Patent-based inventor profiles as a basis for human resource decisions in research and development

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Profiles of inventors' technological competence are a valuable source of information for decision-making in research and development (R&D) management, e.g. concerning inventor assessment, human resource development and R&D team-building. In the following exposition, a new method of inventor profiling will be put forward, which is based in particular on semantic patent analysis and multidimensional scaling. First, in the course of semantic patent analysis, specialized software, equipped with a natural language processor, reads the patent text transferring the contents into a subject–action–object–format (SAO). The extracted SAO structures are then used to create similarity matrices for patents or patent sets, respectively, according to a specific similarity value. Subsequently, an inventor competence map can be produced by means of multidimensional scaling.

The benefits of this method for R&D-related issues in human resource management will be illustrated by the example of a German mechanical engineering company. Two distinct types of profiles were generated and tested: (i) the profile of a single key inventor and (ii) a profile of key inventor sets. The single key inventor profile gives information on the range of competence, i.e. the homogeneity or heterogeneity of a certain inventor's competences, providing far more detailed insights than resorting to bibliographic data like international patent classification (IPC) classes or citations, whereas the latter kind of profile establishes the position of a certain key inventor in relation to others, helping to highlight specific groups of inventors and their domains. These results are clearly apt to support human resource management.

1. Introduction: new opportunities in human resource management

Indubitably, human resource management is a crucial feature of research and development (R&D) management (Allen and Katz, 1992). Like Rothwell (1992), Boutellier et al. (2000) point out that an efficient and effective R&D management is highly dependent upon knowledge and, above all, human individuals. This is confirmed by Jain and Murray (1984): 'Without the right people in the right job at the right time any of the vital management processes can be become so inefficient as to threaten the existence of the organization'. Hence, decisions about people can influence the success of R&D projects as well as learning abilities throughout the entire company.

Human resource management relies on a set of potent conventional instruments such as assessment centres or work development reports. However, in view of the progress of modern information technologies (ITs), the question arises as to whether it is possible to develop new instruments for the support of major functions within human resource management. This exposition focuses on the utilization of patents for the sake of human resource management, as patents represent a substantial source of intelligence that can be exploited in numerous ways. Recent publications have been discussing bibliometrics, classification, theory of inventive problem solving (TRIZ) and neuronal network-based methods (see Trippe, 2003). Here, a completely new line of approach will be presented, in which maps of single key inventors and key inventor sets serve to support the work of human resource managers and R&D managers. It is a method that actually overcomes the limitations of prevailing approaches in two respects: (i) As it contains a calculation of similarities between all patents of one inventor or a complete inventor set, a far more detailed picture of the inventor's know-how and capacities can be extracted. Furthermore, international patent classification (IPC) substructures can be identified within or between classes. (ii) In addition to traditional bibliometrics, this method also applies semantic structures, resulting in a more indicative measurement of similarities between patents.

The suggested approach is particularly recommendable for industrial branches in which patents are considered a key instrument of securing technological competence, e.g. in mechanical engineering or electronics. On the one hand, it is limited to such industries, where other instruments of scanning technological competences, such as trade secrets or product complexity, are predominantly used. On the other hand, this method can also be utilized in fields of industry where great store is set on scientific publications.

According to its purpose and scope, this exposition is divided into four parts: (i) To begin with, the major functions of human resource management in R&D will be addressed, taking account of the aforementioned interrelations between human resource management and R&D. (ii) Then, IT-based semantic patent analysis, statistical evaluation procedures and ordinal multidimensional scaling (MDS) are introduced as appropriate instruments for the generation of patent maps. (iii) Following our new approach, the utilization of these instruments is proposed for locating technological competences in inventors' patents. (iv) And finally, human resource management and IT-based patent mapping will be brought together, accompanied by practical recommendations concerning the use of inventor profiles for meeting emerging requirements of an R&D-related human resource management.

2. Functions of human resource management

Since the 1980s, the concept of human resource management has continually been gaining importance (see Hendry, 1995; Boxall and Purcell, 2003; Özbilgin, 2005). It is based on the notion that human resources are indispensable for the attainment of organizational goals. Consequently, human resource management can be seen as widening the perspective of personnel management by including strategic aspects linked to the company's resource-based view. There are various concepts of human resource management, resulting in different classifications of its functions. For the following analysis, we have settled on the classification given by Thom (2001), mainly because of its integrating view.

Human resource management was introduced in order to overcome the limitations of so-called personnel management, which was often regarded as an isolated specialist task, focusing on administrative work and as being basically short term. In contrast, human resource management is typified by a general management perspective (Beer et al., 1985). Akin to management processes it includes a whole set of management decisions, requiring typical management functions like planning, organization, leadership and controlling (DeCenzo and Robbins, 2002). Thus, human resource management is integrated into the general process of business management and is given the same status as e.g. marketing within an organization.

