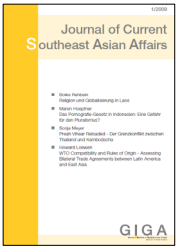

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Knowledge Cluster Formation as a Science Policy in Malaysia: Lessons Learned

Hans-Dieter Evers and Solvay Gerke

Abstract: Regional science policy aims to create productive knowledge clusters, which are central places within an epistemic landscape of knowledge production and dissemination. These so-called K-clusters are said to have the organisational capability to drive innovations and create new industries. Many governments have used cluster formation as one of their development strategies. This paper looks at Malaysia's path towards a knowledge-based economy and offers some evidence on the current state of knowledge cluster formation in that country. If the formation of a knowledge cluster has been the government policy, what has been the result? Is there an epistemic landscape of knowledge clusters? Has the main knowledge cluster really materialised? Data collected from websites, directories, government publications and expert interviews have enabled us to construct the epistemic landscape of Peninsular Malaysia, and Penang in particular. We identify and describe several knowledge clusters with a high density of knowledge producing institutions and their knowledge workers. An analysis of the knowledge output, measured in terms of scientific publications, patents and trademarks, shows that knowledge clusters have indeed been productive – as predicted by cluster theory – although the internal working of clusters require further explanation.

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Keywords: Malaysia, science policy, knowledge and development, knowledge-based economy, knowledge clusters, knowledge corridors

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Introduction: Industrial and Knowledge Clusters for Development

International agencies, governments and experts have identified industrial cluster formation as an important way to induce innovations, increase GDP and help develop a nation (OECD 1996). The beneficial effects of the formation of industrial clusters have already been investigated by Alfred Marshall (1920) and Alfred Weber (1909). As Michael E. Porter argued in his well-known book, the competitive advantage of nations is greatly enhanced by the formation of industrial clusters. As Porter put it, "The phenomenon of industry clustering is so pervasive that it appears to be a central feature of advanced national economies" (Porter 1990: 149). According to Porter, "a cluster is a geographically proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities" (Porter 2000: 16). A survey of the European Commission concluded that:

> cluster firms are more innovative than non-cluster firms. These innovative cluster companies are more than twice more likely to source out research to other firms, universities or public labs than were the average European innovative firms in 2004. This supports the view that clusters are encouraging knowledge sharing which may further stimulate innovation. Moreover, cluster firms patent and trademark their innovations more often than other innovative companies (European Commission 2013: 22–23).

More specifically, 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 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 (Evers 2010).

The present paper looks at Malaysia's path towards a knowledge-based industrial economy. We start by providing evidence of the current knowledge cluster formation in Peninsular Malaysia, which we then check against the current measures to form "corridors", "economic zones" or "cyber cities" and answer the question or whether these planned "corridors" have already developed into knowledge clusters; in

other words, how far "natural" clustering conforms to regional cluster planning. By forming innovative knowledge clusters, additional resources become available on a local level, either through channelling government funds and corporate investments into the "epistemic landscape" (Evers and Bauer 2011) or through the benefits produced by effective cluster policies. We then seek to answer the question of whether cluster (or corridor) policies have been successful and what lessons can be learned from the experience of Malaysia.

Cluster Formation as Development Policy in Malaysia

Malaysia and Singapore have followed vigorous cluster policies (Hornidge 2007; Evers, Gerke, and Menkhoff 2011).[1] In 1991, Prime Minister Mahathir pronounced the long-term development goal that Malaysia was to be an industrialised and developed country by the year 2020 in its 'own mould' (Mahathir 1998: 21). The policies that Mahathir highlighted were implemented in the Sixth Malaysia Plan (6MP) to the Tenth Malaysia Plan (10MP). Knowledge-based development started with the utilisation of information and communication technology (ICT) in all sectors of the economy to increase productivity. The MSC Malaysia and Cyberjaya were created in order to put into practice the vision of making Malaysia a knowledge-based economy (KBE) by utilising ICT. The government also encouraged the growth of companies related to biotechnology, advanced electronics and software development. The Malaysian Technology Development Corporation (MTDC) and Technology Park Malaysia (TPM) set up incubation centres to support industries with high-technology solutions. MSC Malaysia and TPM are examples of the formation of clusters that utilise technology to strengthen their innovative power with new resources (Evers, Nordin, and Nienkemper 2011; Evers and Nordin 2012; Gerke and Evers 2012).

The Nineth Malaysia Plan (9MP), which covered 2006–2010, emphasised the use of knowledge and ICT. The establishment of information-technology-based clusters was suggested in order to shift from low-end industries to high-end technology. Regional development was given a new 'branding'. The formation of economic corridors or clusters was spearheaded by the major GLCs (government-linked companies). On 30 March 2010, the Malaysian Prime Minister, Najib Razak, unveiled

1 The case of Singapore has been discussed elsewhere (Hornidge 2008; Menkhoff and Evers 2011; Menkhoff et al. 2011).

the New Economic Model (NEM), which was designed to ensure that Malaysia would be able to achieve the target set by Mahathir's Vision 2020. The NEM, inaugurated in March 2010, strengthened the policy of a formation of high-tech clusters and of corridors with a focus on different economic activities.

