Sonderdruck

Techno-economic Clusters in Flanders and Switzerland: an Input-Output-Analysis

L. Peeters, M. Tiri, A. Berwert

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IDENTIFICATION OF TECHNO-ECONOMIC CLUSTERS USING INPUT-OUTPUT DATA: APPLICATION TO FLANDERS AND SWITZERLAND

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Information	Patrick Vock Tel +41-31 322 96 63 patrick.vock@swr.admin.ch
Graphik	Michael Kurmann

Vorwort

Die Wettbewerbsfähigkeit eines Standortes hängt mehr und mehr von der Funktionsfähigkeit seines Innovationssystems ab, insbesondere von der Generierung, Diffusion und Nutzung von Wissen. Ein Grossteil dieses Wissensaustausches - über den Markt oder informell abgewickelt - findet in Clustern statt, welche als Innovationssysteme der Mesoebene verstanden werden können und Netzwerke und Wertketten von Lieferanten, Kunden und/oder Wissensorganisationen beinhalten.

Seit mehreren Jahren werden in verschiedenen OECD-Ländern Studien zu Clustern und deren Innovationsdynamik durchgeführt (vgl. z.B. OECD 1999 Boosting Innovation - The Cluster Approach). Die vorliegende Studie flämischer und schweizerischer Cluster basierend auf Input-Output-Daten ist ein Kapital aus dem jüngsten Sammelband der OECD, welcher Beiträge zu Clusteranalysen und -politik verschiedener Länder beinhaltet. (OECD (2001) Innovative Clusters. Drivers of National Innovation Systems. Paris. p. 251-272).

Den Autoren möchte ich für die vorzügliche Zusammenarbeit in diesem Projekt sowie für die Erlaubnis zu diesem Sonderdruck herzlichen danken.

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P. Vock

Chapter 12

IDENTIFICATION OF TECHNO-ECONOMIC CLUSTERS USING INPUT-OUTPUT DATA: APPLICATION TO FLANDERS AND SWITZERLAND

by

Ludo Peeters, LUC, ITEO-DAM, **Marc Tiri,** LUC, ITEO-DAM, and
Adrian Berwert, Rütter & Partner, Concert Research, Switzerland*

Introduction

Since the appearance of Porter's work on the competitive advantage of nations (Porter, 1990), cluster analysis has become a popular instrument in determining the innovativeness and competitive power of national and regional economies. This chapter reports the results of a workable methodology for identifying aggregate techno-economic clusters – so-called "mega-clusters" – in the regional or national economies of Flanders and Switzerland, using readily available input-output (I/O) data. Clusters are identified, based on existing trade linkages (Hauknes, 1999; Bergman *et al.*, 1999). Further, the underlying assumption of the approach adopted here is that economic (supplier-user) linkages between industries – as reflected in the I/O tables (intermediary flows of goods and services between industries) – are the main "carriers" of technology diffusion in an economy, through interactive learning processes (Lundvall, 1992; DeBresson *et al*., 1994; Edquist, 1997). In this sense, economic clusters are part of national innovation systems on a smaller scale, acting as relatively independent "units" of innovation diffusion. The analysis here is closely related to that of Roelandt *et al.* (1997) and van der Gaag (1995), who investigated clusters at sector level.

The clusters that emerge from this I/O approach are made up of *industries* that are closely connected, and not necessarily *companies* that develop innovations through co-operation. In this respect, the notion of "clusters" used in the present analysis deviates from Porter's notion of clusters. Specifically, Porter (1998, p. 199) defines a cluster as "a geographically proximate group of interconnected *companies* [emphasis added] and associated institutions in a particular field, linked by commonalities and complementarities", while the present study focuses on *industries* rather than companies. Moreover, Porter uses a qualitative approach where we will use a quantitative approach. In addition, aspects such as location factors (proximity) and innovativeness are lost. On the other hand, the method presented here covers the whole economy, thus allowing empirical results to be compared across regions and/or industries.

This chapter contains three sections. The first gives a brief account of the I/O-based algorithm used for the identification of economic clusters. The second section presents the empirical results of the cluster analysis at the macro level, as applied to Flanders and Switzerland, respectively. In addition, the economic and technological profiles of the clusters are described, following investigation of a number of important indicators. The final section summarises the major findings of the study and formulates some policy considerations.

* The authors are grateful to Dr. Theo Roelandt and to Drs. Hessel and Verbeek of the Dutch Ministry of Economic Affairs, for their co-operation in developing the methodological basis of the cluster algorithm. The Swiss part of the study was supported by the Centre for Science and Technology (CEST), attached to the Swiss Science and Technology Council. The usual disclaimer applies.

Methodology of cluster identification: the "Method of Maxima"

The cluster analysis presented here is conducted at the macro level. In other words, linkages within and between sector aggregations – designated here as "mega-clusters" – are considered. By using the I/O methodology, the analysis focuses on the intermediate supplier-user linkages. In addition to flows of capital goods, the intermediate supplier-user linkages are viewed as the most relevant type of linkages to define techno-economic clusters, because they follow a pattern that is strongly correlated with the inter-sectoral exchange of information, common R&D and innovation activities, and the diffusion of embodied technology. Capital flows are not covered by the analysis due to insufficient data availability. In addition, our attention is limited to domestic flows of intermediate goods and services, leaving the influence of linkages with foreign suppliers and users open for further investigation.

The method used, the "Method of Maxima" (M-method), classifies sectors according to substantial mutual dependency through their deliveries and purchases in the same economic cluster, and is applied in two consecutive phases. The first phase examines the forward linkages, *i.e.* we look primarily for deliveries that are important from the suppliers' point of view; the second phase investigates the backward linkages, *i.e.* we identify those deliveries that are particularly important from the customers' point of view (for further detail, see Annex). The M-method uses cut-off points (in terms of percentage of total output or total input). When these threshold values are reached – and a sector hence exhibits strong linkages with another sector – both sectors will be attributed to the same cluster. Careful analysis of these cut-off values is necessary as too-low values cause excessive aggregation. On the other hand, setting the threshold values too high could result in many very small clusters and runs the risk that some sectors may not be assigned to any cluster at all.

In the final phase of the M-Method, where the results of the two steps described above are combined, two alternative approaches can be adopted. The first, which is applied to the Swiss I/O data, implies a "strict" cluster delineation that is fully determined by the (objective) outcome of the algorithm. Obviously, when using such an orthodox approach, an appropriate choice of weights is of crucial importance. The second approach, that applied to the Flemish I/O data, allows for some "degree of freedom", in the sense that it is explicitly acknowledged that any final cluster delineation is difficult and involves some prior (subjective) judgement by the researcher. This implies that any particular cluster identification that emerges from the strict application of the algorithm can only be considered as a "starting point" for the final cluster analysis. Hereby, additional clustering criteria like "functional dependency" of the sectors are taken into account.

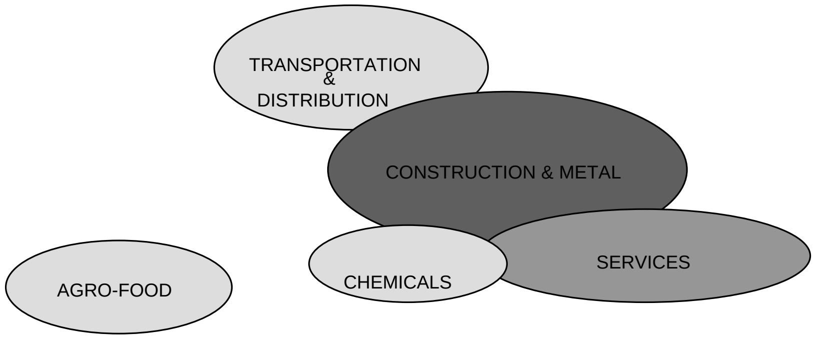
Empirical results for Flanders and Switzerland

Identification of Flemish mega-clusters

Applying the M-method to the Flemish I/O table for 1995 led to the identification of five mega-clusters (Figure 1): "Agro-food" (AF), "Construction and Metal" (CM), "Chemicals" (CH), "Transportation and Distribution" (TD), and "Services" (SV).

