KNOWLEDGE TRANSFER – A TOOL FOR INNOVATION AND TECHNOLOGICAL PROGRESS

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Summary: Innovation is considered as the most important factor determining competitiveness of the manufacturing enterprises. The notion of innovation covers technical, technological aspects as well as style of management. In the most advanced cases innovation is based on completely new, fundamental scientific ideas, in other cases it may consist of a modification of already known concepts or transfer of knowledge. It is relatively rare that all needed knowledge is created inside the enterprise. In majority of cases knowledge is transferred from outside. The ways and methods of acquiring appropriate knowledge are discussed, including the involvement of professional brokering organization.

Keywords: knowledge transfer, knowledge brokering, innovation, rationalization, bibliometric analysis, knowledge based economy, scientific information databases.

1. Introduction

Transfer of knowledge, plays significant role for technical and technological innovations in manufacturing industry. The knowledge based economy forces the commercial and professional approach to creation as well as to the transfer of knowledge. The present work gives an analysis of methods of acquiring technical, economic and business information being indispensable for innovative manufacturing enterprises.

The idea of knowledge based economy appearing as the next stage of social development becomes widely accepted. Knowledge is the main factor influencing the competitiveness of the economy, and leading to the social and economic progress. The character of indispensable knowledge is dependent upon a number of factors, and in the considerable degree depends upon the level of development already achieved, as well as upon the wealth of the country. In the recent book Urszula Płowiec [1] underlines, that in contrast to well developed countries, in which the acceleration of development, and the growth of PKB is mainly due to technological innovations, the poor countries having the lower level of development, should base their growth in the larger degree on the beyond-technological innovations, that would manifest themselves in building the human capital, the conceptions of structural changes, and the increase of management efficiency, and the progress in creation of the infrastructure. The role of innovation in the various aspects of the economic life is also perceived in political spheres with the indication on the influence of the innovation on the competitiveness of the economy [2]. Relationships among innovativeness and the processes of knowledge management are also underlined [3]. Concerning the actual position of Polish economic and technological situation it can be concluded, that the competitive future of enterprises, regions, deciding about the level of citizens life, should be based on both: the technical and technological innovations as well as organizational and social ones. The present work, however, is mostly devoted to the technical or technological innovations.

The aim of this work is an analysis of the processes of knowledge transfer directed to support innovation in manufacturing enterprises. The next aim is the discussion the tools, available to the broker of knowledge as well as the discussion of the requirements and expectations posed by potential partners and customers.

2. Knowledge and Innovation

According to the traditional way of thinking knowledge is created as a result of scientific investigations. The science is known as the sphere of the man's intellectual activity aimed to understanding of existing reality. Traditionally, cultivation of science, and consequently creation of knowledge is the domain of scholars specializing in the definite disciplines, and organized at universities or research institutes. Scientists observe a reality and pose questions regarding unknown aspects of reality. In situations when answer cannot be found in the existing literature, they look for own solutions creating the own explanations. Since the particular conception is created, its development leads to the broadening of knowledge, what means understanding of the laws obeyed by the observed phenomena. In this pattern of building the knowledge, usually basic or fundamental, the explorer is not often able to figure out what practical use can be made out of the formed knowledge. The understanding of mechanisms ruling the chosen fragment of the nature is sufficient to be considered as a scientific result. The development of knowledge can schematically be considered as waves circularly propagating from randomly generated centers. In the picture shown in Fig. 1 the ideas represented by individual circles appear and grow on the field of ignorance. The probability that arbitrarily chosen point on the field is not reached by any of the circles, or reached by only one, or eventually covered by several circles can be expressed through Poisson equation:

$$f(n;\lambda) = \frac{\lambda^n e^{-\lambda}}{n!} \tag{1}$$

where: λ is the expectancy for a number n of covering circles.

The cumulative probability corresponding to this distribution resembles logistic curve, which on the other hand is frequently observed in bibliometric research describing time dependence of a number of publications appearing in a new field of research. The saturation observed after some time, can probably be interpreted as a signal of maturity of the discipline. It could indicate a possibility of applications.

The exchange of knowledge among various research centers occurs through publications and personal contacts - the exchange of the staff and as a rule has the noncommercial nature. The model, described above, can be considered as an example of the Mode 1 style of the scientific progress [4]. A new paradigm, described by Gibbons [5] as Mode 2, requires that knowledge is created in the context of application, become trans-disciplinary and heterogeneous; moreover its formation takes place in diverse organizations.

