Knowledge hubs and knowledge clusters: Designing a knowledge architecture for development.

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Knowledge Hubs and Knowledge Clusters: Designing a Knowledge Architecture for Development[1]

Hans-Dieter Evers

Abstract

With globalisation and knowledge-based production, firms may cooperate on a global scale, outsource parts of their administrative or productive units and negate location altogether. The extremely low transaction costs of data, information and knowledge seem to invalidate the theory of agglomeration and the spatial clustering of firms, going back to the classical work by Alfred Weber (1868-1958) and Alfred Marshall (1842-1924), who emphasized the microeconomic benefits of industrial collocation. This paper will argue against this view and show why the growth of knowledge societies will rather increase than decrease the relevance of location by creating knowledge clusters and knowledge hubs. A knowledge cluster is a local innovation system organized around universities, research institutions and firms which intend to drive innovations and create new industries. Knowledge hubs are localities with a knowledge architecture of high internal and external networking and knowledge sharing capabilities. Countries or regions form an epistemic landscape of knowledge assets, structured by knowledge hubs, knowledge gaps and areas of high or low knowledge intensity.

The paper will focus on the internal dynamics of knowledge clusters and knowledge hubs and show why clustering takes place despite globalisation and the rapid growth of ICT. The basic argument that firms and their delivery chains attempt to reduce transport (transaction) costs by choosing the same location is still valid for most industrial economies, but knowledge hubs have different dynamics relating to externalities produced from knowledge sharing and research and development outputs.

The paper draws on empirical data derived from past and ongoing research in the Lee Kong Chian School of Business, Singapore Management University and in the Center for Development Research (ZEF), University of Bonn.

Keywords

knowledge and development, knowledge governance, innovation, space, Vietnam, Straits of Malacca

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

With globalisation 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.

Globalisation 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. 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. 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 minimisation 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 organisation 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 emphasised 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 organisational knowledge, i.e. turning a firm or government agency into an intelligent learning organisation.

The conversion of tacit to explicit knowledge is difficult and provides an essential challenge to the practise 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 neighbouring 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. 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).

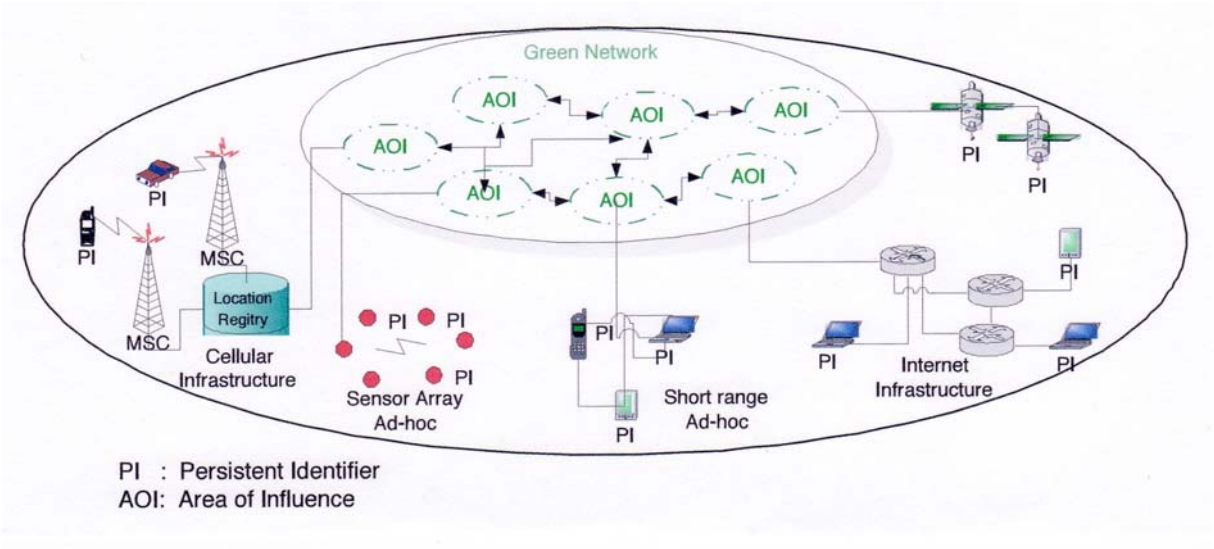
From these studies we can conclude that whereas industrial clusters gained their competitive advantage primarily from a reduction of transaction costs (Iammarino and McCann 2006), knowledge clusters emerge primarily through a direct transfer of tacit knowledge.