Some overlap between these mega-clusters is apparent and is the result of the existence of linkages between sectors of different clusters. For example, there is an important overlap between the SV cluster and the other mega-clusters. In general, the identified mega-clusters are built on one or two core sectors, around which there exists a network of supplying and using sectors. The members of a mega-cluster exhibit strong preferential linkages with each other, but in a number of cases, there are also important linkages with sectors belonging to other mega-clusters. Further, it can be seen that the various clusters show important differences in size, shape and the number of linkages between the constituent sectors. The largest and most centralised cluster of the Flemish economy is the CM cluster, which has important links with other clusters. The AF cluster, on the other hand, has only weak linkages with the other mega-clusters and is primarily self-sufficient.

Figure 1. **Overview of the five Flemish mega-clusters (AF, CM, CH, TD and SV)**

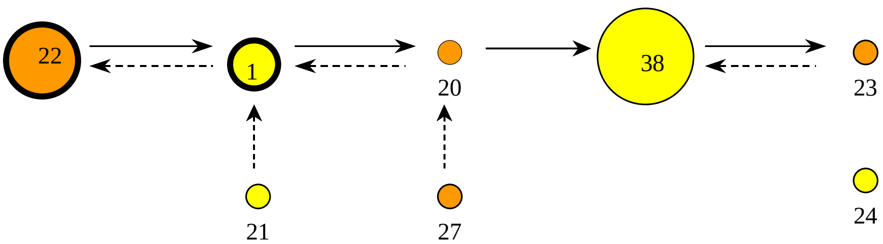


Box 1. **Interpretation of cluster figures for Flanders**

The Agro-food(AF) cluster

The AF cluster is a "compact" mega-cluster, almost entirely made up of sectors involved in the food production system (Figure 2). The various sectors belonging to the AF cluster have strong mutual linkages, yet only weak linkages with sectors from other clusters. Furthermore, the "Agricultural, forestry and fishery products" sector [1] and the "Meats and meat products" sector [20] are obvious and mutually dependent core sectors of the AF cluster. The (small) sector of "Tobacco products" [24] does not meet the predetermined threshold values. Yet, it was assigned to the AF cluster based on the fact that a very large part of its purchases originate from this cluster and because of the nature of the products involved.

Figure 2. **Structure of the Agro-food cluster**

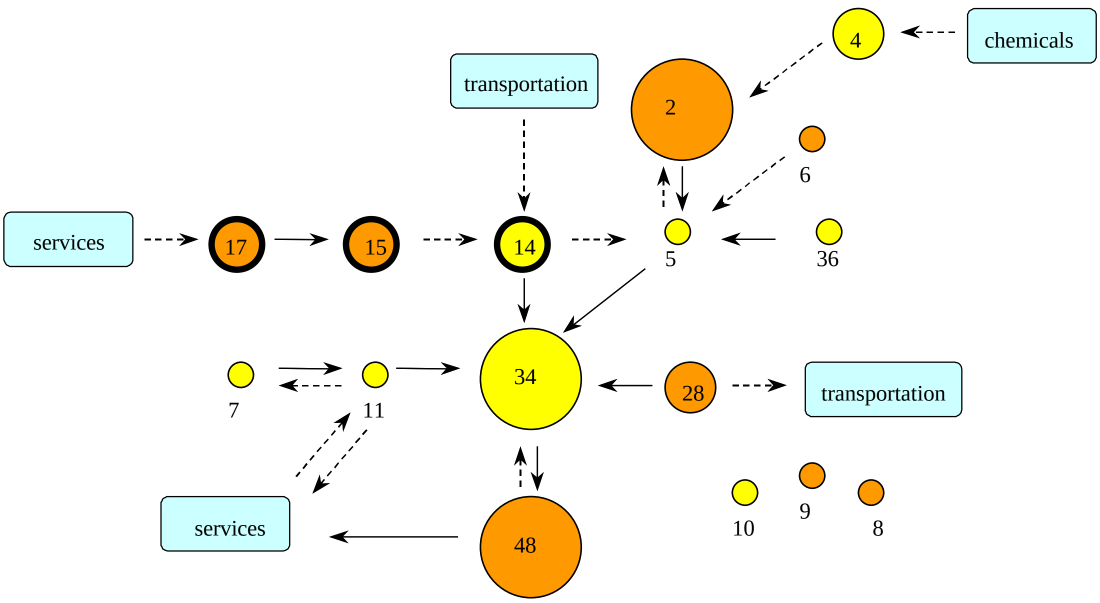


Key: [1] Agricultural, forestry and fishery products; [20] Meats and meat products; [21] Milk and dairy products; [22] Other food products; [23] Beverages; [24] Tobacco products; [27] Leathers, leather and skin products, footwear; [38] Lodging and catering services.

The Construction and Metal (CM) cluster

The CM cluster is a large mega-cluster, dominated by the "Building and construction" sector [34] and the metal-related sectors of "Iron and steel products" [5] and "Metal products" [14]. Around those core sectors, a network of supplying and using sectors is built (Figure 3). The CM cluster is very closely linked with the other mega-clusters. Hence, the CM cluster is an "open" mega-cluster, keeping up important linkages with sectors from other mega-clusters.

Figure 3. **Structure of the Construction and Metal cluster**

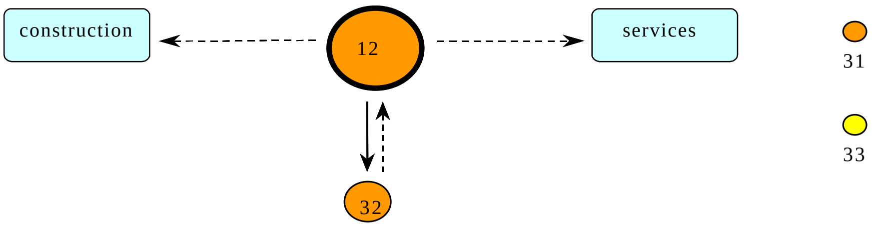


Key: [2] Energy (excluding electricity); [4] Electricity; [5] Iron and steel products; [6] Non-ferrous metals; [7] Cement, lime, plaster; [8] Glass; [9] Earthenware and ceramic products; [10] Other minerals and derived (non-metallic) products; [11] Construction materials; [14] Metal products; [15] Agricultural and industrial machinery; [17] Electrical equipment; [28] Timber and wooden furniture; [34] Building and construction; [36] Recycling and repair services; [48] Renting of immovable goods.

The Chemicals (CH) cluster

The CH cluster is a small cluster, consisting only of four sectors (Figure 4). In this cluster, the sectors of "Chemical products" [12] and "Plastics" [32] take a central role. Both sectors exhibit strong mutual linkages. In addition, the "Chemical products" sector has strong linkages with the CM and SV clusters. The other two sectors belonging to this mega-cluster are the sectors "Rubber products" [31] and "Other manufactured products" [33].

