

# Functional Concept for a Web-Based Knowledge Impact and IC Reporting Portal

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**Abstract:** Knowledge and Intellectual Capital (IC) are key resources and crucial fields of investment in today's business organisations and the economy. Problems in strategically and effectively using those resources mainly consist in: (i) how to specify, summarize, visualize the current state of knowledge and IC; (ii) how to comfortably provide access to scattered and ill-structured information on the current state of knowledge and IC; (iii) how to define, understand, visualize the impact of knowledge on organizational performance and of IC on the economy; (iv) how to assess and evaluate strategies and activities for purposefully intervening in organizations and economies by means of knowledge and IC. To overcome this, the paper presents methods, functionality and tools forming a web-based infrastructure which provides user-friendly access to information and understanding of knowledge impacts and IC market at company, sector, national and global levels. This infrastructure basically consists of two sections. The first section enables us to immediately benchmark a company's knowledge management maturity according to specific input data and information, provide tailored feedback and suggest changes in the company's strategy concerning knowledge-related activities. With this, companies should be motivated to provide their data and support continuous testing, evaluation and improvement of all methods, models, measures and benchmarks following an experimental design. The second section consists of a "World Atlas on Intellectual Capital" comprising world-wide data on the following constituents of the IC market: demand, supply, equilibrium, investment, need, stock, flow, and returns. With this, the web-based knowledge impact and IC reporting portal will support decision makers at company and political levels to purposefully intervene on the attitude towards knowledge and IC through guidelines. Consequently, the paper contributes to research and development to measure and with this to develop a better understanding of the impact of knowledge (management) and IC on the delivery of effective business processes and high value services.

**Keywords:** knowledge management maturity, impact analysis, intellectual capital, companies, benchmarking, clustering, logistics

## 1. Introduction and motivation

The role of knowledge as a strategic resource is well accepted in the business world. Nevertheless, the question of how to best make use of it still remains insufficiently answered. A decade ago when knowledge management mainly has been seen as a matter of introducing information technology, knowledge databases and intranet solutions into companies, it lost a lot of its credibility in many business sectors. Further introduction of knowledge management methods and approaches into company practice as well as further identification of new application areas were slowed down or even prevented. Although situation with regard to knowledge-related activities and investments into knowledge looks more promising today, there is still just a slack implementation of knowledge management in certain sectors, like e.g. logistics (see Tomé and Neumann, 2007), and especially in small and medium-sized companies. To overcome this, knowledge management needs to be seen as a supporting service addressing a company's personnel, organisation and IT basis at the same time. Especially under the impression of the current global financial and economic crisis, any knowledge management activity and investment into knowledge must aim to purposefully intervene in a company's business processes. For this, companies require comprehensive knowledge and in-depth understanding on how to implement knowledge management methods in a customized way.

In order to provide companies with respective information and eventually lend them a hand in managing their human resources, selecting technology or changing the organisations, the role of knowledge in business organisations needs to be investigated and assessed. Here, influences from cultural specifics, organisational diversity and the national economies' different levels of economic development on the current level of and future needs for integrating knowledge management activities into a business organisation have to be taken into consideration. In particular, we need to (i) identify barriers hindering a wider use of knowledge and application of knowledge management in companies, (ii) understand future needs and constraints for integrating knowledge management into business organisations, and (iii) understand how to cope with subjectivity in defining priorities of knowledge-

related activities in companies. This understanding forms the basis for case-based and company-specific assessment of the potential value of a certain investment into knowledge and for deriving specific suggestions and recommendations for increasing the company's level of knowledge management maturity.