Obviously, human resource management affects the organization itself as well as its employees, while the business strategy and other functional departments have an influence on human resource management. In the 1990s, the close connection between human resource management and strategy led to the development of a strategic human resource management, which is proactive and centres on a long-term perspective. The strategies of human resource management are vertically linked with the general business strategy and with one another horizontally (Armstrong, 2001; Price, 2004).

Within the context of the resource-based view, Prahalad and Hamel (1990) identified the potential of employee skills as a resource or core competence of vital importance for the successful implementation of strategies. However, it does not suffice to take on the most intelligent or most highly qualified applicant for a post. Human resources, also referred to as human capital, need effective management in order to yield innovations (Guimaraes et al., 2001; Tseng and Goo, 2005). This has to take into account the fact that e.g. technically oriented R&D professionals, such as inventors, are likely to differ from other groups of employees with respect to their careers, values and reward preferences (Kim and Cha, 2000).

The most influential modes or mainstream theories of human resource management are the so-called Harvard Model (Beer et al., 1984) and the Michigan Model (Frombrun et al., 1984), both of which define human resource management as a form of philosophy and emphasize its strategic impact. These two schools of thought have since given rise to other interpretations in many parts of the world. For this reason, there is no consistent and commonly accepted definition of the term 'human resource management'. Dissimilarities in view occur e.g. between North America and Europe as well as within Europe itself, because of different cultural traditions or legal frameworking (Harris et al., 2003; Harzing and Ruysseveldt, 2004).

The consequence is that there are in fact various approaches to classifying the functions of human resource management. Dessler (2005), for instance, suggests four functions: (i) recruitment or placement, (ii) training and development, (iii) compensation and (iv) employee relations. To this classification, Noe et al. (2006) add two more functions, namely planning and performance (evaluation). Mathis and Jackson (2005) and Armstrong (2001) define their human resource management functions analogously, but also attach functions like health, safety and security, knowledge management or organization. Our exposition is founded on Thom's (2001) approach, as it integrates several different views of human resource management, e.g. (i) emphasizing the strategic role, linking functions with one another horizontally as well as vertically with the general business strategy, (ii) structuring key activities as a process analogous to the management process and (iii) regarding employees and their potential as essential for the organization's success.

Thom (2001) distinguishes three main categories: (i) meta functions, (ii) cross-section functions and (iii) process functions, which can be coherently visualized in Table 1. In this model, the meta function of strategic human resource management underlines the significance of involving human resource management in strategic considerations right from the start. At the same time, the meta function is seen as a function that controls and co-ordinates the cross-section and process functions. The cross-section functions like personnel controlling (supporting the planning and control of all human resource management activities), personnel marketing (increasing an employer's attractiveness on the internal and external labour markets), personnel information (providing the necessary background for information and communication) and the organization of personnel management (regulating the interaction of agents in the field of human resource management) relate to all process functions. The process functions as such are divided into six sub-categories, each of which can be described by formulating a key question:

(i) *Determination of personnel requirements:* How many employees (quantitative aspect) with what kind of skills (qualitative aspect) will be

Table 1. Functions of human resource management according to Thom (2001).

Meta functions **Strategic Human Resource Management**						
Cross-section functions	**Process functions**					
Personnel controlling	Determination of personnel requirements	Personnel recruitment	Personnel development	Personnel placement	Personnel retention	Personnel release
Personnel marketing						
Personnel information						
Organization of personnel management						

required at what location (spatial aspect) at what time and for how long (temporal aspect) in order to carry out corporate tasks effectively and efficiently?

(ii) *Personnel recruitment:* How could/should required supplementary employees be acquired on the internal or external labour market?

(iii) *Personnel development:* How could/should employees' qualifications be improved in order to meet personnel requirements at present and in the future?

(iv) *Personnel placement:* How can employees be appointed to forthcoming tasks in accordance with actual requirements as well as their individual qualifications?

(v) *Personnel retention:* What instruments can help to stimulate employees' performance and strengthen their commitment to the company?

(vi) *Personnel release:* How should/could personnel redundancies be dealt with?

3. A four-step process for patent mapping and its framing within patent analysis

Having described the functions of human resource management in the previous chapter, we shall now investigate how patent-based inventor profiling can help human resource managers (and R&D managers alike), by introducing the method's basic component of patent mapping, and by proposing a four-step process. This process will be illustrated by a case study on a major German manufacturing company, market leader for sealing and damping devices, and predominantly active in the field of mechanical engineering. Once the four-step process that was developed by the authors has been fully explained, it will be framed by classic and advanced methods of patent analysis.

