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Methodological framework for cluster analyses

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1 Characteristics and success factors of clusters

According to Porter (e.g. 1990, 1998, 2000), spatial proximity to other actors within a regional or national territory can increase the international competitiveness of branches. **By clusters we understand the spatial concentrations of enterprises, research institutions and intermediaries of a branch or related branches, which as linked by value-added chains.**[1] Depending on the cluster forming activities and the mix of important cluster actors, clusters can be restricted to production activities in a sectoral specialisation, but can also focus on certain (emerging) technologies and related innovation activity (Audretsch/Feldman 1996; Brenner 2005; Carbonara 2004). Nevertheless, innovation activities can also be the characteristic of mature clusters (Alfonso-Gil et al. 2003).

Due to the spatial concentration, agglomeration advantages can be assumed, which above all take the form of positive external effects such as access to specialised human capital, preliminary inputs and information spillovers. Porter proceeds from the central assumption that international competitiveness can be strengthened above all by means of such a competitive and simultaneously supportive environment in close spatial proximity. He thus at the same time provides an explanation for the attractiveness of certain locations. He distinguishes **four relevant environmental conditions (dimensions of the diamond)**, which determine the competitiveness of a cluster (cf. figure 1).

In the ideal case, these conditions mutually encourage each other in a cluster, so that the system-immanent dynamic leads to cumulative growth of the enterprises. Learning effects and the long-term development of trust play an important role in this model (cf. Porter 1990: 26-27). At the core of Porter's concept lies the assumption that enterprises in a global economy can only achieve a sustainable competitive advantage through local assets to which distant competitors have no access.

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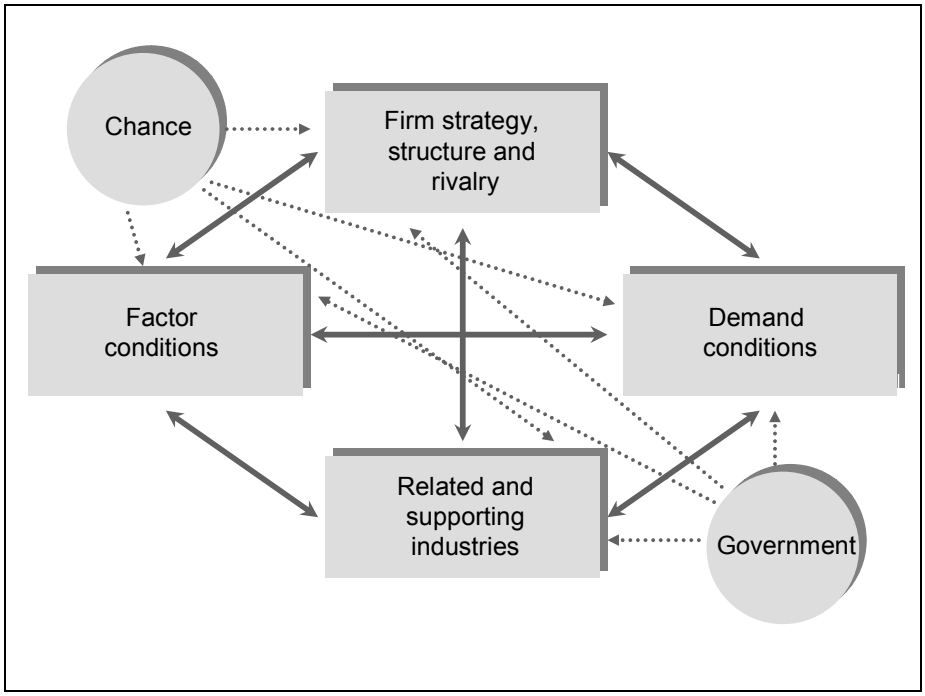
1 Porter defines clusters as "geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. They include, for example, suppliers of specialized inputs. Clusters also often extend downstream to channels and customers and laterally to manufacturers of complementary products and to companies in industries related by skills, technologies or common input. Finally, many clusters include governmental and other institutions that provide specialized training, education, information, research and technical support." (Porter 1998: 78).