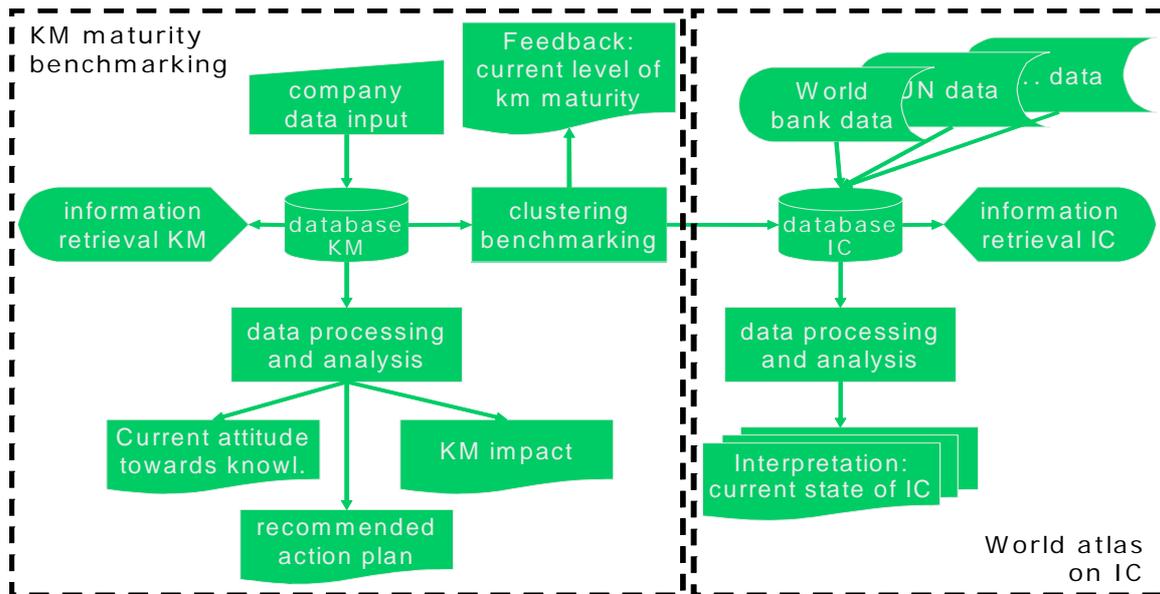
As pre-condition a methodology for qualitatively assessing and quantitatively measuring significant target variables, i.e. key performance indicators, is required. For example, the suitability and appropriateness of knowledge management tools and systems is characterized by indicators like the amount of knowledge units stored or access rates and response times. The latter aspect is represented by categories such as trust or intelligibility and so, it is very difficult to be measured. The concept of Intellectual Capital (IC) should account for those intangible aspects in companies. According to the mostly used model by Kaplan and Norton (1994) IC comprises human capital (as human resources), structural capital (related to organizational routines), customer capital (related to clients) and social capital (related to the human relations in the organization). As the IC constituents are assets possessed by individuals, by organisations, by regions and by countries, the effect of IC can thus be analysed at various levels. IC consequences in its possessor's situation seem to be decisive in economic, social and even political terms. To cope with the complexity of the task, several models for evaluating the use of knowledge in organizations have been produced, the more important being the Skandia Navigator (Edvinsson and Malone, 1997), the Intangible Assets Monitor (Sveiby, 1997) and the Balanced Scorecard (Kaplan and Norton, 1994). Those models assume the diversity and complexity of the notion of knowledge. Furthermore, those models also assume the diversity and complexity of the consequences of the use of knowledge producing positive results in certain perspectives, like business processes, employee satisfaction, customer satisfaction, financial results, learn and growth (North and Hornung, 2003). With this, the focus is clearly set on the evaluation of knowledge management projects and the economic assessment of a company's IC (North and Hornung 2003; North, Reinhardt and Schmidt 2004), but models used are not appropriate to quantify the impact of knowledge management on a company's performance.

To contribute to current research in this area an empirical (questionnaire-based) impact study has been run to (i) understand the current state-of-implementation of KM in logistics companies, (ii) identify general and company-specific needs for KM activities, and (iii) develop a model and methodology for specifying (or even better quantifying) the impact of KM on a company's economic performance (see Tomé and Neumann, 2007). From applying the underlying microeconomic impact model on the full set of available data a number of positive and negative knowledge management impacts could be derived. But due to the small number of respondents this analysis is based upon, its findings cannot be considered statistically significant and the question to what extent knowledge management activities have an effect on a company's performance still remains open.

As previous experiences show, the database gained from direct company input on the basis of questionnaires and interviews can be extended to a volume necessary for delivering reliable, valid results only when spending excessive efforts. To reduce efforts and allow ongoing standardised data collection and analysis, a web-based infrastructure is being developed comprising methods and tools for benchmarking a company's knowledge management maturity, analysing the impact of knowledge management on a company's performance and supporting IC reporting at company, sectoral, regional and national levels.