The suggested process covers four steps (see Figure 1): (i) In step one, the selection of valuable patent literature is made, in keeping with the type of profile that is to be generated. For a single key inventor profile, all patents granted to one particular inventor have to be located. A profile of a company's inventor team requires the selection of all patent literature assigned to the relevant inventors. (ii) Afterwards, the selected patent literature is subject to a semantic patent analysis supported by Knowledgist™ 2.5 software. (iii) Based on the information extracted, a quantitative analysis is conducted focusing on underlying similarities, and producing a similarity matrix. (iv) The similarity matrix is then transferred into a patent map by means of advanced techniques of multidimensional scaling (MDS).

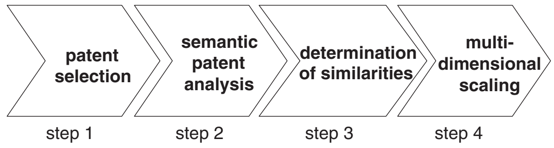


Figure 1. Four-step process for patent map determination.

3.1. Step 1: Patent selection

Patent maps are generated from a specific patent basis. In order to obtain the requisite patents a selection has to be undertaken. First of all, it is necessary to determine whether a single inventor profile or that of a complete R&D team is to be generated. With this decision in view, specific patents capturing technological competence are pooled.

In the enclosed case study, the key inventors of the aforementioned company will be analysed. To be classified as a key inventor, one has to hold five patents at least. The studied company employs 29 inventors meeting this criterion, with a total of 246 patents.

3.2. Step 2: Semantic patent analysis

The use of Knowledgist™ 2.5 software with its semantic processor helps to identify the meaning and coherence of a patent text and extract the knowledge it represents (see Invention Machine, 2000; Tsourikov et al., 2000). In detail, the semantic processor of Knowledgist™ 2.5 conducts a four-layer process to analyse the information captured within a text or patent document. This process comprises (i) a pre-formatting treatment of the text in which the format of a patent document, e.g. rtf, doc, pdf or html, is transformed into a simple text, ignoring images and other non-text objects, errors are corrected and the text is split into single sentences. (ii) A lexical analysis verifies the status of all elements in the text. This analysis involves the computer-based reading of the inputted sentences and the retrieval of possible word classes aided by a dictionary database. Each word is tagged with the corresponding word class or word classes. Consequently, words that might belong to several word classes can have more than one tag. (iii) The syntactic analysis serves to ascertain whether or not the syntactic rules of the language have been observed. It also completes the tagging of all words within a sentence, ideally reducing the number of tags attached to only one. Applying grammatical rules and statistical information, the context in which the sentence is situated is taken into account. This process is supported by the use of a Hidden–Markov Model (Rabiner, 1989). (iv) Finally, a semantic analysis is carried out to detect the key aspects contained in the text. For this purpose, the sentence structure is analysed, major structural elements (subject, action, object – abbreviated SAO) are identified and the meaning of the sentence (if there is any!) is determined. SAO structures represent a means–end relationship and can be organized in a problem–solution format in which the action–object (AO) constitutes the statement of the problem while the subject (S) forms the solution.

For the case study, Knowledgist™ 2.5 software was used to carry out the semantic patent analysis. The analysis of all 246 patents produced a total of 7.437 SAO structures. The quantities of SAO structures within single patents cover a wide range, the median being in the vicinity of 30 SAO structures per patent. An SAO structure as such consists of three elements, which can be illustrated by a simple example from the area of sealing and damping: *seating flange* (S) – *accommodate* (A) – *annular elastic spring element* (O). This SAO structure represents a means–end relationship in a patent held by the inventor Hamaeker's, showing Hamaeker's ability to use the means *accommodate annular elastic spring element* (AO) for the end *seating flange* (S).

3.3. Step 3: Determination of similarities

The Institute of Project Management and Innovation (IPMI) affiliated to the University of Bremen (Germany) has designed and developed a software tool called PIA to support the processing and statistical preparation of SAO structures. These structures, which can be regarded as concepts of inventor competence, are compared for the purpose of identifying similarities.

The PIA tool supports the import of SAO structures extracted from either a single patent or a number of patents. Additionally, bibliographic data like the IPC classification, the date of issue or the assignee are saved to a specific data set for reasons of organization but not involved in computing similarities. All information is stored inside a database which is accessible at any time. Each SAO dataset can be compared with any other. Consequently, it is possible to compute similarity values for every single patent included in the dataset (for the development and examples of similarity values, see Moehrle and Geritz, 2004). Similarity values can serve as input for various techniques of visualization.