The first knowledge cluster development plan was designed to intensify the knowledge content in various economic activities (K-Based Master Plan 1993). The Multimedia Super Corridor Malaysia (MSC) was constructed in 1996 and was originally a 15 x 50 km zone that stretched from the Kuala Lumpur City Centre (KLCC) to Kuala Lumpur International Airport (KLIA) (Ramasamy, Chakrabarty, and Cheah 2002; Bunnel 2006). The MSC included Putrajaya, the new administrative capital, and Cyberjaya, the ICT hub, in addition to the Kuala Lumpur Conference Centre and the Kuala Lumpur International Airport (KLIA and its low-cost carrier extension KLIA2). The MSC Malaysia was the physical visualisation of Mahathir's vision towards transforming Malaysia into a knowledge-based economy. Revenue from MSC Malaysia rose from 12.99 billion MYR in 2006 to 17.06 billion MYR in 2007, with total employment created at 63,883 (MSC Malaysia 2009). Meanwhile, the MSC concept was expanded and companies all over Malaysia were awarded MSC status through the Multimedia Development Corporation (MDeC). Several new policies were added to the MSC concept in 2014–2015. Digital Malaysia describes itself as:

> a unique programme based on three strategic thrusts. It will create an 'ecosystem' that promotes the pervasive use of ICT in all aspects of the economy to connect communities globally and interact in real time, resulting in increased Gross National Income, enhanced productivity and improved standards of living (Digital Malaysia 2015).

Since 2014, multi-media companies have been subsidised by a MAC3 Fund.

The potential to create new sources of growth has encouraged the government to designate areas in different parts of the country as cyber cities and cyber centres. These areas are based on a development strategy that locates industrial companies of similar technology within the same geographical area (*Malaysian Business* 2009). This cluster policy is vigorously pursued further under the latest Malaysian Development Plan, covering the years 2011 to 2015.

Cyberjaya, opened in 1999, was the first cyber city development in MSC Malaysia and remains the leading one today. The city covers an area of 7,000 acres and was designed as a cutting-edge multimedia centre to

attract world-class multimedia and ICT companies (Neo et al. 2008). The city is located adjacent to Putrajaya and between Kuala Lumpur International Airport (KLIA) and Kuala Lumpur. In 2009, there were 414[2] companies in Cyberjaya providing employment to 35,000 people. Today there are three universities located in Cyberjaya – Multimedia University, Limkokwing University of Creative Technology and Cyberjaya University College of Medical Science – which cater for more than 15,000 students.[3]

The Emergence of Knowledge Clusters in Malaysia

The 1990s saw a policy shift in line with the global higher education restructuring (Lee 2004; Sivalingam 2006). In Malaysia, the number of public universities almost tripled from merely eight prior to 1990 to 20 in 2009, and then nearly doubled again to 39 in 2015. Apart from universities, the government also increased the number of polytechnics and community colleges to cater for the needs of the industries. The number of private universities grew from none in the 1990s to 39 in 2015, while other forms of private institutions grew from 156 in 1992 to more than 500 in 2015. The expansion of these institutions has created different types of ownership, including individual proprietors, private companies, consortia of companies, publically listed companies, government corporations, foundations, philanthropic organisations and community financing (Lee 2004: 1). The formation of these different types is derived from the lucrative business of higher education in Malaysia (Evers and Nordin 2012).

The decades of regional development planning have resulted in the formation of knowledge clusters with different degrees of "knowledge density". By this, we mean that certain areas show a disproportionately high number of knowledge-producing institutions and knowledge workers.

The knowledge cluster map shows that knowledge clusters in Peninsular Malaysia are still concentrated on the West Coast, with three main locations – Kelang Valley, Johor Bahru and Penang – having the highest

2 This was the official figure given by the Multimedia Development Corporation (MDeC), but our field survey between April and December 2009 only managed to locate 348 companies in Cyberjaya (Evers and Nordin 2012).

3 The unpublished figure of the total number of students was provided by the Ministry of Higher Education during fieldwork in 2009.