## **2. Requirements for a web-based knowledge impact and IC reporting portal**

The web-based knowledge impact and IC reporting portal is intended to provide both a source of trustful, i.e. correct and up-to-date, information on the current state of knowledge and IC from company to national levels and a toolkit to identify chances or needs for changes in the attitude towards knowledge and IC and to assess the potential of appropriate interventions by managers and policy makers. Assuming that knowledge is more a company-based resource for which an internal market may be defined and IC is more a national resource for which a national market may be defined, the portal consequently needs to consist of two interlinked sections (see Figure 1).



**Figure 1:** Functional specification of the portal

The *first section* basically aims to support companies in managing their knowledge and knowledge-related activities. For this, particular functionality is needed to:

- enable comfortable data input and intuitive information retrieval by company managers;
- analyse company-specific data according to the effect of investments into knowledge-related activities and needs for adjusting investment strategy to current requirements;
- present analysis results in order to identify a company's current attitude towards knowledge and visualise areas where changes are needed in or which should be investigated in further detail at least;
- provide immediate and tailored feedback on the company's current level of knowledge management maturity in comparison with the own past and with the level reached by other (similar) companies;
- recommend measures and activities helping in changing knowledge management attitude or reaching the next level of knowledge management maturity;
- help company managers in estimating the effect and benefit of knowledge-related change processes and certain investments into knowledge.

In addition to providing this kind of support to a particular company (and its management), the portal should allow structured search on and comprehensive analysis of knowledge management impact on companies in a more general approach. This requires clustering companies according to sectors, regions, knowledge-related types or other criteria and deriving findings generalized for the different groups of companies. With this also a link is drawn from the really company-specific view on knowledge to the more economy-related approach on IC.

The *second section* of the portal is formed by an atlas on IC visualizing the very different situations regarding IC at European level and worldwide. This atlas mainly addresses policy makers in order to adjust their strategic decisions, but it may also allow managers and citizens (as members of the civil society and as voters) to take note of regional differences and act upon them. For this, the atlas must:

- bring together scattered information from various trustful sources;
- allow user-friendly access to information in different ways;
- provide sophisticated support in interpreting data.

A first version of a European Atlas on Knowledge and IC has been specified by Tomé and Neumann (2008) clearly pointing out the need for a user-friendly web-based service and infrastructure. Apart from questions for the frequency and procedure of updating the atlas database and methodology or its extension to other countries/regions in the world the key question for how to draw the link between the company and the economy perspectives remained open. To help in answering this question and

contribute to respective research we define the methodological background of our portal at company level leading into tools which at least partially might be used at economy level as well.

### **3. Methodological background of the portal**

The methodological background of the portal covers research areas that are related to

- retrieving information from a large set of data;
- evaluating and assessing a company's performance, monitoring changes in terms of both improving and worsening of company processes and understanding the company's level of evolution;
- comparative analysis and best practice identification;
- organisational learning, change process management and development path definition.

More particularly, we need to apply those general methods to problems in knowledge and knowledge management impact analysis with companies and even further in leveraging knowledge for innovation and company performance increase.

**Knowledge management maturity modelling:** Specification of a company's knowledge management maturity helps in determining both the current attitude towards knowledge and state-of-knowledge in the company and a company-specific strategy for implementing knowledge-related activities in order to improve company performance. Knowledge management maturity models provide a staged framework to initiate a step-by-step change within an organization based upon its current level of knowledge management maturity. In literature a number of knowledge management maturity models can be found (see Kochikar 2000, Langen and Ehms 2004, Joslin 2005). They usually originate from maturity models in software engineering and support companies in self-assessing their knowledge management maturity by answering questionnaires. Answers specify certain observable capabilities with regard to people, process and technology from which the current maturity level is derived. Kochikar (2000), for example, elaborates the following five levels of knowledge management maturity:

- Level 1 – Default. "Knowledge, we've got plenty of – what we need is to work hard."
- Level 2 – Reactive. "We need to leverage all our knowledge, but we're too busy to do that."
- Level 3 – Aware. "At least we've made a beginning in managing our knowledge."
- Level 4 – Convinced. "We've reached where we are by managing our knowledge well, and we intend to keep it that way."
- Level 5 – Sharing. "We're sharing knowledge across the organization, and are proud of it."

Problems in applying those models result from the pure qualitative design of the questionnaires which gives a lot of room for individual (mis-)interpretation and sometimes makes it difficult to the companies to identify the correct maturity level. Here, quantitative measures, e.g. key performance indicators, and a comparative approach might be of help both of which can be achieved from applying benchmarking methodology.