The similarity value used in this study is based on a patent-to-patent measurement, using a quotient, the numerator of which captures similar SAO, AO and S structures and weighs them individually. The denominator represents the smallest number of SAO structures within both examined patents.

For the case study, the PIA tool was used to generate two similarity matrices based on the 7.437 SAO structures extracted earlier: one for a single inventor analysis, and the other for an inventor set analysis.

3.4. Step 4: Profile development with multidimensional scaling

The similarity matrices produced in step 3 were then taken as a basis for multidimensional scaling, a standard method of visualizing similarity data that can be used to develop inventor profiles (for a short introduction to multidimensional scaling, see Borg and Groenen, 1997).

Multidimensional scaling is an approved method of visualizing similarities and distinguishing specific connections between scaled objects. There are diverse algorithms, like ALSCAL (Young, 1981), PROXSCAL or PREFSCAL (Busing, 2003; Busing et al., 2005), most of which are implemented in the SPSS software package. The main difference results from the structure, sparseness and size of the similarity matrices used.

The method of multidimensional scaling emerged in the 1990s and has become increasingly popular ever since. The first studies were undertaken by Peters and van Raan (1993a, b) and by Engelsman and van Raan (1994). Contrary to the approach proposed in this exposition, they used key words and their co-occurrence as well as bibliographic data for capturing similarities between patents.

Apart from multidimensional scaling, a number of other approaches to patent mapping have been developed. Recent methods (Kohonen, 2001; Yoon et al., 2002; Yoon and Park, 2004) often include the use of neural networks or self-organizing mapping techniques for the visualization of similarity data.

In our case study, the similarity matrices were visualized as patent maps by means of ordinal multidimensional scaling implemented in the SPSS-module PROXSCAL.

3.5. Framing of the suggested method for patent mapping

The method of patent mapping presented here is not the only possible way of providing human resource management with an insight into patent data. Another classic method is the IPC-based analysis, that should be carried out prior to or at least in parallel with the process we are suggesting. As more recent methods make use of advanced software developments such as visualization tools, text mining tools and neural networks, they – like our approach – will permit a more detailed insight than the IPC analysis itself can provide.

3.5.1. IPC analysis

The traditional way of acquiring patent information is via international patent classification (IPC). The IPC is a comprehensive subject classification system applied to all patents by the patent-issuing authorities (for general aspects of IPC vs. USC classification, see Adams, 2001). The IPC comprises a hierarchy of sections, classes, subclasses and groups. For example, one patent of Hamaekers' is assigned to the IPC subclass F16F, indicating that the invention was made for *SPRINGS; SHOCK-ABSORBERS; MEANS FOR DAMPING VIBRATION*.

A human resource or R&D manager, who is looking for a particular competence and using the IPC for reference, would first have to find the subclass or group of subclasses in which the required competence appears to be represented, and would then proceed to identify inventors with patents in the selected subclass(es). This would result in (i) a simple set of statistics including inventors and the respective number of patents found within the selected subclass(es), and (ii) a more detailed set of statistics, including inventors whose patents applicated to more than one subclass. Accordingly, it is quite possible to obtain helpful information by means of IPC analysis. However, there are limitations regarding the identification of substructures within one IPC subclass or between IPC subclasses. Also, the measurement of similarities between patents using preceding or succeeding subclasses is rather doubtful.

3.5.2. Recent methods for patent analysis

Although IPC analysis is acknowledged as the classic method of acquiring information on inventors, its shortcomings have prompted several authors to present more advanced approaches of their own. In this context, Trippe (2003) introduced the term patinformatics, describing the science of IT-based patent information analysis for the purpose of discerning relationships and trends. Trippe distinguished nine basic techniques, also compiling an overview of related software tools (see Trippe, 2003). The basic techniques he proposes include (i) list cleanup and grouping of concepts, (ii) list generation, (iii) co-occurrency matrices and circle graphs, (iv) clustering of structured (fielded) data, (v) clustering of unstructured (text) data, (vi) mapping document clusters, (vii) adding temporal components to cluster map citation analysis, (viii) citation analysis and (ix) SAO functions.

The technique of list cleanup and grouping of concepts, for instance, is used for automatic standardization of terms within a data field. List cleanup is used to reduce a list by deleting terms that are not relevant for the requested search. The grouping of concepts entails the elimination of misspelling and the introduction of relevant synonyms and alternative terms for specific concepts. Examples of software supporting this technique are Aureka by Micropatent (see Trippe, 2003) or VantagePoint by Search Technology (see Porter, 2005; Porter and Cunningham, 2005).