Figure 1: Porter's Diamond



Source: Porter (1990)

Competition according to Porter is no longer decided by low factor costs, but through the productive utilisation of input factors. This implies the necessity to constantly innovate (cf. Porter 1998: 78). Two environmental conditions are particularly prominent: competition and domestic customers (cf. Larsson/Malmberg 1999: 4-5). According to Porter, not only the proximity to competitors but also to customers contributes decisively to technological and industrial development. Despite the emphasis on the competitive aspect, the cluster concept is also characterised by collaborative elements – however, only along the value-added chain, that means in the vertical dimension (cf. Cooke 1998: 5).[2]

Malmberg and Maskell (2002) argue that agglomeration advantages refer less to (static transaction) cost savings, but are rather of a subliminal and institutional respectively socio-cultural nature. A common location offers language and cultural similarities, which promote communication and thus can increase the diffusion rate of knowledge. This **local communication and interaction context** is especially advantageous in the case of knowledge which is difficult to codify or impart, because it provides a joint

2 Porter argues that the spatial concentration enables firms to discern effects of scale without forming formal networks, but merely by means of informal exchanges: "A cluster allows each member to benefit *as if* it had greater scale or *as if* it had joined with others formally – without requiring it to sacrifice its flexibility" (Porter 1998: 80).

knowledge basis on which the exchange of knowledge can build (cf. Lagendijk 2001: 86; Malmberg et al. 1996: 91; Malmberg/Maskell 2002; Maskell/Kebir 2005). In contrast to the traditional agglomeration approach, Maskell does not differentiate between localisation and urbanisation effects, but between horizontal and vertical dimensions of agglomeration and their significance for the local knowledge base. Spatial concentration of the vertical dimension can promote acceleration of knowledge growth in the cluster, as a result of division of labour and specialisation. The advantage of agglomeration of the horizontal dimension lies on the other hand in the diversity and breadth of the available knowledge (cf. Maskell 2001: 12). The **advantage of a sectoral or technological concentration** of firms lies in the fact that due to different perception capabilities, insights and attitudes, an entire range of solutions for similar problems can be observed. The observation, comparison and discussion of these diverse approaches make a continuous learning process possible for enterprises, which can ensure their survival (cf. Maskell 2001: 9-10). Table 1 summarises the most important characteristics which are necessary attributes of a cluster and by which it is possible to distinguish different types of clusters.

In a comprehensive study, van der Linde (2003) collated investigations on 773 clusters from 49 countries and analysed the most important data of these clusters. Most of the clusters are to be found in Great Britain (144) and in the USA (141), whereas only 29 clusters were identified in Germany.[3] The clusters show a great variety with regard to size, whereby the mean is 150 firms per cluster and the number of smaller clusters predominates. Over two fifths of the identified clusters had less than 100 firms[4], approx. one quarter consists of more than 600 firms. Clusters in Germany consist on average of 76 firms and 5,000 employees. In particular Canadian, US American and British clusters on the other hand are many times larger. Across all country borders however approx. one quarter of all the clusters investigated exhibited significance only at the national level, a further quarter is described as weak and not competitive (van der Linde 2003: 135-138).

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3 It must be assumed that these figures represent less the real cluster population than the differences in the public and academic interest in the respective countries. Brenner (Brenner 2004) identified 400 local industrial clusters in Germany, on the basis of job market data, which was collected for districts and district-free towns at the three-digit level of the NACE classification. In 158 districts and district-free towns there was at least one cluster. Admittedly, no technology-specific clusters can be identified with a branch-related approach, but the study clearly demonstrates the versatility of cluster activities in Germany.

4 The smallest cluster investigated consists of a core of only three firms, which however together capture circa 90% of the world market share, employ hundreds of qualified staff, have their own specialised suppliers and distinguish themselves by extremely tough competition.

Table 1: Characteristics of Clusters

Typical feature	Characteristics		
Actors	Competitive firms of one branch/one specific technology	Firms of one branch/ technology that are active in different markets	Cross-branch or cross-technology mixture of firms of a value-added chain
	Complementary and supplier firms and services (including private research activities)		
	Mixture of large, medium-sized and small firms		
	Research organisations (including universities) and innovation intermediaries		
	State and semi-state organisations of the branch (among others, specialised educational institutions)		
	Demanding customers		
Spatial extension	Local	Regional	Supra-regional (national)
Number of actors	Branch-specific (reference: over 30 firms or large world market share)		
Geographical orientation	Closed internal / regional networking	Regional interaction / network density in connection with inter-/national relationships	Low internal coherence with strong integration in inter-/national division of labour
Job market	Qualified and specialised staff		
Relationships between enterprises	Formal relationships mainly in the vertical direction		
	Hardly any formal relationships in the horizontal direction		
	High degree of information/communication relationships		
Competitive type	Nightcap competition, "lock in"	Cooperative competition	Tough competition
Competitiveness	Low competitiveness	Nationally competitive	Internationally competitive