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.

The following diagram depicts a general internet architecture conceptualization (Jerez, Khoury and Abdallah 2008:3).

Figure 1 Conceptualization of an Internet Architecture



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 organisations 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 organisations to acquire, assimilate and adopt new knowledge" (Henry and Pinch 2006). What holds true for individual organisations can also be applied to a knowledge hub within a large corporation or a knowledge hub, consisting of several smaller organisations. 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 organisation or a cluster of organisations. A "knowledge architecture" is therefore a property of an organisation 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 organisation is more than the sum of knowledge of its members. The knowledge of organisations is, indeed, different from personal knowledge, because "organisational or institutional knowledge resides in de-personalised, anonymous rule systems" (Willke 2007:113) and, we would argue, its knowledge architecture. In a modern knowledge society, Willke argues, large organisations tend to be more knowledgeable, more intelligent than individuals. No single individual is capable of building a modern airplane (Willke 2007:114). It needs organisational 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).The cluster concept emphasises 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 organisations that are production-oriented. Their production is primarily directed to knowledge as output or input. Knowledge clusters have the organisational 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 organisations in knowledge clusters are universities and colleges, research institutions, think tanks, government research agencies and knowledge-intensive firms.

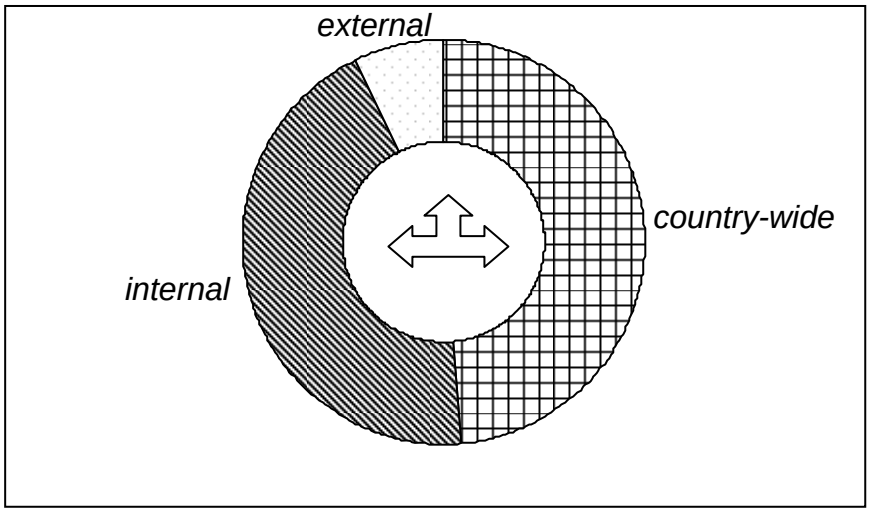
Knowledge hubs may exist in the same locations as knowledge clusters and may be nested within them.

Knowledge hubs are local innovation systems that are nodes in networks of knowledge production and knowledge sharing. They are characterised by high connectedness and high internal and external networking and knowledge sharing capabilities. As meeting points of communities of knowledge and interest, knowledge hubs fulfil 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 organisations and knowledge hubs (see figure 1). E-mail communication is supplemented by attendance of formal meetings, discussion groups und informal chats in coffee rooms or canteens, mostly within an organisation, 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.

Figure 2 Internal versus external communication:
E-mail communication of junior staff in a research institute



To visualize a complex matter in simple terms we may say that clusters are most visible as an agglomeration of organisations 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. 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), Singapore and Germany (Hornidge 2007a). Developing industrial regions, clusters or knowledge hubs are, indeed, standard practice in many regional planning departments around the world.

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. This may be the topic of a specialized research conference or advanced level monograph. Agent based modelling 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 intend to 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[2]. The allocation of human and financial resources creates knowledge assets which can be measured, mapped and made to depict the contours of an epistemic landscape.

6. Case Studies of K-Hubs and Epistemic Landscapes in ASEAN.

(1) Centres of Trade as Hubs of Learning in the Straits of Malacca.