During the clustering of unstructured (text) data, to cite a further instance, the full text of patents is examined as an unstructured text (Camus and Branceleon, 2003). One purpose of this being the detection of concepts and phrases that have not yet been examined, and another the tracking of similar patents (based entirely on co-word analysis regardless of semantic relationships). Patents are defined as similar if a high percentage of identical concepts or phrases are identified therein. Here, Delphion Text Clustering by Delphion (2005) is a good example of applicable software.

More recent methods of patent analysis generally allow deeper a insight into patent information than conventional methods. Which method (or related software tool) is actually the most attractive and appropriate for certain tasks in human resource management remains to be elucidated by further research (see conclusion).

4. Two types of inventor profiles

Following the explanation of the four-step process for the generation of a patent map in the previous chapter, we shall now demonstrate the application of this process in inventor profiling. Inventor profiles can be a valuable source of answers to a variety of R&D-related questions. Two major questions will be considered:

- What kind of technological knowledge does one particular inventor possess?
- What clusters of inventor competences can be identified?

These questions are answered by means of two types of competence profile: the single key inventor profile helps to visualize the main technological competences of one inventor, whereas the key inventor set profile helps to identify inventors with similar competences and detect those working in different fields of technology.

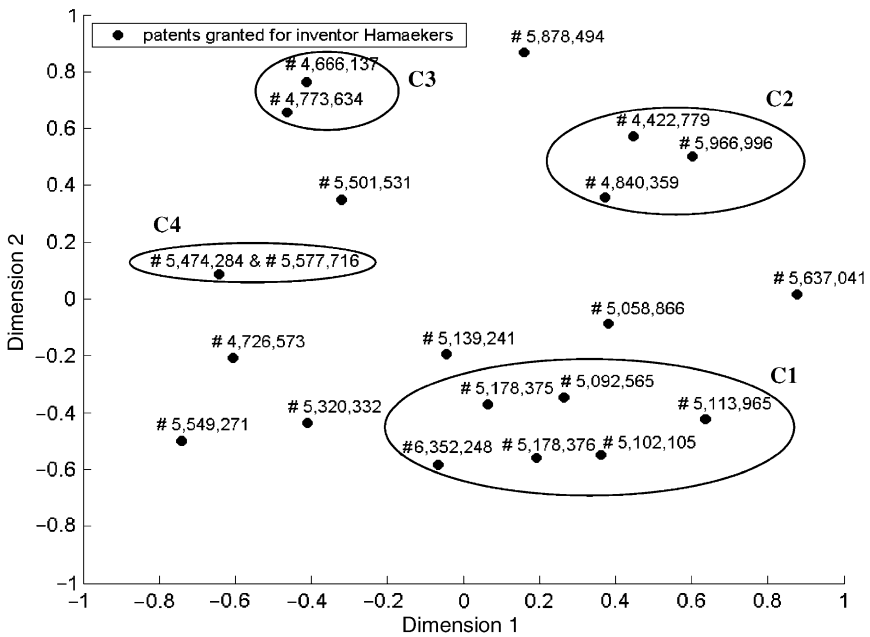
4.1. *Competence profile of a single key inventor*

One central question connected to different functions of human resource management in R&D is: what kind of technical knowledge is to be associated with a particular inventor (inside or outside the company)?

Inventor profiles are designed to deal with this problem. They provide information about the special technological interests of individual inventors. Our case study concentrates on the inventor Arno Hamaekers, who is working for the aforementioned German manufacturer of sealing and damping devices. His profile is based on 21 patents issued to his name between 1983 and 2002, and was generated by application of the previously described four-step process (see Figure 2).

In this profile, the authors have identified four clusters (C1–C4) and eight outliers. The clusters are a result of a formal classification and interpretation (for this technique, see Hair et al., 1995). (i) Cluster 1 contains six patents. A careful examination of the patent abstracts revealed that all patents of this cluster describe inventions for damping vibrations. Without exception, these inventions involve rubber components designed to absorb vibrations. For this reason, the cluster was named rubber components for damping vibrations. (ii) Cluster 2 contains three patents, in which hydraulic elements for damping vibrations are specified. (iii) Cluster 3 consists of two patents. In keeping with the technical competence distinguishable in the respective patent abstracts this cluster can be labelled hydraulically damped motor elements. (iv) Cluster 4 is called a shock-absorbing bearing cluster. Both patents contained therein refer to inventions for shock absorption e.g. in automobiles. (v) More specific inventions are located outside the four clusters, giving human resource management an indication of this particular inventor's wide technological scope.