**Benchmarking:** Company benchmarking is a method of continuous comparing and measuring against other companies to gain information and learn from their experiences, processes and practices. Benchmarking allows developing plans on how to adopt such best practices, usually with the aim of increasing some aspect of performance. Several different types of benchmarking are defined in literature; the most common ones being internal and external benchmarking. Both techniques have already been applied to knowledge management as well (Carpenter and Rudge 2003, Viedma 2004). Internal knowledge management benchmarking over time is performed by comparing company activities in knowledge management in different time periods. It helps to reveal knowledge management activities that have a significant impact on a company's performance in contrast to those activities that do not fulfil expectations and therefore should not be continued. External knowledge management benchmarking uses other companies' experiences in knowledge management to reveal situations in the analyzed company. It shows what knowledge management activities companies of the same type usually use and allows concluding on what might be appropriate knowledge management activities to achieve an intended improvement in the company's performance. The success of benchmarking depends on the selection of appropriate benchmarks. Apart from identifying criteria and performance indicators to be used, definition of the matching

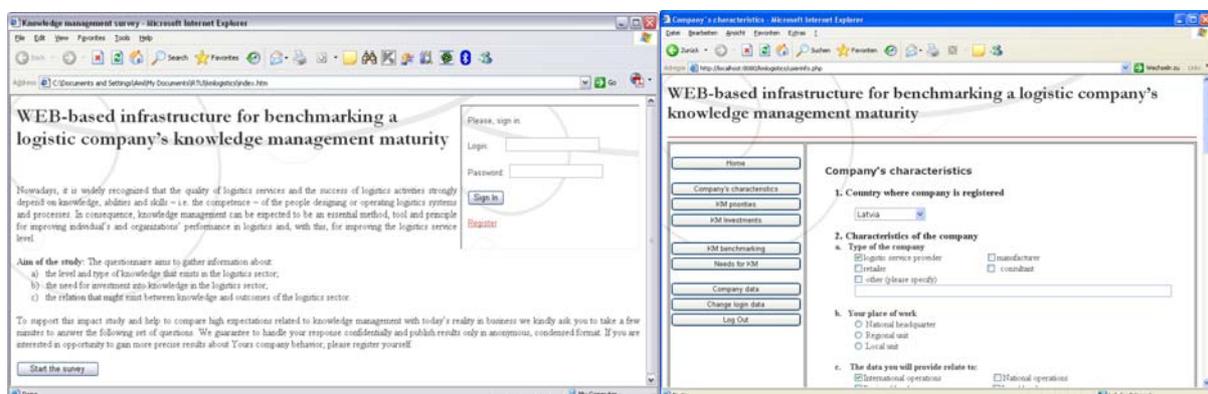
benchmark companies is a crucial success factor. For the latter cluster analysis might be a useful methodology.

**Cluster analysis:** Clustering is the classification of objects into different groups, or more precisely, the partitioning of a data set into subsets (clusters), so that the data in each subset (ideally) share some common trait - often proximity according to some defined distance measure. Data clustering is a common technique for statistical data analysis used in many fields, including machine learning, data mining, pattern recognition, and image analysis (MacKay 2004). To cluster companies for the purpose of knowledge management benchmarking two basic approaches are applicable. We either might define criteria for grouping companies according to standard measures such as company size, business sector or the value of certain performance indicators if it is approved that this leads to clusters of companies showing a comparable behaviour in terms of the subject of investigation. In our case this would mean to find clusters of companies showing the same attitude towards knowledge in a particular business sector. As there is no approved set of clustering criteria available for this, clustering criteria need to be derived from company data collection. This is a particular challenge because we need a critical mass of data for initial clustering and to set up a learning algorithm for continuous improvement of cluster specification. After defining clusters companies grouped together should show some similarities which can be used for characterising the cluster, deriving clustering criteria, and defining company classification rules.