Figure 4. **Structure of the Chemicals cluster**

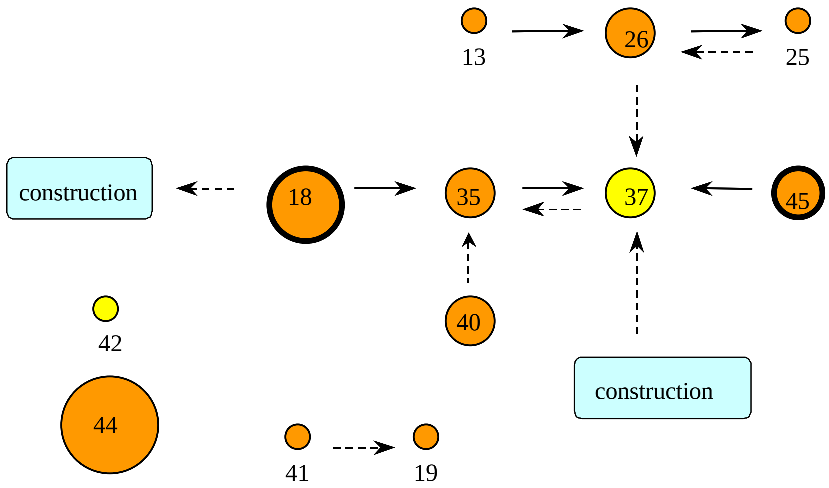


Key: [12] Chemical products; [31] Rubber products; [32] Plastics; [33] Other manufactured products.

The Transportation and Distribution (TD) cluster

The TD cluster is a large and heterogeneous cluster, where the various composing sectors exhibit strong mutual linkages (Figure 5). It is a "bipolar" sub-cluster, in the sense that two sub-systems can be detected: *i)* a sub-system built on sectors related to the "Motor vehicles" sector [18], including the "Car repair" [35] and "Wholesale and retail trade" [37] sectors; and *ii)* a sub-system built around the "Textiles" industry, including the sectors of "Synthetic fibres" [13], "Confection" [25] and "Other textiles" [26]. Further, the TD cluster comprises many transport services sectors that are split up into several “sub-sectors”. This leads to a fragmentation of the supplier-user linkages. However, they are attributed to the TD cluster based on considerations of obvious functional dependency.

Figure 5. **Structure of the Transportation and Distribution cluster**

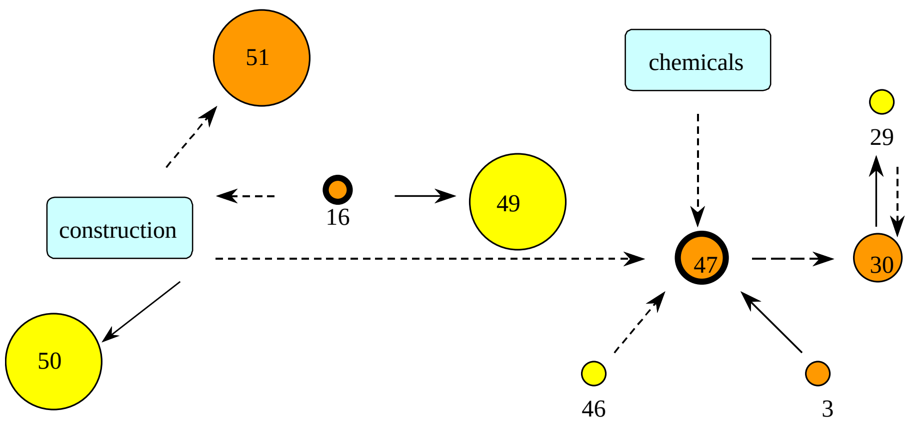


Key: [13] Synthetic fibres; [18] Motor vehicles; [19] Other transport equipment; [25] Confection; [26] Other textiles; [35] Car repair services; [37] Wholesale and retail trade; [39] Railway transport services; [40] Road transport services; [41] Inland navigation; [42] Maritime navigation; [43] Air transport services; [44] Auxiliary transport services; [45] Communication services.

The Services (SV) cluster

The SV cluster contains both commercial services, such as “Banking & insurance” [46] and “Business services” [47], and non-commercial services, such as “Health care” [49], “Public services” [50], and “Education and research” [51] (Figure 6). The central sector “Business services” exhibits strong linkages with the “Banking and insurance” sector, the “Water” sector [3], and the sector of “Paper goods and products of printing” [30]. This latter sector in turn has strong linkages with the “Pulp, paper, board” sector [29]. Several constituent sectors have important connections with other clusters due to the very nature of services, but are categorised here given their functional association with this cluster and the rather important backward linkages.

Figure 6. **Structure of the Services cluster**



Key: [3] Water; [16] Office machines; [29] Pulp, paper, board; [30] Paper goods, products of printing; [46] Banking and insurance; [47] Business services; [49] Health care; [50] Public services; [51] Education and research.

Economic and technological profiles of the Flemish mega-clusters

The economic profiles of the mega-clusters are summarised in Table 1 which shows production value, gross value added, employment, imports and final demand for the various clusters. Relatively speaking, the TD cluster is the most important cluster, in terms of gross value added, closely followed by the SV and CM clusters. The SV cluster is by far the most important cluster in terms of employment, accounting for 50% of total employment in Flanders.

Table 1. **Economic profiles of the Flemish mega-clusters, 1995**

Percentages

Mega-cluster	Production	Gross value added	Employment	Imports	Final demand
AF	13.5	8.7	7.7	15.2	13.0
CM	32.7	27.9	15.0	38.7	32.4
CH	8.5	5.4	2.4	15.3	9.1
TD	25.5	29.7	25.8	23.8	26.1
SV	19.8	28.3	49.2	7.1	19.4
Total	**100**	**100**	**100**	**100**	**100**

Insight into the domestic (Flemish) transaction matrix for the identified mega-clusters is presented in Table 2. The intermediary deliveries (outputs) are to be read horizontally; the intermediate purchases (inputs) vertically. It can be seen that, for example, for the AF cluster, 92.2% of the deliveries of the constituent sectors occur to sectors within this cluster. At the same time, 61.4% of its purchases originate from sectors within this cluster. These high percentages of intra-cluster deliveries and purchases are apparent in all clusters and are a direct consequence of the algorithm, which attributes sectors having strong (mutual) linkages in the same cluster. Further, the so-called “diffusion indices” are shown. The diffusion index of a cluster is calculated as the (natural) log of the ratio of the row-total over the column-total. A negative value of the diffusion index indicates that the cluster is a net-user of intermediary products and services; a positive value means that a cluster is a net-supplier of intermediary products and services.

Table 2. **The Flemish I/O table at the mega-cluster level, 1995**

	AF	CM	CH	TD	SV	Total interm. deliveries
AF	**254.2**	5.3	3.2	3.4	9.5	275.6
	92.2 %	1.9 %	1.2 %	1.2 %	3.4 %	100.0 %
	61.4 %	*0.8 %*	*1.2 %*	*1.2 %*	*3.4 %*	
CM	29.0	**406.4**	30.1	77.1	57.0	599.6
	4.8 %	**67.8 %**	5.0 %	12.9 %	9.5 %	100.0 %
	7.0 %	***62.7 %***	*24.0 %*	*25.4 %*	*20.8 %*	
CH	17.2	25.3	**40.8**	12.8	12.1	108.2
	15.9 %	23.4 %	**37.7 %**	11.8 %	11.2 %	100.0 %
	4.2 %	*3.9 %*	***32.5 %***	*4.2 %*	*4.4 %*	
TD	69.4	114.3	24.9	**155.8**	43.5	407.9
	17.0 %	28.0 %	6.1 %	**38.2 %**	10.7 %	100.0 %
	16.8 %	*17.6 %*	*19.9 %*	***51.3 %***	*15.9 %*	
SV	44.3	97.0	26.4	54.5	**152.1**	374.3
	11.8 %	25.9 %	7.1 %	14.6 %	**40.6 %**	100.0 %
	10.7 %	15.0 %	*21.1 %*	*18.0 %*	***55.5 %***	
Total interm. purchases	414.1	648.3	125.4	303.6	274.2	1 765.6
	100.0 %	*100.0 %*	*100.0 %*	*100.0 %*	*100.0 %*	
Diffusion index	-0.177	-0.034	-0.064	0.128	0.135	