A closer scrutiny of the clusters reveals some interesting aspects (see Table 2): considering the contents of the four clusters, one might expect that all patents belong to the same IPC back-



	Characterisation of clusters
C1	Rubber components for damping vibration
C2	Hydraulic elements for damping vibration
C3	Hydraulically damped motor elements
C4	Shock-absorbing bearing

Figure 2. Competence profile of single inventor Arno Hamaekers. Patents represented by United States Patent and Trademark Office numbers.

ground. This, however, is not the case. Cluster 1, for example, contains two patents with the subclass symbol F16F along with four patents classified in subclass F16M. Only clusters 3 and 4 are homogeneously assigned to specific IPC subclasses. While an IPC analysis as described in section 3.5.1 would have provided a first insight, the method presented in this exposition additionally produces substructures both within and between IPC subclasses. Therefore, profiles of inventor competence based on semantic patent analysis are able to overcome the barriers of IPC classification and build a profile by simply using the means–end structures that are embedded in a patent or a patent set.

4.2. Competence profiles of key inventor sets

After displaying the main results deducted from the competence profile of a single inventor, our next target is to visualize the different fields of competence represented by a group of inventors.

Questions like 'Is there one mainstream or more discernible in a company's set of technological competences, and is there one understream or more discernible in a company's set of technological competences?' as well as 'Can a specific inventor be found in a specific cluster?' will be answered.

Compared with the creation of a single inventor profile, the procedure of generating a profile of key inventor sets is slightly different. It is helpful to produce an SAO profile for each of the analysed inventors prior to computing a matrix of similarities between all inventors.

In our case study, each of the 29 inventors is merged separately. Inventor no. 4, for example, holds nine patents. (i) First, all specific SAO structures were extracted from these patents and were subsequently (ii) combined into one single inventor set. For the creation of this competence profile, all of the company's inventors holding five or more patents issued between 1983 and 2002 were entered. After generating a similarity matrix and applying multidimensional scaling, the different technological competences of these 29 inventors can be isolated.

By means of formal classification, three clusters (C1–C3) and four outliers (indicated by arrows) can be identified. The clusters represent the company's mainstream technologies, whereas outliers can be interpreted as specific understream technologies (see Figure 3).

The analysis of the three clusters produces a remarkable result. (i) Cluster 1 consists of eight inventors. All patents pooled in this cluster refer

Table 2. Separation of IPC subclasses inside the four clusters.

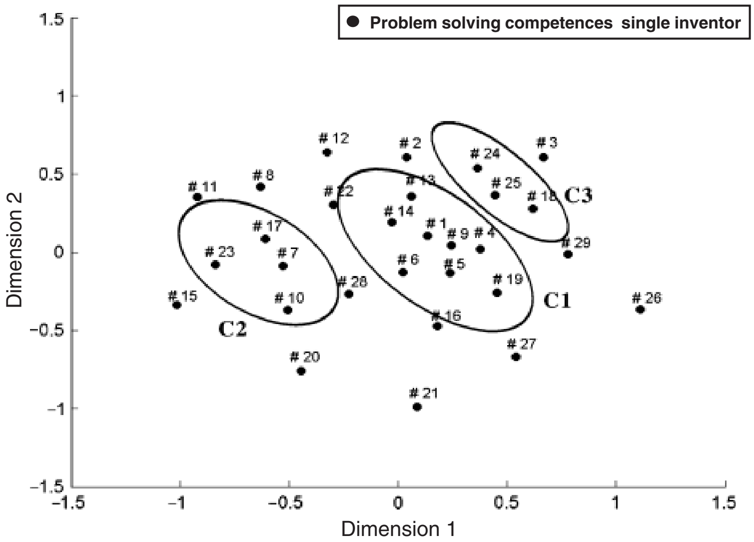
		IPC subclass			
		B60G	F16C	F16F	F16M
	Description	Wheel suspension	Shaft	Spring	Frame
Cluster	C1			• •	• • • •
	C2		•	• •	
	C3			• •	
	C4	• •			

IPC, international patent classification.

to some kind of sealing and damping device. (ii) In cluster 2, containing four inventors, methods for the production of fibres and textiles are described. (iii) Cluster 3, consisting of three inventors, focuses on inventions concerning hydraulic elements for shock absorption.

There is obviously a high degree of correspondence between the identified clusters and the organizational configuration of the analysed company. Apart from a strong business unit that combines resources dealing with the production of sealing and damping devices, there is also one business unit focusing on the fabrication of non-woven fabrics. While clusters 1 and 2 can be assigned to the first unit, cluster 3 coincides with the latter.