Knowledge hubs take time to develop. They often emerge on the basis of earlier social and economic conditions; in other words they are strongly path-dependent. The institutions that were created in earlier times show their own dynamics and strongly influence outcomes at a later date. This statement goes beyond the simple assertion that history matters and argues that the knowledge architecture, as defined above, has its roots in local conditions and local knowledge. as well as local concepts of knowledge, i.e. the creation of what types and forms of knowledge are especially fostered (Hornidge 2007b). Development strategies aiming at the creation of knowledge hubs and ultimately knowledge societies will produce different outcomes dependent on which location is chosen. We shall substantiate this argument on the basis of our case study of knowledge hubs in the Straits of Malacca region (Evers and Hornidge 2007).

The history of the Straits of Malacca is until today strongly determined by international trade (Evers, Gerke and Hornidge 2008). At different points in time different ports in the Straits

[2] 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).

formed the main centres of commercial activities and as such arose as crucial contact zones for the exchange of not only products but also commercial and nautical knowledge as well as religious beliefs including state-craft. Reason for visiting these knowledge hubs was trade and for some the spread of a certain faith. But once the travellers arrived in these ports, access to knowledge became of ultimate importance, as it became the precondition for reaching the long-term goal, namely success in trade or conversions.

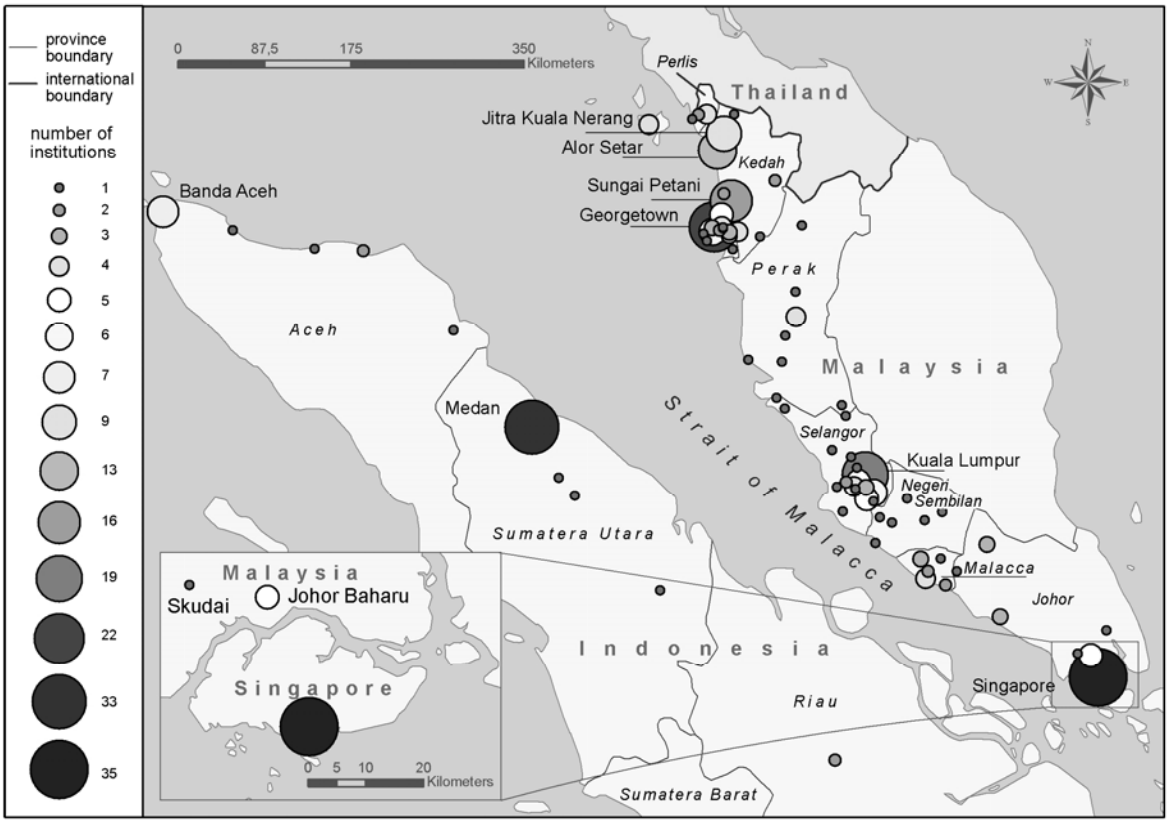
Consequently, knowledge flowed or was transferred from the foreigners to the local communities, from one group of foreign traders to another (i.e. from Indians to Chinese, Arabs to Indians, Europeans to Arabs, etc.) as well as from local communities to foreign traders. Up to now Singapore's cultural diversity provides access to a wide range of culturally specific knowledge pools as well as of course to multiple ethnically defined and historically grown trans-boundary business networks (Evers and Hornidge 2007:432). The transfer of knowledge took place in institutionalised modes of knowledge transfer (i.e. schools of religious learning, traders associations, the feudal courts) as well as in informal ways (i.e. spontaneous exchange of mostly tacit knowledge through interaction with traders from a different ethnic group). Basic facts are known but research on the modes and extend of knowledge transfer through trade and on the knowledge architecture of the trading centres still awaits further analysis.