The study points to a positive and statistically significant link between the cluster size in terms of employees and its competitiveness. Clusters with more than 30,000 employees are the most competitive, while those with smaller numbers of employees occupy a less significant position internationally. Under the 10,000 employees limit, however, competitiveness increased again slightly. It was conspicuous in clusters with less competitiveness that they did not display all factors of the diamond, above all not the condition of tough competition, which played an important role in the clusters with international significance. Coincidences or state influence on the other hand tend to play a role in clusters which are less competitive (van der Linde 2003: 140-141). The most

decisive success factors of competitive clusters which emerged from literature studies are presented in table 2).

Table 2: Success factors of clusters

Success factor	***Kind of measurement***
1. Cluster structure	
Spatial proximity to other actors within a regional or national territory with consistent institutional framework conditions	quantitative
Critical mass of firms and / or institutions which have an outstanding position in a national comparison	quantitative/ qualitative
Competitive environment/ tough competition	quantitative/ qualitative
Factor conditions in form of specialised human capital and inputs (including research)	quantitative/ qualitative
Demanding customers who stimulate innovations	quantitative/ qualitative
Related and supporting branches	quantitative/ qualitative
Scale effects even without forming formal networks, merely through informal exchanges	quantitative/ qualitative
Learning effects, long-term development of trust, similar values	qualitative
Dynamic agglomeration effects, above all information and knowledge spillovers, also between competitors/ via central institutions	qualitative
Internal/regional network density and cohesion, at the same time inter-/national integration	quantitative/ qualitative
2. Impacts and results	
International competitiveness of the sector	quantitative
Sustainable competitive advantages through local elements to which distant competitors have no access	quantitative/ qualitative
Continuous innovation	quantitative/ qualitative
Attractiveness of the location for the manufacturing firms, service providers, research institutions, and intermediaries active in or for the sector	quantitative/ qualitative

Depending the corresponding value-added chain and the selected region, the thresholds for the economic, institutional and geographical concentration of a cluster may vary. The **ideal of a functioning cluster** is characterised by a pronounced internal functional differentiation and manifold, redundant exchange and communication relationships. Transaction relationships exhibit a high network density and cohesion, in connection with strong supra-regional integration at a national and international level.

The institutional infrastructure of the cluster is functionally versatile, whereby the cluster-specific, innovation-relevant institutions have a central role as regards information diffusion.

Like the cluster concept, a **strategy to promote clusters** can also be clearly delineated only with difficulty. Although various studies comparing different cluster types already exist, the question, which development strategy achieves the best results under the given sectoral and regional conditions, still cannot be satisfactorily answered (cf. Fromhold-Eisebith/Eisebith 2005). There exists not only the danger that novel and small, but growth-intensive product fields are not sufficiently taken into account, but also that the orientation to popular trends with similar promotional focuses as in other regions takes place. In any case an estimate is necessary whether the regional firm concentration already represents a "critical mass" (or could reach one) to which structural policy strategies can be meaningfully linked (cf. Krätke/Scheuplein 2001). In general, cluster promotion builds on already existing potential and thus takes the existence of regionally concentrated firms and other organisations for granted. Measures aim to activate and strengthen promising qualities of "proto-clusters", whose development should be encouraged. In some Asian newly industrialising countries (NIC) there are also political approaches to establish clusters without any previous basis "on green fields". Generally, however, in cluster research it is assumed that these strategies will only seldom be crowned with success (see Fromhold-Eisebith/Eisebith 2005).[5]

5 In Japan also not all clusters planned by the Industry and Research Ministry have proved to be successful (cf. NISTEP 2004).

2 Identification and characterisation of clusters

Due to different sizes and forms of clusters and their "natural" development difficulties arise in the identification of clusters which should not be underestimated. The functional relationships of clusters cannot be gathered directly from official statistics. Clusters particularly in the areas of high technology and higher quality services are frequently "milieu-based" and are driven forward by the interaction between discretely developing technologies and products which cannot be recorded with statistical methods. The challenge consists in (see Krätke/Scheuplein 2001):

- demarcating clusters on the functional and spatial plane,
- showing the internal interlinkages of the actors and
- making a comparison (intra-regional or supra-regional) possible.