**Classification rules and decision trees:** Classification rules summarize cluster characteristics to automate the classification of future instances – they predict the behaviour of an unknown attribute based on the values of known attributes. In other words, these rules are based on characteristics of the companies which belong to the cluster, and if a new company has similar characteristics then it also belongs to this group of companies. From the methodological point of view classification is one of the main tasks of data mining. *Data mining*, which is also referred to as knowledge discovery in databases, means a process of nontrivial extraction of implicit, previously unknown and potentially useful information (such as knowledge rules, constraints, regularities) from data in databases (Witten and Frank 2005). Goals of data mining are: (i) prediction, i.e. using some variables or fields in the data set to predict unknown or future values of some other variables of interest; (ii) description, i.e. finding patterns describing the data that can be interpreted by humans. Classification rules as the results of a data mining application are usually represented in the form IF-THEN prediction rules or graphically as decision trees.

#### 4. Structure and components of the portal

The knowledge impact and IC reporting portal is a web-based infrastructure providing access to two separate areas, one for benchmarking a logistics company's knowledge management maturity and the other one for the world atlas on knowledge and IC. Later on it might be extended by further sections, like e.g. a toolkit to support a purposeful selection of appropriate knowledge management tools for the specific situation of a particular company (Strubelt and Neumann 2006) or a model for simulation-based analysis of knowledge management impact (Neumann and Düring 2008).



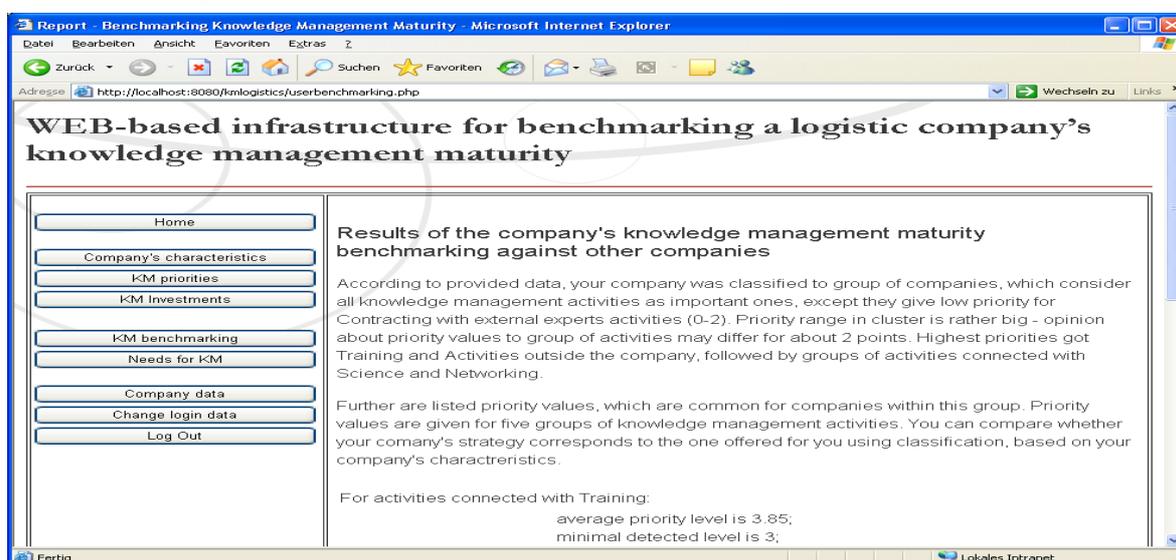
**Figure 2:** The web-based infrastructure to benchmark a company's knowledge management maturity

The company-focussed section of the portal allows knowledge management maturity benchmarking either anonymously or based upon registration. In the latter the user creates a login and password which allows him or her to update company data and information provided in order to re-run the benchmarking after some time and compare results with previous achievements. No matter if data are

provided by an anonymous or registered user they are all completed by a time stamp and stored in a database.

For providing company data an online questionnaire needs to be filled in (see Figure 2). The questionnaire follows the structure used by Neumann and Tomé (2005) to run an empirical evaluation of the current state-of-implementation of knowledge management in the logistics sector: (i) company characteristics; (ii) role of knowledge in the company; (iii) investments into knowledge-related activities; (iv) priority to get access to knowledge-related activities; (v) company performance. After having provided all necessary information the user gets a report containing graphical and textual information (see Figure 3):

- a summary of the results from statistical analysis (e.g. average, minimum, maximum values per category);
- feedback on the company's needs for further investments into knowledge-related activities or recommended changes in the investment strategy;
- results from benchmarking the company's knowledge management maturity against companies with a similar attitude towards knowledge (external benchmarking including a brief description of the cluster the company was grouped into);
- results from benchmarking the company's knowledge management maturity over time (internal benchmarking).