In defining the technological profile of the mega-clusters, the R&D intensities of the mega-clusters are calculated as weighted averages of the R&D percentages of the constituent sectors, based on the results of the most recent Flemish R&D survey. The R&D percentage of a sector is defined as the ratio of the internal R&D expenditure of the sector over the total value of production (excluding

VAT). Several important differences with respect to R&D efforts are noticeable between the various economic sectors in Flanders; specifically, the R&D percentages range from 0% for certain sectors to 8.4% for the “Electrical equipment” sector. These differences are present in the mega-clusters as well (Table 3). For the mega-clusters, the AF cluster exhibits the lowest R&D percentage (0.1%). This figure contrasts sharply with the R&D efforts of the CH cluster (2.6%). Moreover, the CH cluster is responsible for 39% of the total R&D expenditures in Flanders. Also, the R&D intensity of the CM cluster is higher than the average percentage (0.65%); the CM cluster is responsible for 48% of the total Flemish R&D expenditures. The internal R&D efforts of the AF, TD and SV clusters are relatively low. Yet, the technological positions of the TD and SV sectors are possibly influenced to an important extent by “externally” (*i.e.* from other clusters) purchased intermediary products and services and the corresponding embodied technology.

Table 3. **Technological profiles of the mega-clusters**

Mega-cluster	R&D % (1993)	Innovation % (strongly improved products 1997)	Innovation % (new products 1997)
AF	0.1	12.9	8.3
CM	0.8	13.9	14.4
CH	2.6	9.9	11.6
TD	0.3	14.6	11.2
SV	0.4	14.6	12.0
Weighted average	0.6	13.7	12.1

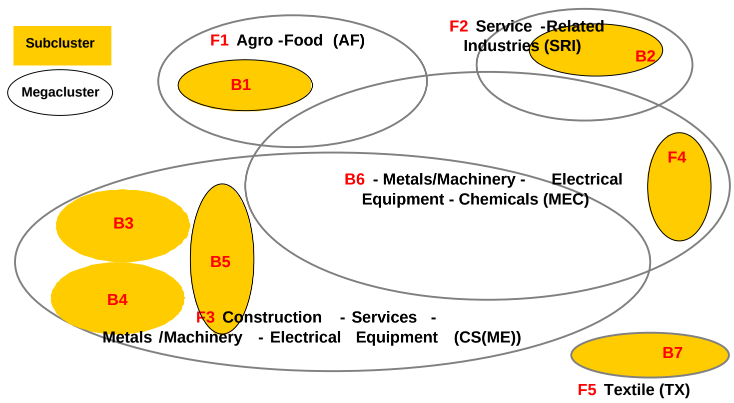
In the preceding paragraph, the focus was on the “input side” of the innovation process. A high level of R&D expenditures does not necessarily mean a strongly innovative output, although a high correlation between innovation input and innovation output can be expected. Using the results of the latest (1997) Flemish survey on technology diffusion, the average innovation intensity for each cluster was calculated, distinguishing between (incrementally) “strongly improved products” and (radically) “new products” (that were non-existent two years ago). The calculations are based on the weighted innovation intensities per sector, where “intensity” is defined as the share of the strongly improved and new products in the total production assortment. From these results, the low value of the AF cluster stands out: only 8.3% of the total assortment is designated as “new”. This is not surprising given the low R&D intensity of the AF cluster. It appears that the SV cluster is by far the most innovative in terms of innovative output. Combining these cluster maps with sector data on innovation allows the key transmitting sectors of innovation and the potentially benefiting sectors within each cluster to be identified. In Figures 2 to 6, the key R&D performing sectors (in terms of R&D intensity), as well as the key innovative sectors are shown.

From this, it becomes clear that there is no strict relationship between R&D efforts and innovation output. Sometimes a sector which invests heavily in R&D scores low on innovation output. On the other hand, moderate innovation efforts sometimes generate high innovation output. This is also observable at cluster level. For example, in the AF cluster, the Agricultural, forestry and fishery products sector scores high on R&D investment (0.13%), but very low on innovation output. This indicates that R&D figures only tell part of the story. In addition to identifying these key transmitting sectors of innovation (high share of new and/or improved products), it would be worthwhile in future research to investigate in more detail how the innovation performance of the cluster is influenced by the degree of interconnectedness – and the possibility of knowledge transfer – between the sectors within the clusters.

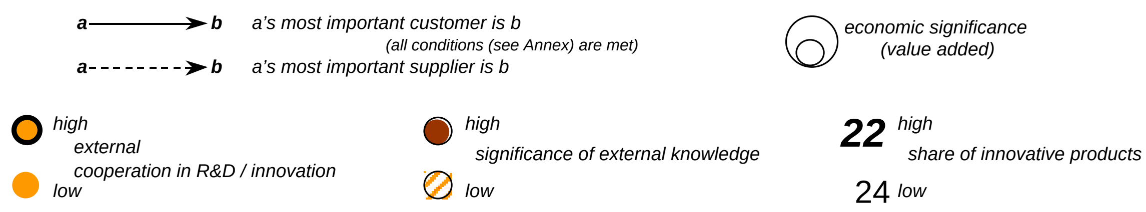
Identification of Swiss mega-clusters

Based on the Swiss I/O table of 1995, the orthodox approach of the "Method of Maxima" led to the identification of five pure forward clusters and seven pure backward clusters (Figure 7). Merging the two types of clusters gives five mega-clusters: *i)* Agro-food (AF); *ii)* Service-related Industries (SRI); *iii)* Construction-Services-Metals/Machinery-Electrical Equipment [CS(ME)]; *iv)* Metals/ Machinery-Electrical Equipment-Chemicals (MEC); and *v)* Textiles (TX). All of the mega-clusters comprise internal backward or forward sub-clusters. Further, the mega-clusters are not strictly delineated and exhibit substantial overlapping.

Figure 7. **Overview of the five Swiss mega-clusters (AF, SRI, CS(ME), MEC and TX)**



Box 2. **Interpretation of cluster figures for Switzerland**

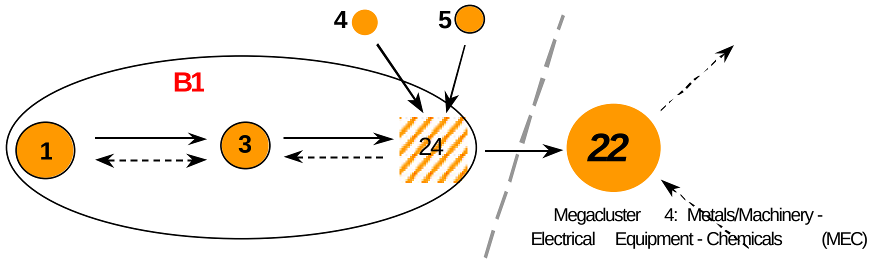


In addition to the main user and supplier linkages, each of the following cluster diagrams indicates the economic importance (value added) of the sectors within the cluster. In each case, there is also an innovation and diffusion oriented characterisation with regard to: *i)* high/low external co-operation in R&D and innovation; *ii)* high/low significance of external knowledge; and *iii)* high/low share of innovative products.