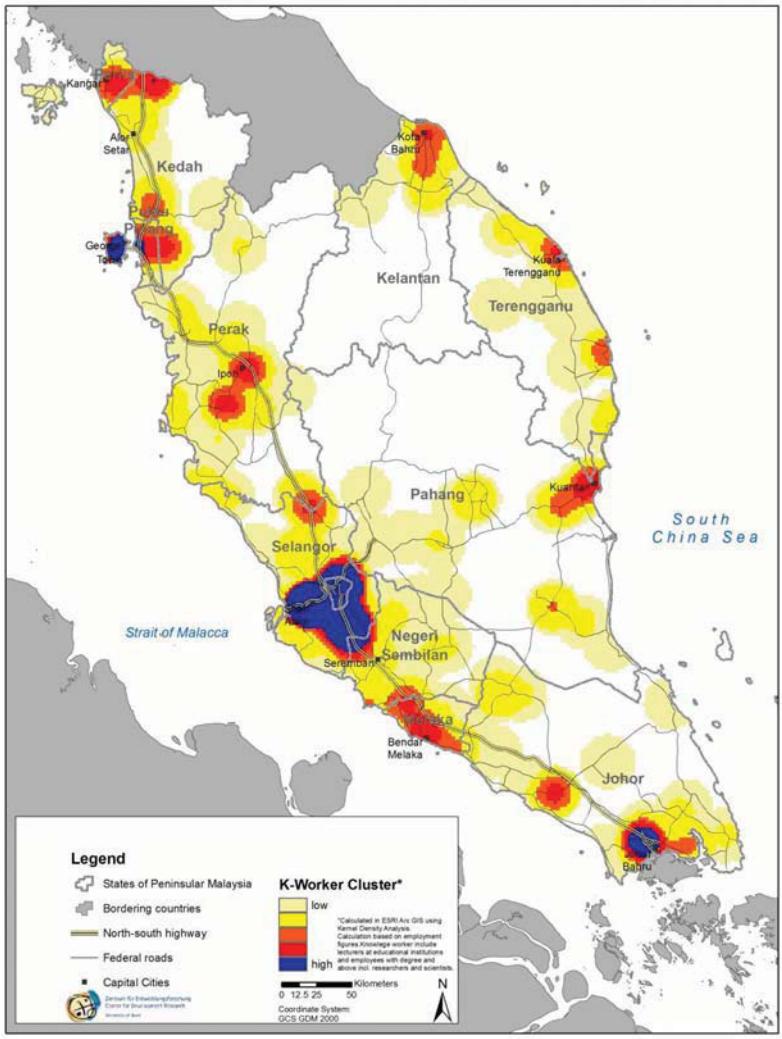
concentration of knowledge-producing institutions and knowledge workers. Penang has the densest knowledge clusters in the Northern Region of Peninsular Malaysia. Interestingly, the area in Northern Kedah and Perlis bordering Southern Thailand has a strong presence of knowledge clusters, even though both areas are economically less developed than the other areas in the West Coast. The concentration of the knowledge clusters at the West Coast also correlates with the major infrastructures and economic development.

The East Coast of Peninsular Malaysia is still less developed in terms of knowledge clusters. Knowledge clusters are only found at the main cities in the region; that is, Kota Bahru, Kuala Terengganu, Dungun and Kuantan. According to our data, Kuantan has the highest density of knowledge workers of these four cities. Comparing the clusters to the West Coast, the knowledge clusters spread within the main urban areas, where most economic and social activities are concentrated, rather than along the major highways. Also, kernel density[4] in the main urban areas tends to be much lower than on the West Coast.

Recognising that knowledge clusters have emerged, the most important remaining question is whether this clustering process has also resulted in higher knowledge production, as predicted by clustering theory. We have attempted to measure knowledge output by using scientific publications, patents and trademarks as indicators of innovation and knowledge output.

4 Kernel Density, a non-parametric density estimation technique, calculates the density of features in a neighbourhood around those features. We have used ArcGIS to calculate and map kernel density in Figures 1, 5 and 6.

Figure 1: Knowledge Clusters in Peninsular Malaysia

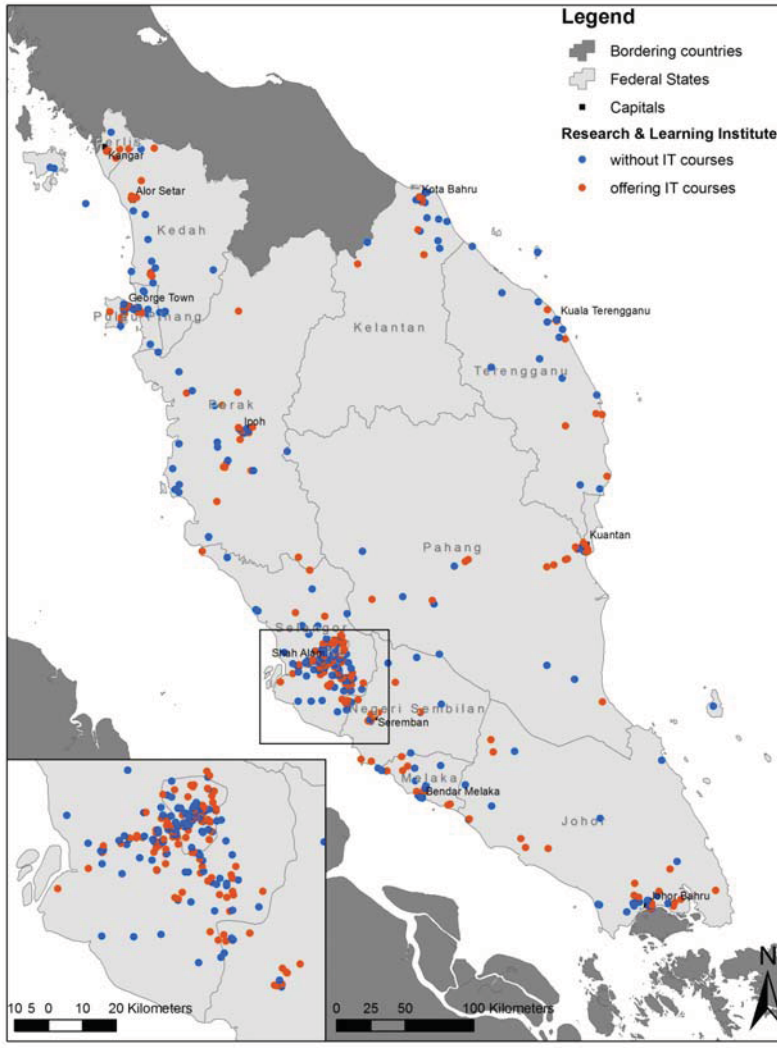


Note: The map is based on the number of employees as of 31 December 2008.