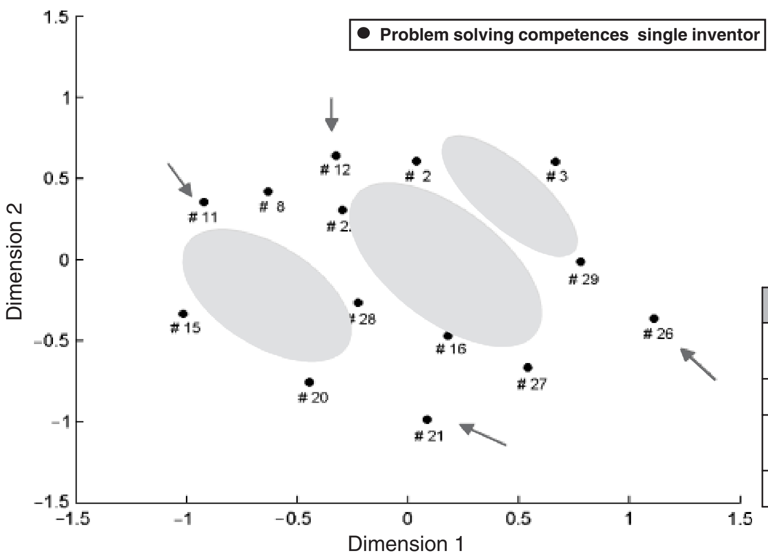
In addition to the analysis of the three clusters, the outliers (see Figure 4 – arrow-marked objects) are well worth examining. They represent specific technological competences, normally in support of mainstream competences. Inventor 11 mainly holds patents referring to different kinds of manufacturing processes, with a focus on technology for the production of sponges. Meanwhile, inventor 12 specializes in inventions for floor coverings. There is also a specific business unit concerned with this field of work. The competence profile clearly indicates the status of the inventors within the company. Although they belong to the competence portfolio, they do not occupy major positions. This can also be said about inventors 21 and 26. Inventor 21 concentrates on inventing new methods of fabric production. His technological competence deviates from cluster 2, marking an isolated position in the profile. The same phenomenon is apparent in the case of inventor 26, whose technological competences and inventions indicate a specialization on cleaning devices. Like the production of specific fabrics, inventions for cleaning devices do not involve the kind of technological competence predominant in this particular inventor set.



No.	Inventor	No.	Inventor
# 1	Andrä	# 16	Kurr
# 2	Brümmer	# 17	Mühlfeld
# 3	Dahlheimer	# 18	Rudolph
# 4	Döhring	# 19	Sausner
# 5	Eckel	# 20	Schlör
# 6	Forsch	# 21	Schmidt
# 7	Föttinger	# 22	Schmitt
# 8	Groitzsch	# 23	Schuhmacher
# 9	Hamaekers	# 24	Schwerdt
# 10	Hartmann	# 25	Simuttis
# 11	Hausdorf	# 26	Specht
# 12	Heckel	# 27	Spies
# 13	Hölzer	# 28	Stief
# 14	Johnston	# 29	Zabeck
# 15	Knoke		

	Characterisation of clusters
C1	Sealing and damping devices
C2	Methods to manufacture fibres and textiles
C3	Hydraulic elements for vibration damping

Figure 3. Competence profile of 29 inventors. Clusters representing inventors with mainstream technological competences.



No.	Inventor	Specialisation
# 11	Hausdorf	Manufacturing processes
# 12	Heckel	Floor covering
# 21	Schmidt	Manufacturing of diverse fabrics
# 26	Specht	Cleaning devices

Figure 4. Identifying inventors with specific technological competences.

5. Supporting decisions in human resource management

Following the analyses of human resource management functions and the development of two inventor profile types, both subjects shall subsequently be brought together in a final synthesis.

Decisions concerning human resource management in R&D can certainly profit from the exploitation of information embedded in patent literature. Inventor profiles generated on the basis of patents and by means of semantic patent analysis represent a substantial source of intelligence for human resource management professionals.

Both types of inventor profile, the single key inventor profile as well as the key inventor set profile, can contribute to human resource management, as described in chapter 2. Above all, they can be of use in the four process functions of (i) personnel recruitment, (ii) personnel development, (iii) personnel placement and (iv) personnel release (see Table 1). These four functions are linked with competences and qualifications of employees more closely than others, and thus show a particularly high degree of compatibility with the method proposed in this exposition.