Although in the meantime many and diverse examples of regionalised innovation and structural policies exist which aim at the spatial concentration of networked companies and organisations in a special sector or technology (cluster) (Porter 1998), the prior identification and selection phase of clusters has been relatively little researched. No general method is available, either with regard to the key variables to be measured or regarding the procedure for spatial demarcation (Sternberg/Litzenberger 2004). Generally, however, it is assumed that the first step in each cluster identification is to determine a spatial concentration. The further analysis can build on the compilation of regional firms and (research) organisations, among which economic relationships are presumed or considered meaningful (Krätke/Scheuplein 2001). Such an analysis proves difficult because clusters are distinguished besides "hard" factors (e.g. firms, research and intermediary actors) also by "soft" factors (e.g. cooperative competition, high degree of information and communication relationships, core competences) (see section 1). The assessment of the size and composition of a cluster is determined in addition basically by the sector / technology or respectively the market segment. The crucial questions to pose in identifying clusters are:

- When can one talk about a cluster?
- Which are the most important functions and value-added connections in the cluster?
- Where are the approaches / starting points for a targeted, cluster-oriented policy?

A comparison of different cluster policies (e.g. Raines 2001; 2003) shows that the techniques with which the fundamental analyses are conducted vary greatly, not only in methodological strictness but also in complexity. The scope ranges from wide-ranging statistical analyses with complex input-output models up to studies based on qualitative interviews. Independent of the selected method, the results of such an analysis form the necessary basis for developing specific cluster promotion measures. In general, no

previously unknown competitive sectors are discovered. The analysis can however reveal important or missing links and dependencies, also between various industries, and draw attention to niches. Above all, findings about newly emerging or until now untapped research strengths have appeared as important (Raines 2001).

For a first identification of clusters, special quantitative measures can be helpful, such as those recently developed by for instance Sternberg and Litzenberger (2004), i.e. the cluster Index or Rosenfeld et al. (2004), i.e. economic development cores. With the help of these measures similar clusters can also be identified, which can then be used for benchmarking, in order to elaborate missing steps in the value-added chain, or strengths and weaknesses of the cluster.

The so-called cluster index of Sternberg and Litzenberger (2004) correlates the relative enterprise density (ID), the relative enterprise status (UB) and the relative company size (BG) to each other:

$$CI_{ij} = UD_{ij} \times UB_{ij} \times \frac{1}{BG_{ij}} = \frac{\frac{e_{ij}}{\sum_{i=1}^{n} e_{ij}}}{\frac{i_i}{\sum_{i=1}^{n} i_i}} \times \frac{\frac{b_{ij}}{\sum_{i=1}^{n} b_{ij}}}{\frac{a_i}{\sum_{i=1}^{n} a_i}}$$

The indices refer to the respective sector (j) and region (i). The size of the cluster index is proportional to the number of employees (e_{ij}) and the number of enterprises (b_{ij}) as well as conversely proportional to the size of the region (a_i) and the number of inhabitants in the region (i_i) and varies between zero and infinity, whereby one stands for the average. If the value of the cluster index is above one, then a spatial concentration and specialisation begins to emerge, which can indicate a cluster or the beginning of one. Sternberg and Litzenberger (2004) have determined the critical value for the existence of a cluster (arbitrarily) as four. The advantages of the cluster index lie in its flexibility, straightforward calculation and the existence of the necessary data. Problems which emerge because clusters cut across sector classifications or cannot be adequately depicted in the Standard Industrial Classification or in NACE are not solved by the index calculation. It is also not possible to identify the characteristics of a cluster, i.e. its production or innovation orientation. The index can only provide first starting points for identifying a cluster.

In the economic development cores approach developed by the Institute for Economic Research Halle (IWH), quantitative indicators (employees, patents) are linked with

qualitative survey results (Rosenfeld et al. 2004). Economic development cores are given if a region displays

- regional branch focuses (sectoral specialisation according to number of employees, first to seventh most important location within the country or parts of it),
- enterprise networks (internet searches, experts interviewed) and
- innovative competence fields (a minimum of patent applications in a certain period, while the minimum depends on the level of the national patenting activity; additional experts interviews).