Source: Ministry of Higher Education 2008a, 2008b, 2009, 2010 (unpublished data); Ani Asmah and Aminuddin Hamdan 2009 and field data 2009.[5]

5 Data on employees for some of the R&D Institutions were collected by Ramli Nordin through a telephone survey between April and December, 2009. See also Evers and Nordin 2012.

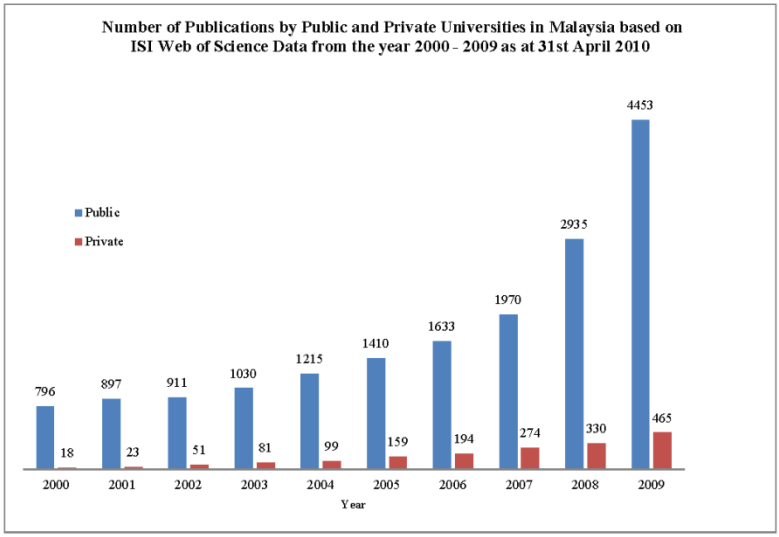
Figure 2: Distribution of Research Institutes and Institutions of Higher Learning with or without ICT Courses, Peninsular Malaysia 2000



Note: Data of courses offered by Private Higher Learning Institutions were collected from individual web pages from April–December 2009.

Source: Ministry of Higher Education 2008a, 2008b, 2009; Ani Asmah and Aminuddin Hamdan 2009; Ministry of Higher Education 2009 (unpublished data) and own field data, 2009.

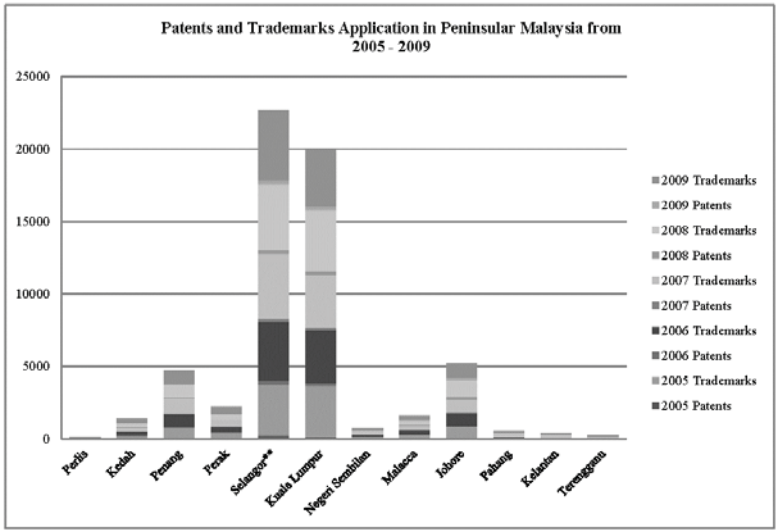
Figure 3: Knowledge Output: Number of Publications of Malaysian University Staff, 2000 to 2009



Source: Web of Science 2010.

We also collected data on another form of knowledge output; namely, patents and trademarks. As shown in Figure 4, Selangor and Kuala Lumpur have the highest numbers of applications for both between 2005 and 2009. Johor and Penang, located in the southern and northern knowledge clusters of Peninsular Malaysia, respectively, also produce the highest numbers of patents and trademarks application. They are followed by Perak, Malacca and Negeri Sembilan, which are located in the most concentrated knowledge clusters in Peninsular Malaysia. The number of applications for Kedah is significant in comparison to data for the state of Perlis. This again shows that the density of knowledge clusters does not necessarily contribute to the knowledge output. The states on the East Coast have the lowest number of applications for both patents and trademarks. As evidenced by our data, Kelang Valley still dominates the knowledge output in Peninsular Malaysia.

Figure 4: Applications for Patents and Trademarks, Peninsular Malaysia 2005 to 2009



Source: MyIPO 2010.

Science Policy: Planning Industrial and Knowledge Clusters in Malaysia

In the1960s, Malaysia's policy makers realised the importance of export-oriented industrial clusters that focused on light and heavy industries. Industrial clusters in the form of free-trade zones were developed to encourage export-oriented industrialization. The clusters were located in the relatively developed West Coast states of Penang, Selangor, Malacca and Johor.