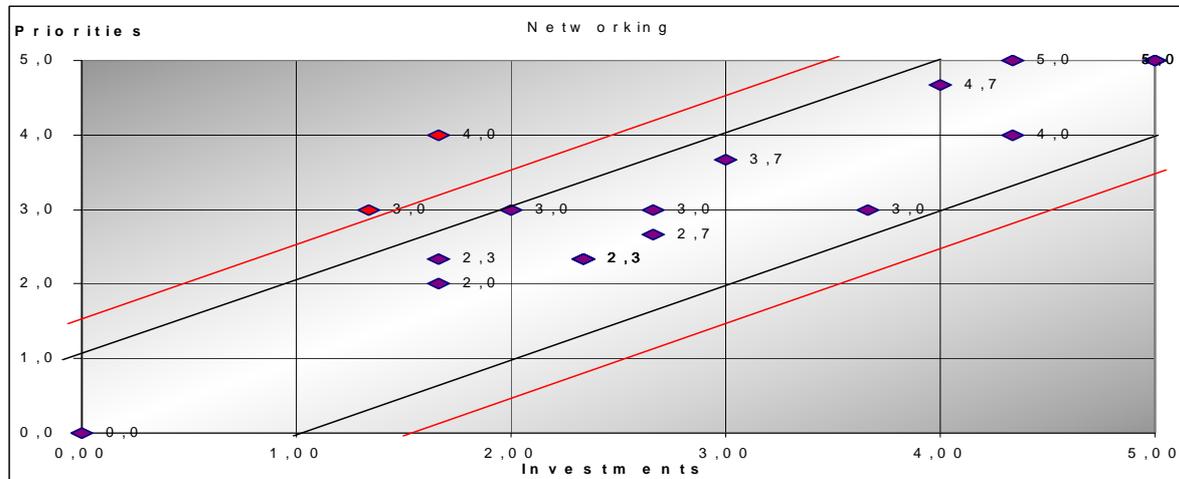
**Figure 3:** Report on the company's knowledge management maturity

Pre-condition for producing those reports are benchmarking and clustering components. The benchmarking component first uses results from the previous analysis (last fixed time stamp) of the same company's attitude towards knowledge to return feedback on developments with regard to knowledge management. Here, useful benchmarks are:

- the level of investments into knowledge-related activities as this reveals the current situation of knowledge management in the company;
- priority levels of different knowledge-related activities as this reveals the company's future knowledge management strategy;
- indicators of needs for changing investment strategies with regard to particular knowledge-related activities.

In addition to this, the benchmarking component also compares the company's attitude towards knowledge with the one companies of the same type show. For this, investments into and priorities of the individual knowledge-related activities of those similar companies are (anonymously) presented in a diagram. As shown in Figure 4 companies are expected to have well-balanced their investments and priorities and therefore should be located on the diagonal. The more the company-dot differs from this ideal line the larger the needs are for re-adjusting investment strategies in this particular type of activity or investigating it in further detail at least. Corridors representing certain levels-of-difference

(e.g.  $\pm 1$  or  $\pm 1.5$ ) as well as seeing the position of comparable companies at the same time help in understanding how strong an eventual need for intervention is. The better benchmark companies here match the analysed company in terms of knowledge management maturity and requirements for knowledge management, the more useful analysis results are. Therefore, the portal's clustering component is of particular importance or the quality of any feedback to the companies.



**Figure 4:** Example for benchmarking company attitudes towards knowledge

As already explained we can neither build upon existing company clusters nor apply approved classification rules since standard criteria like annual turnover, number of employees or even business sector do not help in deriving expectations on a company's knowledge management maturity. Instead, we assume that just those companies might be good benchmarks which first of all have the same attitude towards knowledge. As this is directly visible from the priority level company managers give to a certain knowledge-related activity, we use the companies' priority distribution as main classification criterion before analysing main company characteristics per cluster in order to understand why in a certain cluster priority levels have been defined exactly this way.