Turning to our study of current knowledge hubs and clusters in the Straits of Malacca region (Evers, Gerke and Hornidge 2008) it could be shown that modern knowledge clusters emerged mostly at localities that had a long tradition of trade and learning in the past. The growth and the knowledge architecture of knowledge clusters and hubs appear to be highly path dependent. This fact is often neglected in development programmes advocating the establishment of knowledge hubs "out of the blue" without regards for the existing knowledge architecture and landscape.

To delineate knowledge clusters in the Straits of Malacca region we compiled a directory of research centres and institutions of higher learning. Combining these data with geospatial coordinates we were able to identify areas of agglomeration of knowledge transferring and producing organisations. These were defined as knowledge clusters[3]. Combining these data with output variables, i.e. numbers of internationally recognised academic publications, patents, number of persons graduated and similar data we could identify knowledge hubs. The following map shows the knowledge clusters, using the number of knowledge-producing organisations as an indicator. Four major clusters emerge: a Northwest Malaysian cluster (around Georgetown and Alor Star), a West Malaysian cluster (Kuala Lumpur with the Klang Valley, the MSC and Malacca), the North Sumatra cluster (centred on Medan) and the Singapore-Johore cluster as the major knowledge cluster of Southeast Asia.

[3] We are now using a more refined definition of clusters and hubs and therefore deviate somewhat from the terminology of our earlier study.

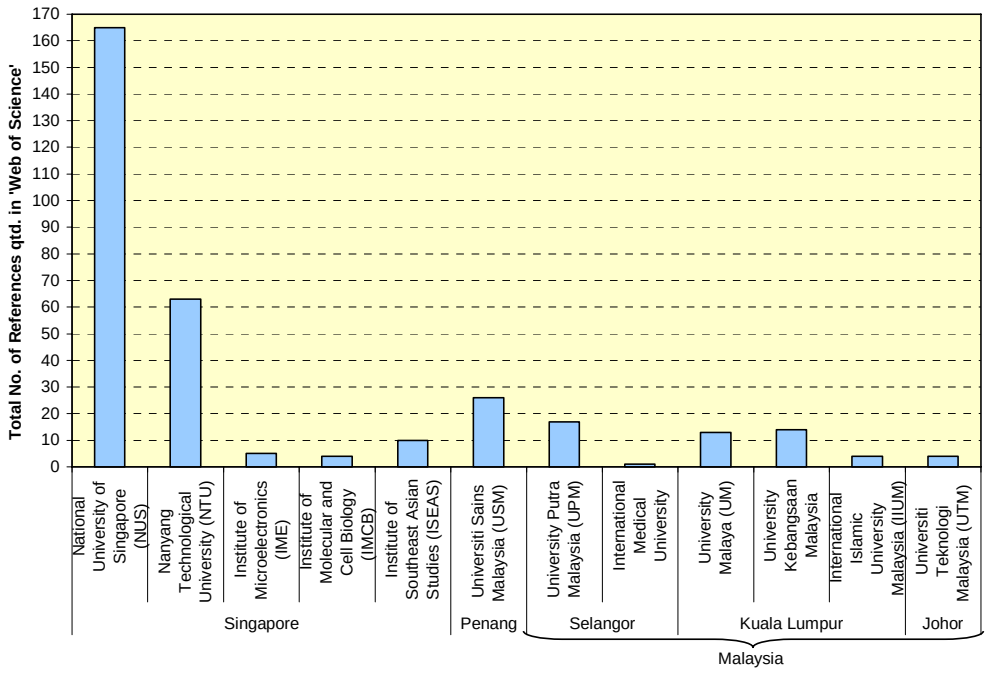
Figure 2 Knowledge Clusters along the Straits of Malacca