(i) Personnel recruitment is of crucial importance to R&D management. It is difficult to identify potential staff possessing specifically required skills on the labour market, and even harder to acquire. Therefore, a targeted personnel recruitment supported by a key inventor set profile can facilitate the singling out of suitable individuals. To generate a key inventor set profile, all relevant patents of any given inventor working in a chosen area of technology are gathered. In addition to inventors already working for the company, inventors belonging to other organizations can be visualized. As a result, it is possible to identify suitable specialists simply by ascertaining whether or not they own inventor set anywhere near the company's. This can be useful for two strategic paths of personnel recruitment: (a) the recruitment of inventors who would supplement the company's present pool of technological competence in a particular field of work (indicated by a short distance between the company's inventors and those visualized in the key inventor set profile), or (b) the recruitment of inventors who are working in completely different areas of technology (indicated by a greater distance). An additional single inventor profile can complement this set of recruitment information, as it clarifies to what sort of special subject a particular inventor could be assigned.

(ii) Personnel development is an issue that does not only concern the employees themselves. It is also significant for an organization to know how employees develop skills in the course of their careers. The quantity of patents granted to an inventor can be an indicator of this professional development. A single key inventor profile that covers a longer period of time facilitates this mode of assessment. Comparing the number of patent clusters and their contents, i.e. the number of patents within a cluster, can help in finding out how an employee has developed over the years. The human resource manager will thus be able to decide whether a particular inventor's progress corresponds with the performance required in a specific sector of R&D. Accordingly, such profiles are apt to support the design of career advancement plans.

(iii) Personnel placement is aimed at a well-directed deployment of employees with regard to individual qualifications. This may prove to be problematic when a new R&D professional joins the company. A key inventor profile can help to determine to what post or task the new employee should ideally be assigned, supported by the visualization of the newcomers' position in comparison with already established inventors. There are different options of generating this sort of profile, either by selecting all inventors associated with a specific field of technology, or by selecting all technological areas that are of strategic importance. If the new employee is included in these profiles, they will indicate which section would be the most adequate for him.

(iv) A further and equally important function is the release of personnel – with its inevitable consequence known as the 'brain-drain'. A key inventor set can reveal where and whether there is an excess of inventors working in a particular field of technology. This may apply to areas that have been excluded from strategic technology management because of radical changes in basic research. The key inventor set profile helps to identify potential candidates for release. A supplementary single inventor profile, on the other hand, highlights the inventor's technological know-how. Consequently, the human resource manager has to decide whether or not to base the release of this employee on the assessment of individual know-how. The suggested profiles support the detection of redundancies in specific technological areas as well as that of inventors working in fields of reduced significance. Moreover, they facilitate the exposure of a possible 'brain-drain'.

There is also another way of rating the technological potential of R&D personnel: Ernst, Leptien and Vitt (2000) founded their capacity measurement on the patent output of R&D staff, and discovered that key inventors have an outstanding impact on the technological capacity of a business (see Vitt, 1998, 1999; Ernst et al., 2000). In spite of the different approach, these findings confirm that patents are of enormous value for the assessment of human capital.

6. Conclusions

Regarding the types of inventor profile presented in this paper, four main conclusions are to be drawn:

- Patents are a rich source of information on inventors' technological competences that can be exploited by use of semantic patent analysis. However, in order to avoid some occurring 'noise effects', further research activities, especially series of testing, will have to be undertaken.
- Inventor profiles offer an accessible means of visualizing specific technological knowledge captured by SAO structures. They can be focused either on single inventors or on sets of inventors.
- Inventor profiles support the detection of clusters. The examination of bibliographic data, titles and abstracts of identified patents in a cluster yields detailed information about inventors and technological entities.
- Human resource management clearly benefits from inventor profiling, e.g. in terms of personnel recruitment, personnel development, personnel placement and personnel release, whether by use of single inventor profiles or inventor set profiles.

Although its application is generally advisable and exploitable, the method of patent-based inventor profiles has some limitations. (i) The value of patents as a source of extractable information on technological competences is limited, especially in terms of technical contents, language and the time lag between application and publication. (ii) Patents are considered crucial for securing technologies in many but not all branches of industry. (iii) Junior professionals with no comprehensive record of patents have to be identified and addressed by other means, such as technical memos. (iv) So far, the method presented here is restricted to some basic features, e.g. due to the definition of the underlying similarity values. In this respect, much could be done to improve its performance and applicability.

Future research should help to attain greater transparency in the field of patinformatics to meet the requirements of human resource management. (i) Benchmarks could be defined, using combinations of process function tasks in human resource management, to test and measure different methods of patent analysis. (ii) A full comparison of methods would mark out their respective advantages and downsides. (iii) Subsequently, application profiles for all methods could be devised, which would facilitate the choice of an adequate method for any task that human resource managers find themselves faced with.

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