The Agro-food (AF) cluster

The AF cluster (Food processing and related activities) is entirely formed by forward linkages. Closer inspection shows that the sector "Hotel and food services" [24] is the most important user of the sectors "Alimentary products" [3], "Beverages" [4] and "Tobacco" [5].[1] Additionally, there are two important backward linkages within the AF cluster. The linkages between the sectors [1], [3] and [24] result in a backward chaining cluster B1. With the exception of sector [22] "Wholesale trade", which is the most important user of sector [24] within the mega-cluster, the cluster is characterised by its internal economic linkages. Sector [22], characterised by a relatively high share of innovative products, has important backward linkages within mega-cluster 4. However, the forward chain between sectors [22] and [24], which is clearly shown in the I/O coefficients, needs further economic interpretation.[2] The AF cluster exhibits a low external co-operation in R&D/innovation for [4] and [24] as well as a low significance of external knowledge for [24].

Figure 8. **The Agro-food cluster**

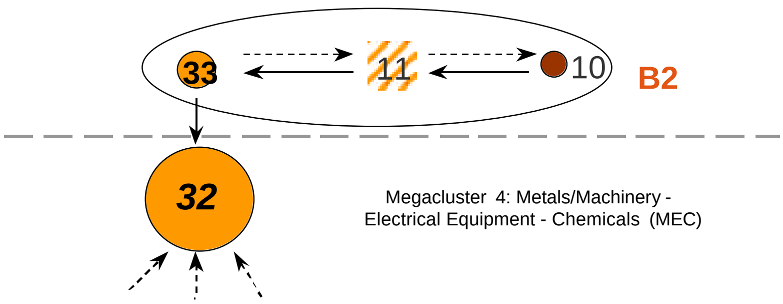


Key: [1] Agriculture; [3] Alimentary products; [4] Beverages; [5] Tobacco; [22] Wholesale trade; [24] Hotel and food services.

The Service-related Industries (SRI) cluster

The SRI cluster is a compact cluster with strong mutual dependencies formed entirely by significant forward linkages in a linear value-added chain. It consists of four sectors: "Paper industry" [10], "Graphical industry" [11], "Education, R&D and general leisure" [33] and a less homogeneous and more economically important sector "Business and personal services (including construction-related services)" [32]. Strong backward linkages can be identified between [10] and [11], as well as between [11] and [33] which result in the backward chain B2. In particular, sector [11] is characterised by low external co-operation in R&D/innovation and low significance of external knowledge. Sector [32], which has a relatively high share of innovative products, is an important transmitting sector between the SRI and the MEC clusters.

Figure 9. **The Service-related Industries cluster**

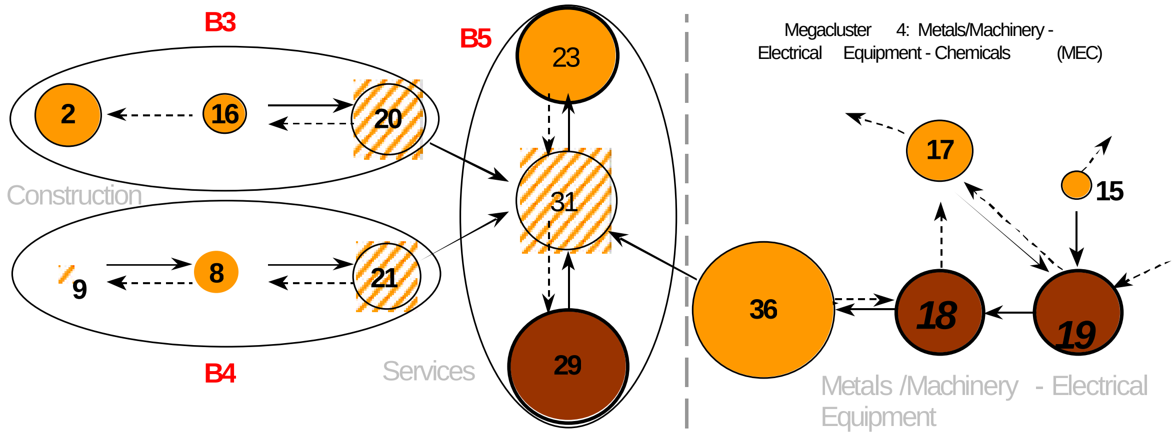


Key: [10] Paper; [11] Graphical industry; [32] Business and personal services; [33] Education, R&D and general leisure.

The Construction – Services – (Metals/Machinery – Electrical Equipment) CS(ME) cluster

The CS(ME) cluster is the largest cluster in the Swiss economy, consisting of 14 sectors. Within this forward cluster, three important backward sub-clusters have been identified. Sub-clusters B3 and B4 belong to the construction sector ("Construction" [20] and "Building [21]) and related activities. These backward clusters have a strong forward link with a third backward cluster B5 "Services". Within this sub-cluster B5, the sector "Real estate" [31] requires special attention due to its central position and the numerous linkages with several forward and backward clusters. Another important feature is related to the large overlapping section with mega-cluster 4.

Figure 10. **Construction - Services - (Metals/Machinery – Electrical Equipment) [CS(ME)] cluster**



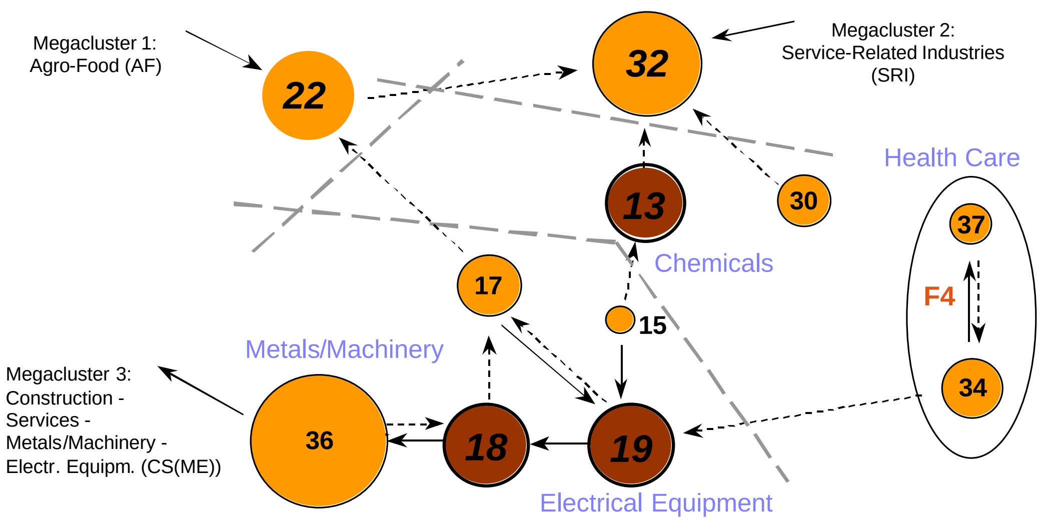
Key: [2] Electricity, gas and water; [8] Wood and furniture; [9] Wood industry; [15] Rubber and plastics; [16] Non-ferrous metals; [17] Metals; [18] Machine building; [19] Electrical equipment and watch industry; [20] Construction (main activities); [21] Building (finishing and completion); [23] Retail trade; [29] Banking; [31] Real estate; [36] Government.