As discussed above, in 1991 Prime Minister Mahathir promulgated a new goal, the "Vision 2020", which promoted the idea that Malaysia would be an industrialised and developed country by the year 2020 in its 'own mould'. In the Seventh and Eight Malaysia Plans, covering the period from 1996–2005, a knowledge-based development started with the use of information and communication technology in all sectors of the economy to improve productivity (Turpin and Krishna 2007: 146). The Multimedia Super Corridor Malaysia and the new city of Cyberjaya

were built to spearhead Malaysia's development into a knowledge-based economy by utilising information and communication technology.

The Ninth Malaysia Plan, which covered 2006–2010, emphasised "knowledge" for development and innovation. The development of high-tech industries was to be concentrated in technology-based knowledge clusters (Gerke and Evers 2011: 5–6). The implementation of economic corridors, or cluster development, was spearheaded by the major GLCs and the government's investment arm Khazanah Nasional. The economic regions and their corridors are shown in Figure 1. Penang is integrated into the Northern Corridor Economic Region (<www.ncer.com.my>).

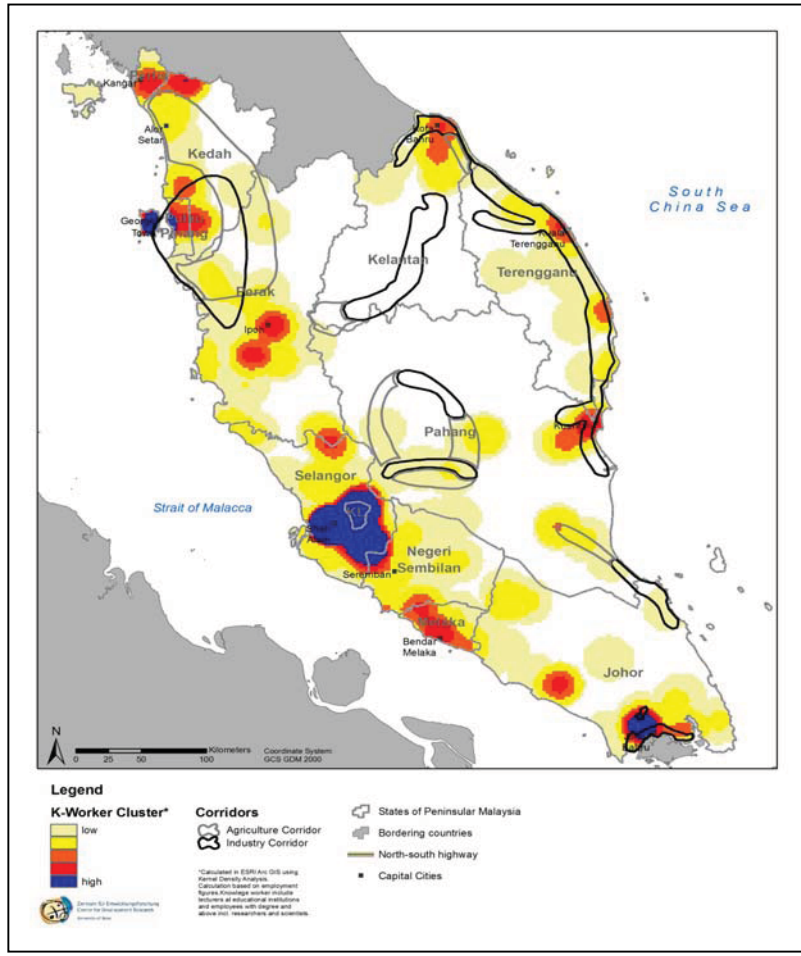
The New Economic Model (NEM) was created to help ensure that Malaysia achieved the target. The NEM emphasises the formation of clusters and corridors concentrated on specific economic activities. Its focus is on innovation and productivity growth, in addition to technological advancement and entrepreneurial development. Development regions and corridors provide the spatial framework for government support and investment plans. Realisation of these plans will depend on the on the government's financial strength and, ultimately, on the economic development of ASEAN and the world economy (Evers and Nordin 2012).

Case Study: Penang as a Knowledge Hub

Malaysia has two strong knowledge clusters: the Klang valley with KL and the MSC, Penang State, and a number of smaller clusters. A calculation of the density of knowledge institutions and knowledge personnel show the epistemic landscape of Malaysia. Penang has the potential to change from an industrial cluster to a knowledge cluster. For this purpose, Penang must reinvent itself as a "knowledge hub" (Evers 2011; Evers and Sezali 2012).

Around Georgetown, Penang (see also Gerke and Evers 2011), as well as in other places along the Straits of Malacca, the modern knowledge clusters emerged mostly at localities that have had a long tradition of trade and learning (Gerke, Evers, and Hornidge 2008). The growth and the knowledge architecture of knowledge clusters and hubs appear to be highly "path dependent"; that is, determined by history. This fact is often neglected in development programmes advocating the establishment of knowledge hubs "out of the blue" without regard for the existing knowledge landscape.

Figure 5: Knowledge Clusters and Development Corridors



Source: Evers, Nordin, and Nienkemper 2011; Evers 2011 and Northern Corridor Economic Region (<www.ncer.com.my>); Iskandar Malaysia Development n.d., East Coast Economic Region <(www.ecerdc.com>).

