-clusters and k-hubs

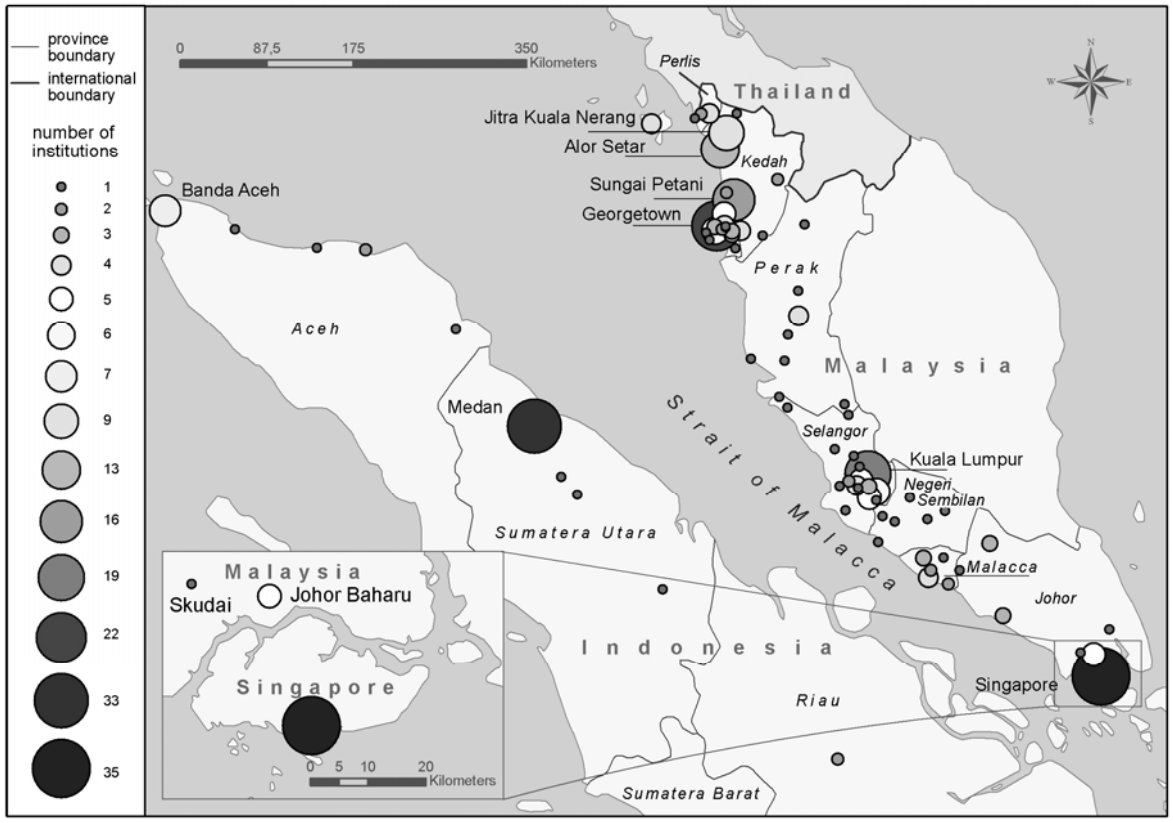
Knowledge clusters and knowledge hubs show distinctive *knowledge architectures*. Countries or regions exhibit *epistemic landscapes* of knowledge assets, structured by knowledge clusters, knowledge hubs, knowledge gaps and areas of high or low knowledge intensity. The emergence of epistemic landscapes will be demonstrated in the following section.

5. Epistemic Landscapes

Epistemic landscapes develop over long periods of time. They are seldom shaped by individual actors, but more often by the collective action of strategic groups (Evers and Gerke 2009). Firms connected by a common interest to capitalize on the competitive advantage of clustering have an impact on epistemic landscapes through their location decisions. More over government strategies to develop knowledge-based societies and economies have often been decisive in shaping epistemic landscapes. Relevant development policies have been assessed in detail elsewhere for Malaysia and Indonesia (Evers 2003), the Straits of Malacca region (Evers and Hornidge 2008), Vietnam (Evers and Bauer 2009), Singapore and Germany (Hornidge 2007). Developing industrial regions, clusters or knowledge hubs are, indeed, standard practice in many regional planning departments around the world.

Figure 1

Epistemic Landscape: the Straits of Malacca Region



Source: Own data, showing the location of knowledge producing organizations, like universities and research institutes (Evers and Hornidge 2007).

In this context we define epistemic landscapes in a geographical sense, i.e. we refer to the spatial distribution of knowledge assets within a predefined region. The term is not yet standard scientific terminology. It has been used in different contexts. One line of argument refers back to Bacon and 18th-century 'encyclopaedism' and defines an epistemic landscape as depicting a synthesis of knowledge (Wernick 2006). In Weisberg and Muldoon's study a single epistemic landscape corresponds to the research topic that engages a group of scientists. Agent based modeling with NetLogo software is used to model the changing epistemic landscape according to research strategies of participating scientists (Weisberg and Muldoon 2007). In our study we follow a slightly different path and focus on the development strategies of governments, strategic groups, firms, research institutes and their success in shaping the epistemic landscape of a region[1]. The allocation of human and financial resources

[1] This refers to ongoing research on knowledge management and knowledge governance in the water sector of the Mekong Delta (WISDOM project http://www.zef.de/1052.0.html), carried out jointly by the Center for

creates knowledge assets which can be measured, mapped and made to depict the contours of an epistemic landscape.