Due to the fact that these two mega-clusters are only linked by the forward chain between the sectors "Government" [36] and "Real estate", a separation of the mega-cluster 4 related part (*i.e.* the ME part of the CS(ME) cluster with the ME part of the MEC cluster) may be more relevant and may lead to a clearer distinction between these two mega-clusters. It is interesting to note that the economically important financial sector in Switzerland, "Banking" [29], has strong and mutual linkages with "Real estate", and is characterised by high external co-operation and use of external knowledge sources.

The Metals/Machinery – Electrical Equipment – Chemicals (MEC) cluster

The MEC cluster, consisting of 11 sectors, comes out as the second largest cluster. Contrary to the other mega-clusters, the MEC cluster is the result of strong backward linkages. The identified cluster is, to a large degree, constructed around two core sectors, "Machine building" [18] and "Electrical equipment and watch industry" [19], both of which have several forward and backward linkages. Other important mutual backward/forward linkages can be observed between sector [18] and the "Government" sector [36] as well as between sector [19] and the sector "Metals" [17]. Further, a strong backward linkage was identified with the forward sub-cluster F4 "Health care". In addition, within the MEC cluster, the three sectors "Chemicals" [13], [18] and [19] play a central role in that they exhibit high external co-operation in R&D and innovation-related activities, high significance of external knowledge, as well as a high share of innovative products. Finally, if we argue that mega-cluster 3 should be separated into two different clusters, then mega-cluster 4 would become the most important cluster for the Swiss economy.

Figure 11. **The Electrical Equipment - Metals/Machinery - Chemicals cluster**

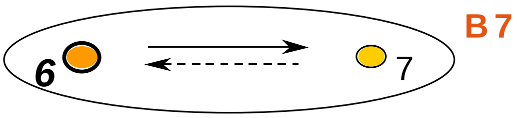


Key: [13] Chemicals; [15] Rubber and plastics; [17] Metals; [18] Machine building; [19] Electrical equipment and watch industry; [22] Wholesale trade; [30] Insurance; [32] Business and personal services; [34] Health care; [36] Government; [37] Social insurance.

The Textiles (TX) cluster

Compared to the other clusters, the TX cluster is a very compact cluster, consisting only of the sectors "Textile industry" [6] and "Confection" [7], between which strong mutual linkages exist. From this analytical perspective, this mega-cluster displays an "introverted" dependency. Despite the relatively small economic significance, the sector "Textile industry" [6] shows high external co-operation in R&D combined with a relatively high share of innovative products.

Figure 12. **The Textiles cluster**



Key: [6] Textile industry; [7] Confection.

Free-floaters

Finally, the quantitative analysis leads to more isolated sectors which do not reach the forward or backward threshold values. Following the orthodox application of the algorithm, they have not been assigned to a specific cluster. In particular, this relates to the following sectors: "Leather and shoe industries" [12], "Oil refineries" [14], "Railroad transportation" [25], "Road transportation and related services" [26], "Waterway transportation" [27], "Communication services" [28] and "Non-profit organisations and household services" [35].

Economic and technological profile of the Swiss mega-clusters

As pointed out in the cluster-related figures above, substantial differences can be found between the various sectors within the clusters in terms of economic significance. At the level of the identified mega-clusters, Table 4 provides an overview of the economic profile for 1995. Among the different mega-clusters, the MEC cluster is the most important in terms of: (1) gross production, (2) gross value added, (3) employment and (6) final demand.[3]

Table 4. **Economic profile of the mega-clusters, 1995**

Cluster	Gross production[1] (as a % of total) (1)	Gross value added[2] (as % of total) (2)	Gross value added per employee[3] (in CHF) (3)	Employment (full-time equiv., as a % of total) (4)	% of imported intermediate consumption[4] (5)	(6) Final demand[5] (as a % of total) (6)
AF	14.9%	(12.0%)	71 297	(18.5%)	9.4%	(14.2%)
SRI	10.4%	(10.6%)	96 373	(12.1%)	5.4%	(4.7%)
CS of CS(ME)	41.1%	(39.7%)	103 033	(42.3%)	10.4%	(56.0%)
ME of CS(ME)	23.3%	(25.3%)	110 823	(25.4%)	2.9%	(21.1%)
MEC	50.7%	(49.6%)	110 741	(49.1%)	8.4%	(56.4%)
TE	0.9%	(0.6%)	68 592	(1.0%)	30.8%	(2.2%)
Total Swiss economy	100% (CHF 640 375 million)	100% (CHF 352 620 million)	100% (CHF 109 69)	100% (3 214 423 FTE)	14.1%	100% (CHF 433 084 million)

1. I/O table 1995 (results per sector).
2. I/O table 1995 (results per good) and conversion to sectors with results from production account 1994.
3. Full-time equivalents.
4. Estimation (Schnewlin I/O table 1990).
5. I/O table 1995 (results per good).

Most of the clusters are quite heterogeneous and consist of industry and service-related sectors. This is shown specifically in (3) gross value added per employee and per branch. This explains the considerably higher numbers in (3) in the construction services cluster with some "high-value-added branches" (Banks, Electricity and Real estate). It should also be noted that there is a comparatively high percentage of imported intermediate consumption in the TX cluster.

Table 5 illustrates the flows of intermediate deliveries and supplies as well as the diffusion index for the Swiss mega-clusters and the rest of the economy.[4] If we look at the diffusion index, the AF cluster is a significant net user of intermediate products and services. On the other hand, the SRI cluster can be interpreted as a net supplier. As expected from the cluster algorithm, the grey-shaded diagonal elements yield the highest values and percentages. Although the level of "internal linkages" is also a function of the size of the mega-cluster, the high values of the linkages within the "Agro-food" cluster are the result of the very strong and mutual forward and backward linkages between the "Agriculture" and "Alimentary products" sectors. Outside of the diagonal elements, important user and supplier linkages can be found between SRI and MEC as well as between MEC and TX.

Table 5. **Transaction matrix on the aggregation level of the mega-clusters and rest of economy, 1995**

Million CHF

	AF	SRI	CS of CS(ME)	MEC	TX	Rest of Swiss economy	Total intermediate deliveries
AF	19 057.8	185.4	1 123.0	4 835.4	165.2	1 531.1	26 898.3
	70.9%	**0.7%**	**4.2%**	**18.0%**	**0.6%**	**5.7%**	**100%**
	50.5%	**1.6%**	**1.7%**	**3.3%**	**4.9%**	**8.0%**	
SRI	1 411.5	5 916.8	2 338.5	6 293.6	51.7	962.6	16 974.7
	8.3%	**34.9%**	**13.8%**	**37.1%**	**0.3%**	**5.7%**	**100%**
	3.7%	**52.2%**	**3.5%**	**4.2%**	**1.5%**	**5.0%**	
CS of CS(ME)	5 754.4	1 064.3	38 724.1	21 151.2	3 63.8	3 428.19	70 486.0
	8.2%	**1.5%**	**54.9%**	**30.0%**	**0.5%**	**4.9%**	**100%**
	15.2%	**9.4%**	**58.1%**	**14.2%**	**10.7%**	**17.9%**	
MEC	8 719.7	3 69.5	20 345.3	104 789.4	1384.5	5 277.1	143 785.6
	6.1%	**2.3%**	**14.1%**	**72.9%**	**1.0%**	**3.7%**	**100%**
	23.1%	**28.9%**	**30.5%**	**70.5%**	**40.7%**	**27.5%**	
TX	262.3	25.6	197.5	1 111.2	1 234.1	290.5	3 121.2
	8.4%	**0.8%**	**6.3%**	**35.6%**	**39.5%**	**9.3%**	**100%**
	0.7%	**0.2%**	**0.3%**	**0.7%**	**36.3%**	**1.5%**	
Rest of Swiss economy	2 548.5	870.5	3 965.1	10 543.6	202.9	7 676.7	25 807.4
	9.9%	**3.4%**	**15.4%**	**40.9%**	**0.8%**	**29.7%**	**100%**
	6.8%	**7.7%**	**5.9%**	**7.1%**	**6.0%**	**40.1%**	
Total interm. supplies	37 754.3	11 332.2	66 693.7	148 724.3	3 02.7	19 166.2	287 073.2
	100%	**100%**	**100%**	**100%**	**100%**	**100%**	
Diffusion index	-0.339	0.404	0.056	-0.034	-0.086	0.296	

Source: Based on Antille (1999).