The history of schools of higher learning in the Straits of Malacca region correlates with the rise and fall of centres of trade along the pathway. Malaysia's first modern school opened in Georgetown, the country's centre of maritime trade at the time. The first university in the region was founded in what was then the British Crown Colony of Singapore, now NUS. While Malacca had been the most important trading port

from the fifteenth century right up to the early nineteenth century (long before the first universities in the Straits region), it was overtaken by Georgetown/Penang and Singapore in the later nineteenth and twentieth centuries. Today, Malacca mainly houses branch offices of Malaysian schools of higher learning, with no main campus, while the knowledge structures of Singapore and Penang (in 1969, the Universiti Sains Malaysia was founded in Penang) rest on a far more diverse environment of universities, polytechnics, private and public research institutes (Gerke and Evers 2011).

Penang is one of the knowledge clusters of Malaysia that has a large number of universities, research institutes, and research and development (R&D) divisions located closely together. Cooperation between the sectors somewhat mirrors the development of Penang's export-oriented industry. "Penang is well placed to become a hub for the Northern Corridor, the Indonesia, Malaysia, Thailand Growth Triangle and the Bay of Bengal […]" (Kharas, Zeufack and Majeed 2011: 53).

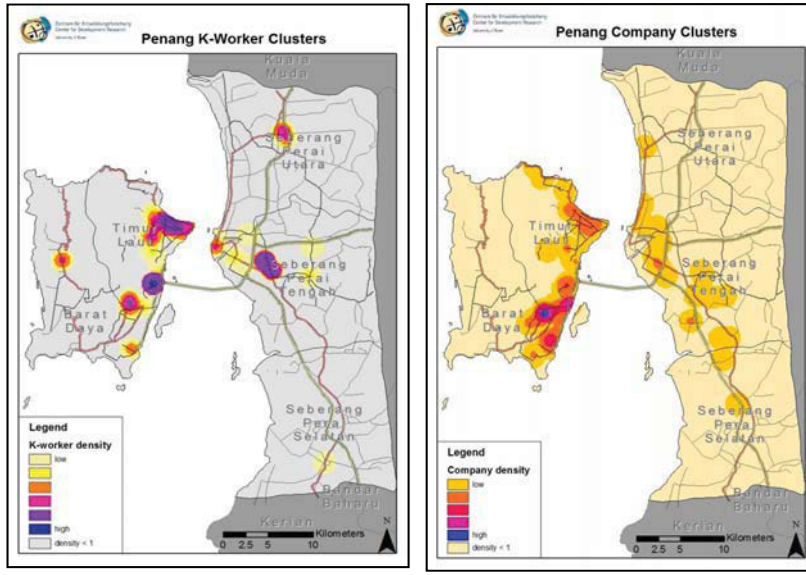
Cluster theory predicts an optimal output of knowledge in the form of innovations, patents and research papers. In the context of our study, we add the idea that the knowledge hub function – that is, close cooperation between the institutions as well as external connections – is an additional precondition for high knowledge productivity. We measured these external connections with an output indicator of joint journal articles to which Penang researchers have contributed. We have only taken scientific research results in internationally recognised journals into account. Therefore, the indicator does not measure all projects of cooperation with international institutions, but only those that are documented by publications that are recognised, visible and accessible.

In the following section we present results of our analysis and data with a focus on changing international cooperation worldwide.

Penang is one of the traditionally grown centres of higher education and research along the Straits of Malacca and within Malaysia. During the past 40 years, USM (which currently has approximately 1,300 researchers, lecturers and professors) clearly emerges as the main producer of published research results in cooperation with international partners, followed by the Penang General Hospital as a leading institution in medical research. Other universities and colleges show surprisingly low international cooperation. Private sector companies are increasingly taking part in collaborative research, but remain dwarfed by USM and other research institutes. The World Fish Center and the Fisheries Research Institute stand out in this regard.

In general, it is interesting to note that most of the international research output is based on cooperation with foreign universities rather than local Malaysian universities and institutions. Therefore, we have concentrated on analysis of the evolving international network of scientific cooperation over the past 40 years.

Figure 6: Penang Knowledge Clusters



Source: Evers 2011: 36.

Patterns of Scientific Cooperation

Social systems theory has taught us that, over the course of history, societal subsystems become increasingly differentiated to reflect and cope with the complexities of modern societies. Highly differentiated systems are the most effective at dealing with external threats and have a higher capacity to cope with the external social and economic environments. Increasing systems differentiation also requires increasingly sophisticated system governance, but differentiated systems produce higher output.

All in all, we can observe changing patterns of scientific cooperation over the last 40 years – changes that may have been triggered by external events rather than by changes in the science system itself.

Table 1: Patterns of Scientific Cooperation

	Dominant Scientific Cooperation	Centuries
Colonial Legacy	Commonwealth Countries, mainly the UK, Australia and Canada	1970s to mid-1980s
Globalisation	EU (incl. UK), China, India, Japan, ASEAN (mainly Thailand)	mid 1980s to mid-1990s
Asian Century	China, India, Japan, ASEAN (Thailand, Singapore, Indonesia) Australia, EU	1990s
India and the West	India and EU and Iran	2000–2011

Source: Authors' own compilation.