Source: (Evers, Gerke and Hornidge 2008; Evers and Hornidge 2007:426)

Nested within these knowledge clusters we find several knowledge hubs that coordinate a large number of highly qualified scientists, are connected to other hubs world-wide, are creative in producing new knowledge in specialized epistemic domains and are transferring innovations to firms and government agencies. Using the output of internationally recognised papers as an indicator several large universities could be identified as knowledge hubs, as shown in the following table.

Figure 2: Knowledge Output, Malaysia and Singapore.



The data were collected from the database 'Web of Science' on all universities and research institutes in Malaysia and Singapore on 24th of January 2007. Only those universities or research institutes referenced in the data base are included in this diagram (Evers and Hornidge 2007:424).

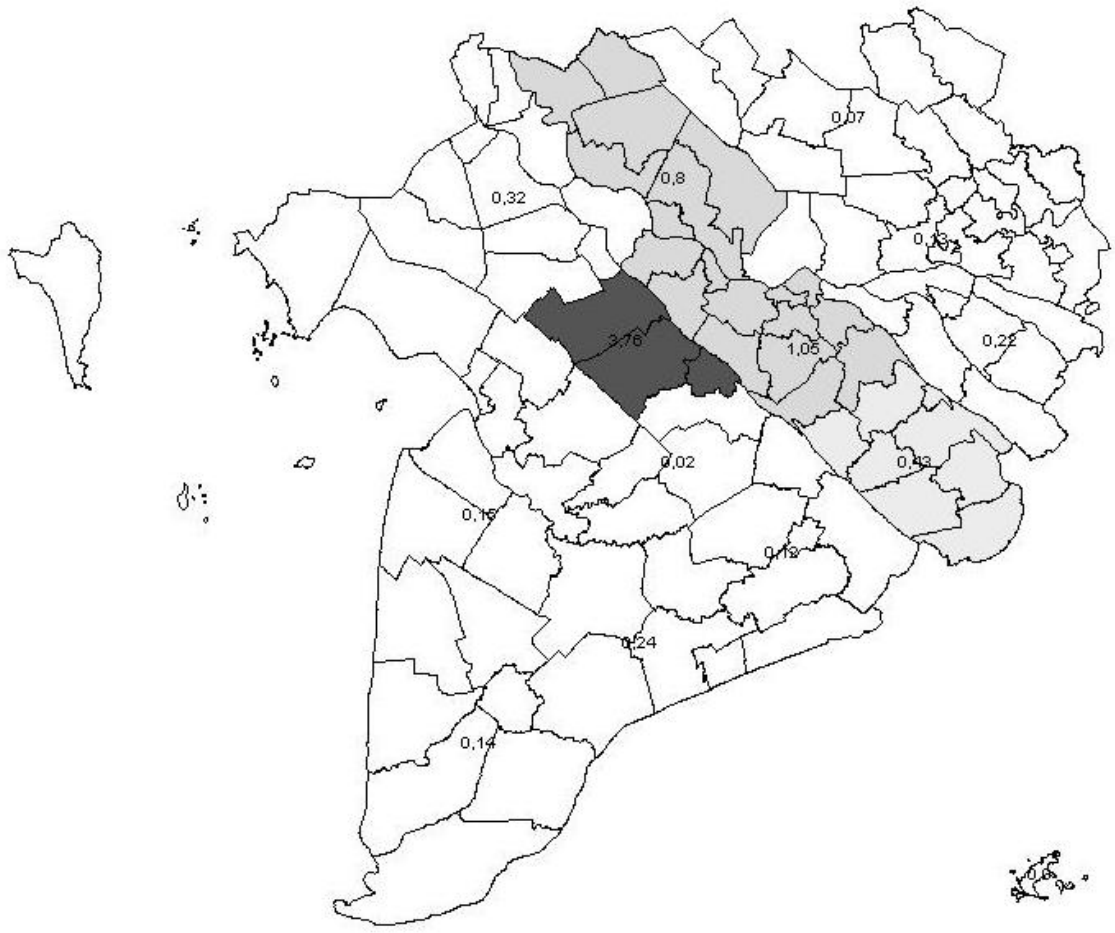
(2) The Epistemic Landscape of the Mekong Delta in Vietnam

With these maps and tables we have still a long way to go until we can construct an "epistemic landscape" showing the contours and the distribution of knowledge assets and the architecture of knowledge production and dissemination. A first attempt towards this goal is made in our current study of knowledge governance in the Mekong Delta of Vietnam[4].