Tables 6 and 7 clearly point out different innovation styles and ways of acquiring knowledge and types of knowledge.

The measurement of the innovation activity within clusters using indicators provides an approximate identification of some important aspects of innovation intensity that cannot be measured directly. This measurement can start at various phases of the innovation process. The indicators chosen in Table 6 can be classified into input-related indicators (1,2), output-related indicators (3,4,5) and market-oriented indicators (6,7). Indicator (8) shows R&D-relevant co-operation activities.[5] The results indicate significant differences among the mega-clusters. In principle, the AF and SRI clusters are significantly lower in innovation intensity and performance compared to the other mega-clusters. Taking a more detailed look at individual sectors and sub-sectors, it is apparent that the sectors “Chemicals”, “Machinery” and “Electronics/Instruments/Electrical Equipment” come out well above average (all are in MEC). The significance of “Paper industry” (SRI) in the area of process innovation and “Textile industry” (TE) in the area of product innovation must also be pointed out. The service sectors and their sub-sectors show an above-average innovation intensity, in particular, innovation performance, especially in a part of the sector “Computer and research” (SRI), less pronounced in the sectors “Banking” (CSME) and “Insurance” (MEC).

The co-operation intensities, with respect to R&D, show substantial variations among the mega-clusters. Taking a more detailed look, sectors [13], [18], and [19] (MEC) show the highest co-operation intensities (MEC). Again, [10] (SRI) and [6] (TE) are above average. Within service-related sectors, above-average intensities can be found in “Computer and research (SRI), [32] (CSME) and [30] (MEC).

Table 6. **Innovation profile of the Swiss mega-clusters**

Mega-cluster sectors	AF (3,4,22,24)	SRI (10,11,32)	CS of CS(ME) (8,9,16,20,21; 23,29,31)	ME of CS(ME) (15,17,18,19)	MEC (13,15,17,18, 19,22,30,32)	TX (6,7)
(1) % of firms with domestic R&D activities	46.0%	57.9%	57.1%	**73.0%**	**73.2%**	**73.5%**
(2) % of personnel in R&D (only industry related sectors within cluster)	2.6%	1.5%	2.4%	**6.5%**	**8.9%**	3.6%
(3) % of firms with product innovation	69.1%	69.3%	58.5%	**76.5%**	**78.8%**	**87.4%**
(4) % of firms with process innovation	65.0%	65.0%	67.2%	**81.2%**	**80.0%**	70.7%
(5) % of firms with patents pending	8.2%	8.5%	27.1%	**45.7%**	**44.6%**	21.2&
(6) % of firms with innovative products and services	**19.9%**	**21.3%**	8.8%	17.1%	**29.0%**	**20.4%**
(7) % of firms with worldwide new products (only industry related sectors)	1.46%	0.69%	3.84%	**6.28%**	**7.16%**	**7.43%**
(8) % of firms with co-operative activities in R&D and innovation	30.8%	56.5%	64.6%	**73.0%**	66.9%	**70.7%**

Source: Arvanitis *et al.* (1998) and own calculations.

Table 7 illustrates the importance of external knowledge sources – user or market oriented knowledge, supplier-oriented knowledge, knowledge from the same sector/company and science-based knowledge – for innovation activities. The analysis shows a general focus on user-oriented knowledge, which is, for example, very important for the beverage, rubber and plastics industries. Emphasis on supplier-oriented knowledge can be found in the alimentary products or the watch industry. Science-based knowledge (universities, research institutes, etc.) is, for example, acquired especially by the chemicals industry. It is interesting that the confection industry relies strongly on different kinds of external knowledge sources. The last column in Table 7 provides information on the importance of exports for the different sectors.

From the strict quantitative analysis of Swiss I/O data, some interesting results arise for discussion, although the analysis only applies to an I/O table with 37 sectors. The linkage between the overlapping mega-clusters is found in sectors which also have above-average importance from the economic or innovation-relevant point of view: Wholesale trade [22], Real estate [31] and Government [36]. A special role is played here by Business and personal services [32]. Within this heterogeneous sector are situated the so-called KIBS (knowledge-intensive business services) companies which are of growing importance with regard to both information transfer and knowledge generation (Reuter, forthcoming).

The quantitative input-output analysis identifies three key sectors, all of which are situated within the MEC clusters – Chemicals [13], Machine building [18] and Electrical equipment and watch industry [19]. They are characterised by: *i)* strong networking by forward and backward linkages; *ii)* high innovation relevance with regard to innovation intensity and performance; and *iii)* above-average economic importance.

Table 7. **Importance of external knowledge and export orientation**

Cluster		Sector	Importance of external knowledge: User linkages	Supplier linkages	Same sector[1]	Same company[1]	Universities / research institutes/ consultants	**Export orientation**
AF	3	Alimentary Products		High				
	4	Beverage	Very high			Very high		
	22	Wholesale Trade					High	
	24	Hotel and Food Service	High					
SRI	10	Paper Industry	High	Very high				High
	11	Graphical Industry	High					
	32a	Renting of Machinery and Equipment						
	32b	Legal and Business Consultancy						
	32c	Architectural and Engineering Activities					High	High
	32d	Computer and Related Activities	High					
	32e	Other Business Activities, Social Activities						
CS	8	Woods and Furniture		High				High
	9	Wood Industry	High	High				
	16	Non-ferrous Metals				High		
	20	Construction						
	21	Building (Finishing and Completing)						
	23	Retail Trade						
	29	Banking	High				High	
	31	Real Estate						
MEC	13	Chemicals			Very high	Very high	Very high	Very high
	15	Rubber and Plastics	Very high				High	High
	17	Metals	High					
	18a	Machine Building	High		High	High	High	Very high
	18b	Office Machinery and Motor Vehicles	Very high					Very high
	19a	Electrical Equipment	Very high		High	High	High	Very high
	19b	Watch Industry		High	Very high			
	19c	Other Manufacturing	High					
	22	Wholesale Trade						
	30	Insurance					High	
	32a	Renting of Machinery and Equipment						
	32b	Legal and Business Consultancy						
	32c	Architectural and Engineering Activities					High	High
	32d	Computer and Related Activities	High					
	32e	Other Business Activities, Social Activities						
TX	6	Textile Industry	High					Very high
	7	Confection Industry	Very high	High	High			High

1. Only industry-related sectors.

Very high   High

Source: Own calculations, based on Arvanitis *et al.* (1998).

The innovation and diffusion behaviour of the Swiss cluster can be regarded in general as more implementation- and application-oriented than science-based (Hotz-Hart *et al.*, 2001). Important impulses for innovation thus arise in the "strategic triangle" between focal firms and their users and suppliers of knowledge/technology. They are largely the result of market relations. In the case of product innovations, the user provides the main information, while in the case of process innovations, the supplier is generally the main source (Eisinger, 1996). The focus of the analysis on national user-supplier linkages – except for the indication of the percentages of imported intermediate consumption in Table 4 and the export orientation in Table 7 – should be seen against the background of a strong trend towards growth abroad (direct investments, R&D outlay), with a simultaneous loss of dynamics in the national economy and a downsizing of the technology portfolio (SWR, 1999).