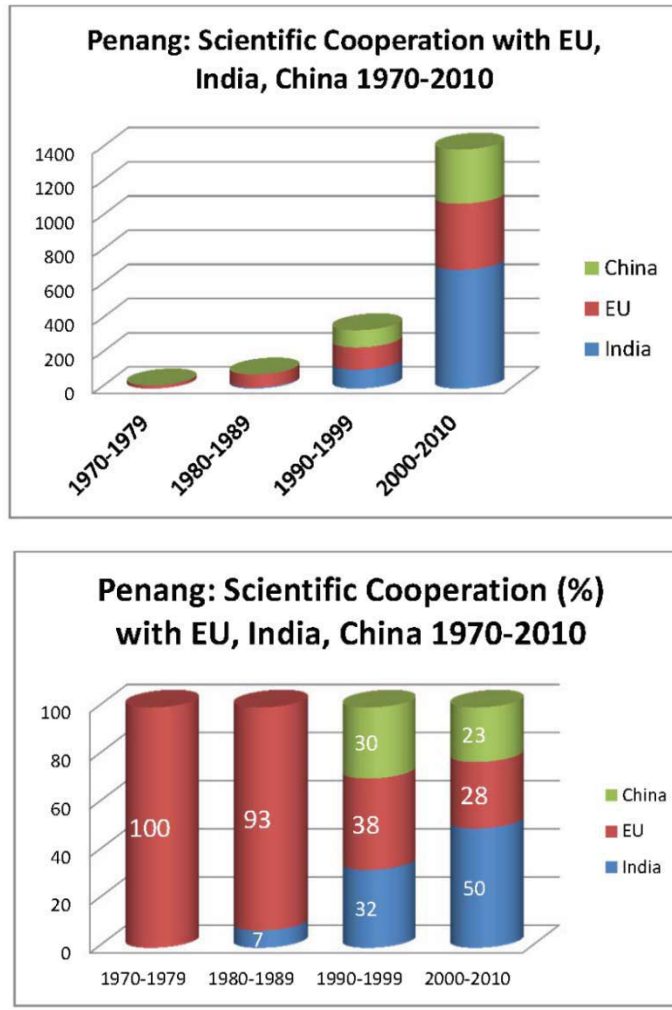
In the following we take a closer look on how international scientific cooperation evolved over the last 40 years (Gerke and Evers 2011). Although we collected data on all countries worldwide, we will look here at measurable output that exceeds one or two publications a year. This is done by looking east from Malaysia at China and Japan, and further east at the United States. If we look west, India is the dominant science hub, whereas researchers in Pakistan and Bangladesh only produced a few joint papers with Penangites. With the exception of Iran, this is also true of Middle Eastern countries. Europe, including the dominant United Kingdom, is the main cooperation partner in the Far West. As we will see later, scientific cooperation with other ASEAN countries is slowly emerging. If we look east, China and Japan are the major cooperation partners, whereas the USA plays a relatively minor role even further east.

The time series of our data show the rapidly increasing international cooperation, especially after the foundation of the second Malaysian university in 1969, first as the University of Penang, then renamed in 1971 as Universiti Sains Malaysia (USM).

The data show evidence that the colonial legacy is mirrored in academic cooperation and joint paper writing in the 1970s and 1980s, as the majority of articles have been published with colleagues from the Commonwealth countries of the UK, Australia and Canada. From 1980–1989 a similar picture emerges, but this changes in the 1990s, when ASEAN countries (especially Thailand and Indonesia) and several European countries appear on the landscape. Scientific cooperation with India and China started in the early 1990s, when joint publications with India and China were nearly at the same level and Japan became more important as a partner. The significant rise of cooperation with China is probably also due to more liberal politics in that country. Since 2000 we can see a dramatic change in science cooperation, as the number of publications written with colleagues from India far exceeds those from China and Europe. Interestingly, cooperation in the form of joint paper writing is lower with colleagues from the US than from Europe. In recent years, scientific

cooperation with India, especially in the sciences, has risen dramatically and overhauled China.

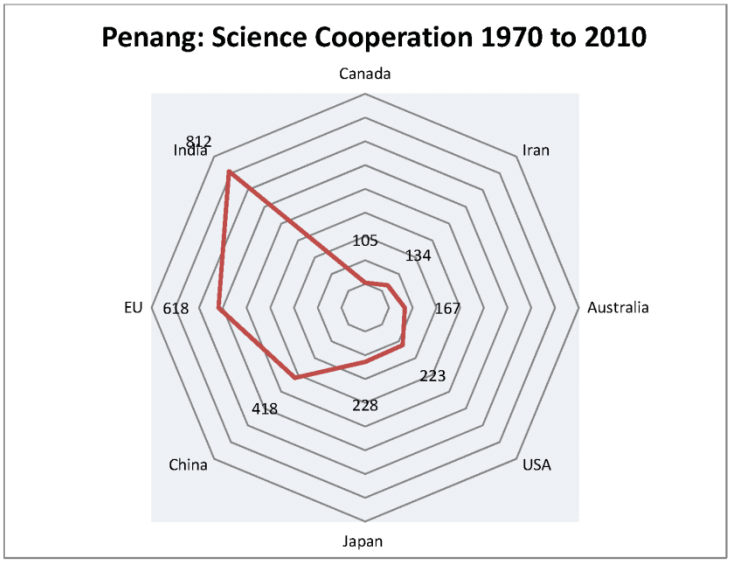
Figure 7: Scientific Cooperation of Research Institutes, Universities and Companies in Penang State with the EU, India and China 1970–2010 (Joint Articles in Scientific Journals, ISI Web of Science)



Source: ISI Web of Science 2011.