For an estimate of whether the regional firm concentration presents or could achieve a "critical mass" to which structural and innovation policy measures could be meaningfully linked, simple measurements with the cluster index or the economic development cores do not suffice. Central problems in the quantitative analysis are

- lack of data on the regional level and
- difficulties in identifying and demarcating the relevant sectors according to NACE classes, as this classification is product- and not value-added-chain-oriented.

In addition, many growth branches like bio- or nanotechnology are not captured by the NACE. Therefore a mixture of quantitative and qualitative methods should be utilised (Austrian 2000; Brown 2000). Table 3 provides an overview of the most important methods and indicators which can be utilised, based on the success factors of clusters (table 2).

Table 3: Methods to identify and characterise Clusters

Dimension	Characteristic	Method/Indicator
1. Cluster structure		
Critical mass and internal functional structure	*Critical mass*	Number and share of firms / employees in the sectors of the total number in the sectors (nation)
		Patent and bibliometric indicators
		National / world market share of the enterprises in cluster product / service area
	Existence of crucial links of a value-added chain (core competences)	Sectoral input-output analysis
		Expert surveys (e.g. research and educational institutions)
	Completeness of the value-added chain	Benchmarking (comparison with as complete as possible, "ideal" value-added chain)

Dimension	Characteristic	Method/Indicator	
1. Cluster structure			
Regional and supra-regional networking	*Quality of regional networking regarding intensity and effectiveness*	Network analysis	Network density
			Network cohesion
			Network centralisation
	Relationship of regional to supra-regional integration, support through complementary clusters, proximity to other agglomerations	Regional input-output analysis	
	Intra-regional information flows, joint utilisation of research results / technologies	Actor survey, patent and bibliometrical analysis	
	Dimensions of the cluster, geographical concentration	Localisation coefficients, variation coefficients	
2. Impacts and results			
International competitiveness	*Growth and growth potential*	Job and turnover growth in relation to regional / national level	
		Productivity, shares of value added	
		Trend analysis of future market development (market and branch trends)	
	Supra-regional competitive situation	Export specialisation, comparative advantages / disadvantages in foreign trade (RCA)	
		Market shares, international direct investments	
	Excellence in research	Regional patent analysis	
		Bibliometric analysis	
		Third party funding in universities	
		Share of international researchers male /f emale	
		Private and publicly funded R&D expenditures	
	Human capital	Ranking of universities and other educational institutions, faculties, numbers of students	
		forecast of demographic development	

The individual methods each have specific advantages and disadvantages. For this reason alone it is meaningful to combine various different methods. A final assessment of the "critical mass" can only be carried out in each individual case against the background of the specific sectoral and technological framework conditions and must include also qualitative analytical methods alongside quantitative ones in order to avoid a too "mechanistic" procedure (Krätke/Scheuplein 2001). Which of these methods and indicators should be applied in the investigation of the development potential of a cluster depends on the respective question, the already existing knowledge base, the cluster structure as well as weighing the costs and benefits of such an analysis against each other. The decision in favour of an effective cluster promotion and the development of a cluster development strategy can only be meaningfully taken on the basis of a prior study. The findings aimed for and the depth of the study depend, however, on

the specific individual case. Generally speaking, a combination of quantitative and qualitative survey methods is to be recommended, in the form of analysis of regional statistical data together with interviewing experts and actors involved (cf. table 4).

Table 4: Quantitative and qualitative approaches for cluster analyses

Regional statistical analysis

to calculate

- concentration measures (e.g. absolute concentration, localisation coefficient)
- innovation indicators (input coefficients in the form of R&D expenditures and R&D personnel, throughput/output coefficients in the form of regional patent profiles)

Expert survey

about

- reconstructing/ understanding information and communication channels
- reconstruction of value-added chains (classification of categories of industrial branch systematics, e.g. NACE)

Interviewing cluster actors (enterprises, universities, research institutions, intermediaries, financial institutions, educational institutions)

to collect data on

- product and performance spectrum
- forms of cooperation
- institutional integration
- formal transaction relationships (economic exchange relationships to suppliers, customers, cooperation partners/ competitors)
- informal communication relationships (contact networks, personal exchanges)

Together with the regional statistical analysis, the survey results produce a more accurate picture of the specific regional profile of the value-added chain, which can be compared with the profile of other similar clusters, in order to determine particular strengths and weaknesses, respectively the absence of links in the value-added chain, or the presence of special core competences. These cluster profiles should in addition be compared with the success factors of clusters (cf. table 2), in order to identify the most significant starting points for promoting future competitiveness.

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