Concluding remarks and policy recommendations

Method

This chapter has presented an workable methodology for identifying aggregate techno-economic clusters – so-called "mega-clusters" – in (regional) economies, using input-output (I/O) data. The I/O method proposed here, which is known as the "Method of Maxima", was applied to the economies of Flanders (Belgium) and Switzerland. Through this application, we have attempted to demonstrate the usefulness of the method proposed and to introduce an (international) comparative element into the analysis. The underlying assumption of our approach is, basically, that economic (supplier-user) linkages between industries – as reflected in the I/O tables – are the main "carriers" of technology diffusion in an economy.

However, the quantitative user-supplier linkages analysed represent only one important part of a national innovation system. Not shown here, in particular, are the linkages to the knowledge system (universities, research institutes), the informal knowledge and innovation networks. Although some qualifications are in order concerning the general applicability of the proposed methodology – and the fact that the method may, of course, not capture all the facets of regional or national innovation systems (due to, for example, the impact of data aggregation, the "too narrow" focus on domestic supplier-user linkages, the existence of technology diffusion even without economic interdependencies, etc.), the applied method is a good starting point for cluster analysis in an international comparative context.

Results

The results of the study revealed some structural similarities between Flanders and Switzerland, but also highlighted significant differences. The results showed clearly that each country has its own collection of clusters and specialisations and that the individual clusters identified – even at the aggregate level of the present analysis – have different characteristics and play a distinctive role in the economy. In addition, inspection of the profiles of the various clusters revealed the heterogeneity of the economic activities, in terms of size, "connectedness", R&D intensity, share of innovative products, etc.

One should be cautious, however, when comparing results across countries. Being fully aware of the fact that alternative methods may lead to different outcomes (we used two "versions" of the M-method, for Flanders and Switzerland, respectively), it should be clear that no uniform or "best" methodology exists from a theoretical point of view, and that any method should take into account the specificities of each country – in terms of the availability and aggregation of the I/O data, the general economic situation and/or the "openness" of the countries involved, as well as the specific purposes of the cluster analysis. Recently, some research efforts have been directed towards comparing different methods (*e.g.* Hoen, 2000), but general conclusive results concerning the appropriateness and robustness of the various methods for different countries are still lacking. Furthermore, we believe that it is not possible or at least not straightforward to test the robustness of one particular method for various countries, given the diversity of (predetermined) national and/or regional policy goals or options and priorities in each country.

Policy implications

In view of the importance of interdependent actors in modern innovation theory and the relation between the interconnectedness of economic agents and the production and diffusion of specialised knowledge (DeBresson, 1996), an overview of the strong linkages within regional and national economies is useful for the purpose of policy design. Therefore, we extended the cluster identification analysis with quantitative and qualitative innovation and knowledge-based indicators. From this we learned, among other things, that although it is easy to accept the idea that the core sectors or clusters characterised by high levels of R&D expenditures should be favoured when designing industrial and technological policies, high levels of R&D expenditure are not necessarily a prerequisite for innovativeness, and *vice versa* – as is the case, for example, for the Flemish services cluster (which shows a low level of R&D and a high level of innovativeness). This is, of course, an important issue from a policy point of view.

Given the existence – or non-existence – of intensively linked clusters, the policy maker has several options available (which can possibly be combined). The first option is to focus on the core clusters and to foster or maintain growth by stimulating the dynamic character of these core clusters (and constituent sectors). In so doing, the optimal leverage of invested funds can be obtained and large parts of the economy can benefit from the measures taken. Alternatively, one might choose to boost those sectors or clusters that display only weak techno-economic linkages with the rest of the economy. Such a policy may trigger new (endogenous) developments that may lead – in the long-run – to positive effects on the rest of the economy. Regardless of which particular policy option is chosen, the question of the appropriateness of direct (and selective) state intervention vs. market-oriented policy (*e.g.* improvement of market conditions or reduction of systemic failures) remains.

The cluster maps presented in this chapter, which point at the strong and privileged innovation potentials and/or weak or missing links in the economy, can act as a solid starting point for designing such policies.

Annex

M-METHOD FOR CLUSTER IDENTIFICATION

In the M-method, the diagonal elements of the I/O matrix (z_{ii}) are initially set to zero, in order to emphasise the inter-sectoral flows (for further detail, see Peeters and Tiri, 1999). Subsequently, the algorithm consists of two phases.

Phase 1: analysing forward linkages

The analysis of the forward linkages is conducted in two steps. The analysis begins with a "horizontal" or "row-wise" reading of the matrix of domestic intermediary flows (step 1). For each supplying sector *i*, the most important delivery (*i.e.* the highest absolute value of z_{ij} in row *i*), z_{ik}, is selected and divided by the total of row *i* (excluding the corresponding diagonal element). If this ratio is larger than a predetermined threshold value q_r, then the buying sector *k* is viewed as closely related with the supplying sector *i*. In other words, it can be concluded that there exists a strong forward linkage between supplying-sector *i* and using-sector *k*. The latter is called the (single) "best" user of sector *i*. Repeating this test for all supplying sectors *i* in the economy yields a binary [0,1] matrix, containing a "1" in the cells indicating strong forward linkages, and a "0" in the remaining cells.

Next, the matrix of the domestic intermediary flows is read "vertically" or "column-wise" (step 2). For each (single) "best" using-sector *k* buying from sector *i*, identified in step 1, the corresponding z_{ik} is divided by the total of column *k* (excluding the corresponding diagonal element z_{kk}). If this ratio is larger than a second predetermined threshold value q_c, then the most significant delivery from the supplier's point of view is also a significant delivery from the user's point of view. Repeating this test for all the sectors *k* identified in step 1 yields a new binary [0,1] matrix, containing a "1" in the cells indicating strong user linkages, and a "0" in the remaining cells.

Finally, the two binary matrices are "merged" or summed, showing several cells containing a value of 2. The algorithm allows for the identification of a number of strictly delimited chains of forward linkages, which represent the final forward-linked economic clusters.

Phase 2: analysing backward linkages

Along similar lines, the backward linkages are analysed in a second phase. For each using-sector *j* in the I/O table, the most important supplier *k* is again identified in two steps, starting with a vertical or column-wise reading of the matrix of intermediary flows, followed by a horizontal or row-wise reading. Applying similar tests as in Phase 1 for all the supplying-sectors *k* and using-sectors *j*, yields two new binary [0,1] matrices, which, when merged or summed, allow for the identification of a second set of strictly delimited chains of backward linkages, which represent the final backward-linked economic clusters.

NOTES

1. Based on the chosen threshold values, at least 20% of the deliveries of these sectors go to "Hotel and food services". At the same time, each of these deliveries represents at least 5% of the input of "Hotel and food services".

2. For an overview of the Agro-food and Construction clusters, see Berwert and Mira (2000).

3. Due to substantial overlapping, the ME-related part of the CS(ME)cluster was assigned to mega-cluster 4.

4. To avoid double counting, the "Wholesale trade" sector was calculated only in mega-cluster 4 and not in mega-cluster 1; and the "Business and personal services" sector was calculated only in mega-cluster 4 and not in mega-cluster 2.

5. Table 6 show some of the results of the 1996 Swiss Innovation Survey, which was analysed according to sectors and aggregated to mega-clusters using weighted averages. For an elaborate analysis of innovation indicators in terms of innovation intensity and performance on a sectoral and sub-sectoral level, see Arvanitis *et al.* (1998).

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