The dramatic increase of joint research and publication with India from 2000 to 2011 is surprising. The next step would be to look at the individual partners, as well as the topics, to see with whom and in which field most of the scientific cooperation takes place. To date, we have no explanation as to why China, contrary to all expectations, has fallen behind.

Figure 8: Percentage Distribution, Scientific Cooperation of Research Institutes, Universities and Companies in Penang State with the EU, India and China 1970–2010 (Joint Articles in Scientific Journals, ISI Web of Science)

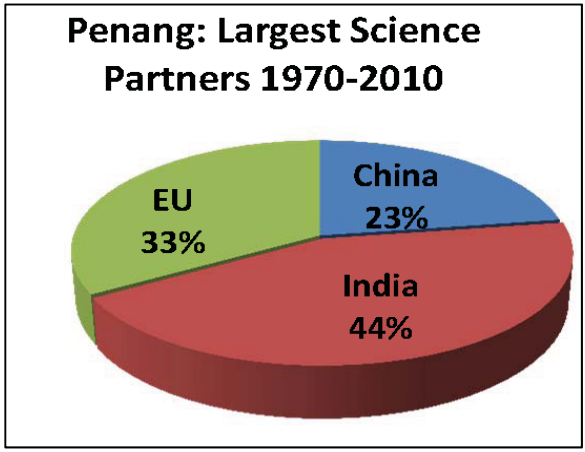


Source: ISI Web of Science 2011.

As Figure 7 shows, India, the EU and China accounted for 55 per cent of all joint article publication between 1970 and 2010.

Although there are insufficient data on knowledge exchange within Penang, it can be assumed that there is room for improvement. The so-called "triple helix" of research institutes, government and industry needs to be strengthened. Our maps show that clusters of knowledge workers and high-tech companies do not completely overlap. This can be taken as an indicator that industrial companies are short of knowledge workers.

Figure 9: Penang Scientific Cooperation 1970–2010



Source: ISI Web of Science 2011.

USM as an APEX university has impressive research capabilities and has improved its international cooperation considerably, but it is still not clear how far this potential is utilized to support industrial R&D, NGOs and government agencies (Gerke and Evers 2012). Penang can develop and integrate its knowledge clusters further and advertise its position as one of the major knowledge hubs in Malaysia and the ASEAN region. The existence of knowledge hubs provides incentives for investment and attracts capital and high-level manpower.

We can sum up our arguments and results so far by saying that, in the case of Penang, the cluster policy has worked. The development of a dense cluster of high-tech industries with their own R&D capabilities, the founding of a major university and a number of other institutions of higher learning, and research and supportive government agencies – in short, a consistent cluster policy – has resulted in economic development with a strong export sector supported by a strong local economy. The salient results of this cluster policy can be summarized as follows:

1. Penang has strengthened its position as one of Malaysia's premier knowledge hubs by engaging in scientific cooperation worldwide. Since its start in the 1970s, scientific cooperation has shown an impressive upswing.
2. Penang has divorced itself from the colonial legacy of sole cooperation with the UK and other Commonwealth countries (such as Australia, Canada) and has gone global, first establishing cooperation

with neighbouring ASEAN countries, then with China, Japan and India.

3. Contrary to expectations concerning the dominance of China in the "Asian Century", India has emerged as the major scientific cooperation partner of Penang, followed by the European Union countries. As the Middle East is also gaining in importance, Penang scientists are increasingly looking west rather than east.

Conclusion

The Malaysian corridors planned by the policy makers mostly centred on the natural resources available in the respective states. Agriculture and natural resources such as petroleum and tourist sites are the main catalyst for the corridors. The GLCs selected to spearhead the respective corridor development (Sime Darby, PETRONAS and Khazanah Berhad) are also concentrated on these sectors. The GLCs are primarily involved in plantation, oil and gas, and property development. None of the corridors are planned for ICT or knowledge-based industries apart from the electric and electronic cluster in the northern corridor.

The corridors do not correlate with the government's aim of becoming a knowledge economy (see Figure 5). The industries planned are mostly engaged in tourism and agriculture. As observed by Fatimah (2009), progress in the Malaysian agriculture and plantation sector in general has not lead to invention and innovation, but to high dependence on foreign labour. The creation of development corridors that neglect the human capital factor will definitely produce the unintended results, as can be seen in the development of Cyberjaya. Physical infrastructure alone will never produce the innovative and knowledge outcome. Despite the increasing number of publications on knowledge clusters, no consensus has emerged on the factors that lead to success. We can guess that a "right" mix of institutions must be assembled in a successful cluster, but what exactly would be the right mix at any stage of economic development is still not clear. However, we can conclude that the foundation of single knowledge hubs, like the foundation of a university or research institute, will not be successful in isolation. As our data show, the spatial connection between research institute, institutes of higher learning, knowledge-based industries and supporting government agencies has been a relatively secure road to success. It can be hoped that, in the case of Malaysia and elsewhere, partisan science politics will not detract from the goal of building diverse and successful knowledge clusters.

The preliminary analysis of our data pertaining to Penang as a knowledge hub and the Malaysian "corridors" has yielded some results of relevance to a successful science policy, but the analysis needs to be developed further to produce more robust outcomes.

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