The following figures show the mapping of an epistemic landscape in Southern Vietnam.

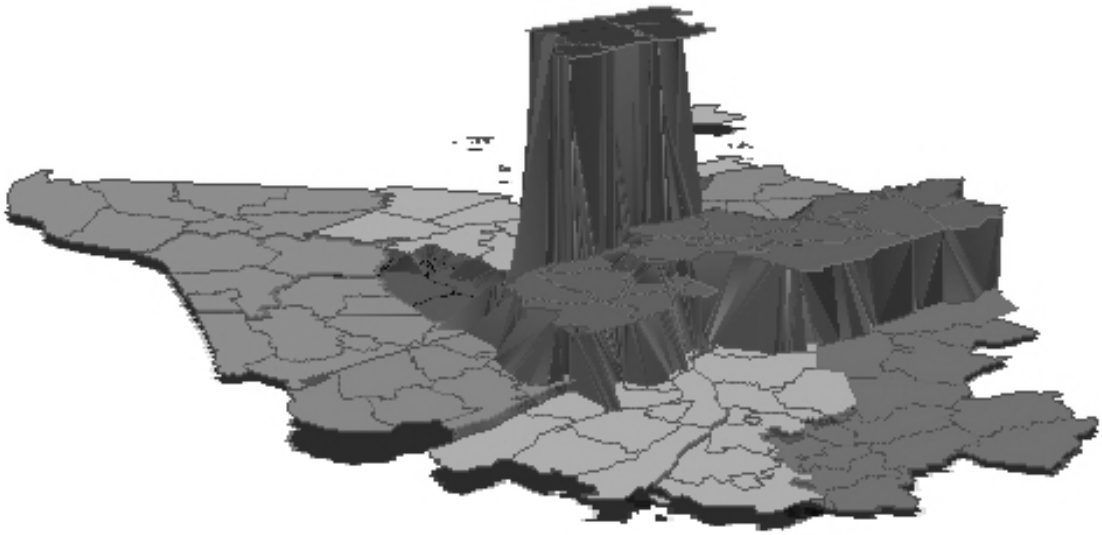
[4] This study is carried out within the WISDOM Project by the Center for Development Research (ZEF), University of Bonn and the Mekong Development Research Centre (MDI) of Can Tho University, with support from the German Aeronautics and Space Agency (DLR), the Vietnamese Ministry of Science and Technology (MOST) and the German Federal Ministry of Education and Research (BMBF).

Figure 3 Epistemic map of the Mekong Delta, Vietnam



This map shows the knowledge intensive areas of the Mekong Delta, measured by a knowledge asset indicator (students in universities and colleges as percent of population). A similar pattern as for the Straits of Malacca region emerges. A corridor of high knowledge assets extends along the historically important arms of the Mekong river delta with urban centres living on water-borne traffic and trade. The knowledge hub of the Mekong Delta is identified as the dark shaded area of Can Tho City, the central "boom town" of the Mekong Delta. Epistemic maps can be used to identify critical areas of knowledge deficiency or knowledge intensity. The following figure shows the epistemic landscape in form of a 3D image of the map. The elevation in the landscape is a function of the knowledge asset indicator.

Figure 4 Epistemic landscape of the Mekong Delta, Vietnam



The ridge of high knowledge assets and the knowledge peak of the provincial capital of Can Tho are clearly visible. Using the metaphor of heights, valleys, peaks and ridges may help us to visualize the uneven distribution of knowledge in the Mekong Delta.

7. 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 2007a: 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 programme 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"[5].

In 2006 the Asian Development Bank announced a programme 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 centres of excellence in the region to support and strengthen

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

research and disseminate new and emerging concepts and technologies. Other centres 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 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 analysed 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 2007a; 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 centres 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.

8. 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 programmes. We also suggest that epistemic mapping is a precondition for the successful implementation of sustainable knowledge architecture for development.

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