6. Towards a New Architecture of Knowledge for Development

Asian governments as well as international development agencies are increasingly banking on knowledge as a factor of production (ADB 2005; Gerke and Evers 2006:2-3; Gerke, Evers and Schweisshelm 2005; Hornidge 2007: 4-10, 62-65). In 2003 the Asian Development Bank identified knowledge as the most important resource in maintaining the region's competitiveness, given the rapid rate of change created by globalization and technological innovation. Besides banking on increased transfer of knowledge through FDI, as well as increased investment in education and R&D, experts are advocating the creation of knowledge hubs as incubators of future economic development. The Ministry of Education, Culture, Sports, Science and Technology of Japan (MEXT) launched a program in 2003 to set up knowledge clusters throughout Japan. Knowledge clusters are described as follows: "A "Knowledge Cluster" is a local innovation system organized around universities, research institutions and firms which have unique R&D themes and potentialities"[2].

In 2006 the Asian Development Bank announced a program to develop knowledge hubs in selected developing countries throughout the Asia and Pacific region to support and strengthen research and disseminate new development concepts and technologies (ADB 2005). Since 2006 ADB is supporting Tsinghua University in Beijing in establishing a regional knowledge hub on climate change. The knowledge hub is to be established under an ADB grant and expertise that is setting up centers of excellence in the region to support and strengthen research and disseminate new and emerging concepts and technologies. Other centers are planned in Thailand and India, strengthening and supplementing the already existing knowledge hubs.

"These knowledge hubs should aim to mainstream new concepts in innovation, science, technology, management development, and related fields for the region. They should also

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Development Research (ZEF), University of Bonn, the Southern Institute of Social Sciences, HCMC and The Mekong Development Research Institute of Can Tho University.

[2] See http://www.mext.go.jp/a_menu/kagaku/chiiki/cluster/h16_pamphlet_e/01.pdf

promote improved exchange of data, information, and knowledge; and increase the capabilities of institutions and organizations in the region. Initiatives have created a wealth of knowledge base and expertise throughout the region. However, the capabilities of regional organizations and institutes in disseminating and sharing their findings are limited. Information is not enriched through regional cooperation, and information and expertise bases largely remain scattered around the region and fail to provide the multiplier effect that could be achieved if it were nurtured with more support for regional knowledge exchange. As the knowledge hub will focus on new development topics, experience and lessons learned from ADB knowledge sharing initiatives such as the Consultative Group on International Agricultural Research (CGIAR) centre of excellence will be applied in the establishment of the knowledge hubs" (ADB 2005:2).

Singapore and Malaysia have followed a similar policy of designating specific areas to house knowledge clusters and identifying special areas of research and development to set up knowledge hubs. We have analyzed elsewhere the strategies to develop knowledge clusters in the Straits of Malacca region in greater detail (Evers, Gerke and Hornidge 2008), in Indonesia (Evers 2003), Malaysia (Evers 2003; Evers 2004a; Evers 2004b; Menkhoff et al. 2008) and Singapore (Evers 2003; Hornidge 2007; Menkhoff et al. 2008). So far these development policies have been fairly successful. It should be noted, however, that the emergence of knowledge clusters and knowledge hubs have been embedded in a wider epistemic landscape. Knowledge capital was created by supporting colleges, universities, research institutes and centers of applied research and development and tacit knowledge was imported through immigration of foreign talents and overseas training schemes. By this an important principle of knowledge management was leveraged, namely that knowledge is needed to use and create more knowledge. This also entails deleting barriers to knowledge flows, building an ICT backbone, increasing knowledge assets and closing knowledge gaps and developing a legal infrastructure that allows and encourages creative and diverse knowledge production. Without the thorough implementation of a knowledge architecture as well as an epistemic landscape, a successful development of a knowledge-based economy and society will hardly be possible.

7. Conclusions

Geographical knowledge mapping and the design of epistemic landscapes is basically a tool to visualize the distribution of knowledge assets. A look at an epistemic landscape will show us

the knowledge clusters, the gaps, valleys and heights of knowledge assets within a predefined region. As in poverty mapping it will allow a more precise targeting of development measures. In this sense knowledge mapping is a planning tool as it will also prove helpful to assess the impact of development measures in the fields of education, research and development and communication. If information or decision support systems are installed, epistemic landscapes will show the availability of certain areas to receive information and implement development programs. We also suggest that the mapping of epistemic landscapes is a precondition for the successful implementation of sustainable knowledge architecture for development.

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