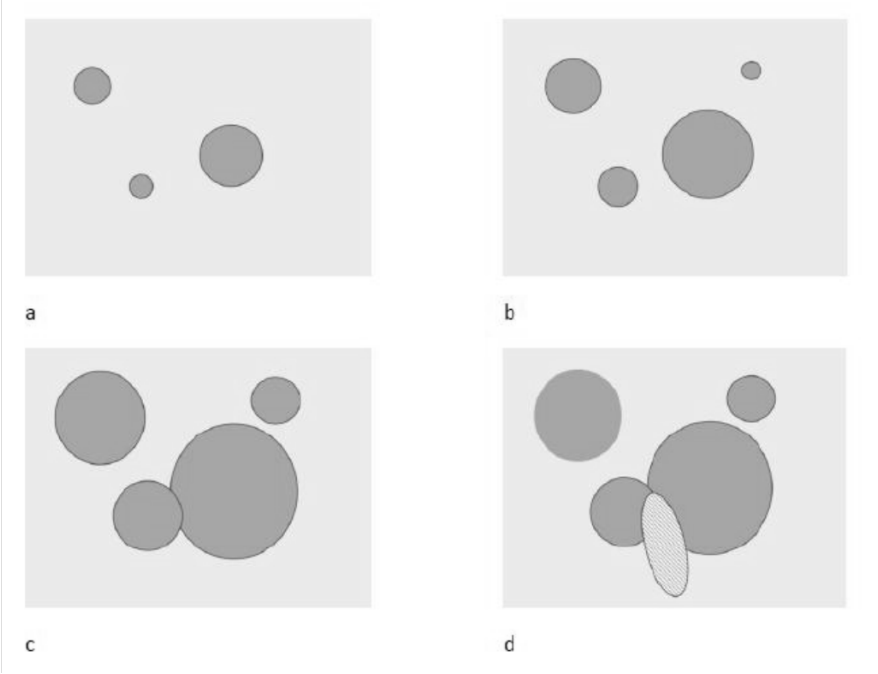

Fig. l. Schematic representation of appearance and growth of ideas
in a field of ignorance

Creation of knowledge should also be accompanied by enlarged social responsibility, and should be subjected to evaluation of its quality. Brokering of knowledge is also mentioned in this paper, and is attributed to the form of governmental activity. In the later publication [6] it is pointed out that knowledge cannot be considered as a public good, but becomes the intellectual property – become the good (or may be the commodity), which is produced and sold similarly to material goods. Such approach forces a revision of the traditional way of dissemination of scientific knowledge through publication of results, and also might affect the ways of evaluation and rewarding creators. In the hitherto existing system, when the pressure is laid on the publication of produced knowledge, the creator's reward is only in small degree dependent on social or technological usefulness of the formed knowledge. Postulated (Mode 2) change of the paradigm of science creation also attracts the change of the approach to the publication of results. In the existing approach, especially in natural and technical sciences, the full description of the solution is expected to appear in publication, enabling repetition of the conducted experiment, and the acquaintance of details of executed investigations being available since the moment of publication. As a result the knowledge contained in publication becomes the public good. In the new approach, if produced knowledge has to be available on commercial principles, the publication will perhaps have only the marketing character - informing about the existence of the solution, rather than making accessible the solution itself. This will make possible drawing the advantage from performed research to the creators of knowledge and their employers. As one can judge, produced knowledge will be priced according to its readiness for application, and according to the potential profits resulting from the

perspectives of implementation. From the second side, it should be concerned that basic knowledge, outdistancing current needs of application can be esteemed considerably lower, and with evident damage for the progress, might harder find buyers. Maybe that funding of this part of knowledge will stay the domain of the state patronage, or the long-sighted politics of the most powerful business organizations.