Database for cluster analysis was taken from company responses during the empirical impact study run in 2006 and 2007 (Tomé and Neumann, 2007). As German companies showed levels of needs, investments and priorities completely different from those in Latvian, Polish and Ukrainian companies, two sets of data were analysed separately. Based upon experiments (see Krasnova, 2007) both the most suitable clustering method and the best fitting number of clusters have been chosen for each set of data individually. In the end German companies were divided into four clusters, whereas Eastern European companies formed five clusters. The clusters significantly differ in the companies' distribution of priorities over all knowledge-related activities investigated in this study which indicates different attitudes towards knowledge with the companies involved. Figure 5 presents priority distribution patterns for the four clusters of German companies. Due to the small set of data available for this analysis (18 German and 46 Eastern European companies participated), results can only be understood as initial clustering. Exceptions still might have a significant influence on clustering results and cluster characteristics; smallest clusters with two or three companies only might not be stable when further companies will have to be added.

Nevertheless, the clusters as identified so far could be used to derive company classification rules from analysing and comparing general company characteristics per cluster allowing adding further companies to the already clustered ones. As a result two sets of rules were created – one for companies from Germany (6 rules – see Figure 6) and one for those from Eastern Europe (9 rules). Both classification models showed quite high levels of correctly classified instances: just 12% of German and 20% of Eastern European data were classified incorrectly. Despite of this, the small size of the sample again caused a methodological problem since it has been impossible to divide available data into training and test sets, and to perform cross-validation. Therefore it hardly can be specified how accurately both sets of rules will work with new data. Because of this, both cluster analysis and rule building will have to be repeated when a sufficient number of additional data (achieved by use of the portal) will be available. If the number of companies in the database is big enough, cross-validation of classification rules becomes possible as well. This will increase precision of the classification models and give an opportunity to discover how many new companies will be classified

correctly. This information can then be presented to users in order increase trust in the knowledge management benchmarking and analysis results.

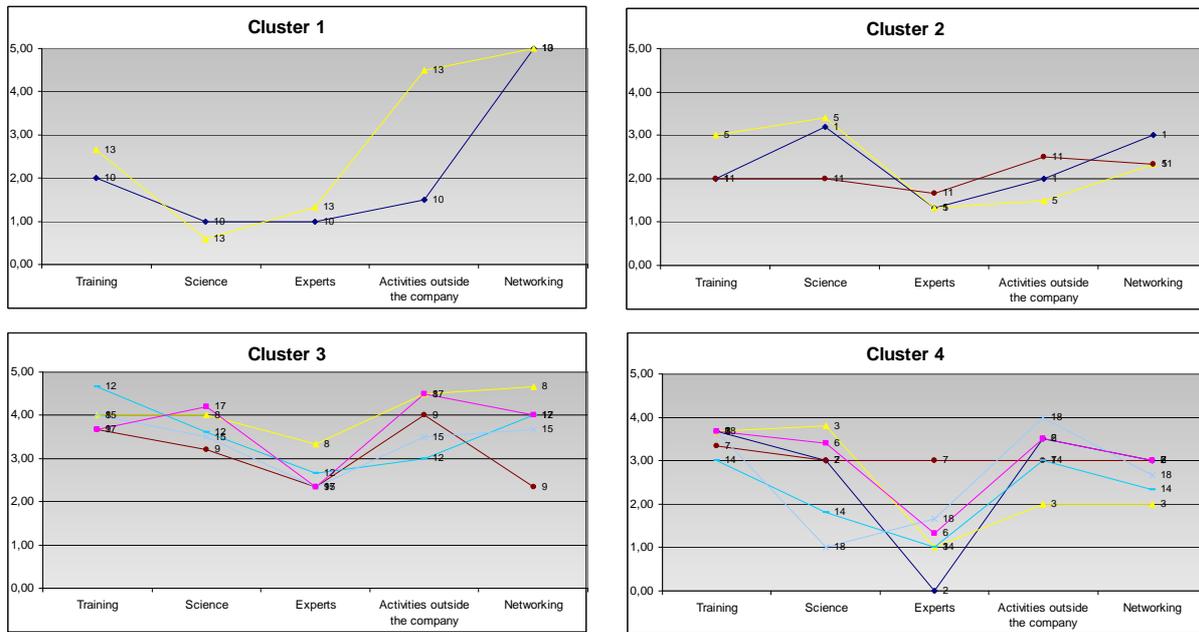


Figure 5: Priority distribution patterns for German logistics companies (see Krasnova, 2007)

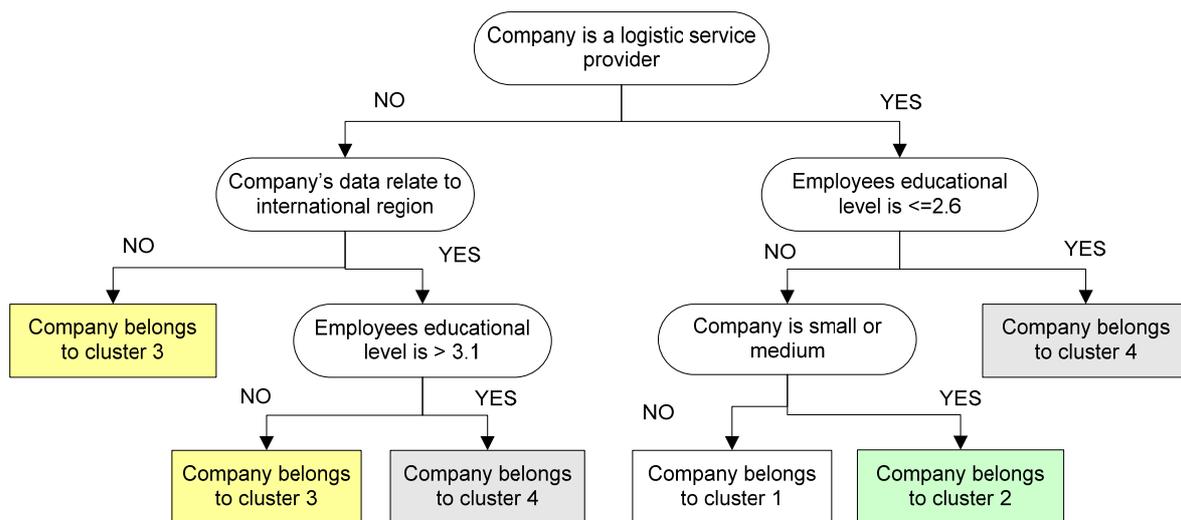


Figure 6: Decision tree derived from analysing German company data (see Krasnova, 2007)

## 5. Conclusions and suggestions for further research

The aim of this ongoing research is to create a web-based knowledge impact and IC reporting portal. This web-based infrastructure is supposed to consist of two sections. The first one is formed by a toolkit for benchmarking knowledge management maturity of companies (a), the second one contains the world atlas on IC (b).

- The first section comprises methods and tools for (i) analysing company data, (ii) classifying the company into a certain cluster, and (iii) benchmark its knowledge management maturity and strategy in comparison with other companies from the same group. Required input data can be provided by company managers using a well-structured online questionnaire.
- For this first section analysis results are returned in the form of reports. By now two reports are offered. The first one summarizes results from analysing company-specific needs for changing attitudes towards certain knowledge management activities. The second report presents results from externally benchmarking the company's knowledge management maturity. Both reports are

composed of texts and figures only, so the task of dynamically creating graphical output still remains open.

- At the moment benchmarking analysis based on current clustering models and sets of rules is a more general one. It provides users with a general idea about what knowledge management is and what does it currently mean to the particular company. Benchmarking against other, to some extent similar companies can also give just some general ideas on how companies usually define their priorities with regard to knowledge-related activities. Despite of these limitations the state-of-work achieved so far is a good starting point as it already demonstrates to the user how the analysis and benchmarking tools can actually work. For further improvements of the quality of results in terms of preciseness of feedback a significant increase of the sample size is required. When the number of companies having provided data has at least doubled the current set of entries, data analysis for cluster and classification rule building will have to be run again in order to evaluate company clusters and validate rule sets for attaching new companies to them. The more data are collected, the more precise company grouping and the more meaningful benchmarking results will be.
- The second section of the portal which is the world atlas on IC presents worldwide data on the IC market collected from trustful sources. Information are listed in tables, accessible per country or region via a map or presented for interpretation using radar charts and other forms of graphical representation. Further research is needed to condense analysis results from company level according to regions or countries in order to derive conclusions on the IC market and develop strategies for purposefully intervening in the global IC market. Here, the intention is to help policy makers from research, education, innovation, consumer policy and other policy areas at regional, national and European levels to identify major trends in the evolution of the European knowledge society and draw policy conclusions from this.

Detailed statistical data on the two sections may be found in Neumann and Tomé (2005) for companies and in Tomé and Neumann (2008) for companies and countries. In both cases we found evidence of important investments, needs and even some impacts of knowledge in companies and countries.

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