3. The Processes of Knowledge Creation and Transfer

Conviction, that knowledge necessary to the accomplishment of the innovation always comes from the results of basic research, being conducted on high degree of the abstraction, if such ever existed, would rather belong to naive or utopian one. The practice shows, that in many cases discoveries that made up the basis for the rise, and the development of whole fields of industry, had appeared as a result of the simple observations of facts and were applied in the practice without deep understanding of the essence of the exploited phenomena. The investigations, including the basic ones, leading to the understanding of used phenomena were conducted considerably later and doubtless they contributed to the improvements of already existing technology. One can observe such situation e.g. in the synthetic fibers industry [7], which came into being already in 19-th century (Chardonnet 1885, Cross, Bevan, Beadle 1892 and many different authors of the technology), while the first publications related to the physical fundamentals of this technology appeared in r. 1932 (Carothers), when powerful industrial companies, using the number of the various variants of production technology, already existed. One can therefore draw out the conclusion regarding the variety of mechanisms and processes, which might realize the technological innovation. An attempt to illustrate those processes is shown on Fig. 2. It is assumed here, that the knowledge, which in final phase leads to innovation, can be created in two ways: as a result of the superficial observation of the reality, as well as the result of basic investigations, aimed to understand phenomena existing in the reality. The exchange (transfer) of information exists among observation and basic investigations. Questions and problems posed to the explorers of basic sciences in the considerable measure come from the observation. The results of fundamental investigations, in the turn, can stimulate new observations, and the search for new phenomena. Conclusions from the observation, not necessarily accomplished on the way of formalized and the correct pattern of the inference (named here as intuitive knowledge) are subjected to verification through the comparison with the results of the fundamental investigations, both experimental and theoretical, and recently enriched by computer simulations. This fragment of knowledge creation can build the closed loop leading to subsequent refining of the level of understanding of the reality. The idea, leading to the practical use, can appear as a result of both types of knowledge (intuitive and scientific as well). The practical realization of the idea requires, however, execution of further investigations and conduction of the development projects. The main question that has to be solved in the case of application research is the way that should be used to achieve the required goal. The aims of these works is known (assumed or required) and clearly defined, however the way of the realization wakes the doubts which have to be solved. These works can bring the rise of completely new product, or completely new technological process, but also to the improvement or modification of existing ones. Hence, we have the invention in the first case, and rationalization in the other. The invention, and sometimes exceptionally original result of rationalization, can be registered at the patents office in the aim to obtain the protection of the intellectual property. Yet the last stage and the true aim of R&D activity is the implementation of the results to the production.

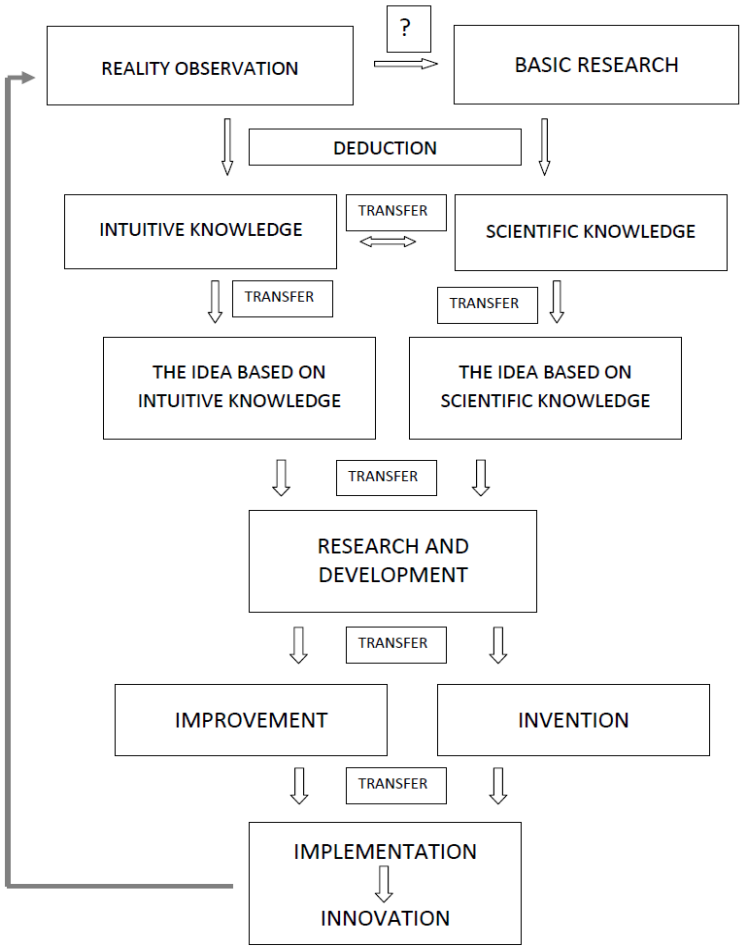

Fig. 2. The schematic representation of leading to the innovation processes of creation and the transfer of knowledge

Fig. 1 shows several places, in which the transfer of knowledge or the transfer of information occurs. At this place we can attempt to specify the role that can be played by the broker of knowledge. It seems that research and development, and the preparation to the implementation are the stages on whose broker of knowledge can be particularly useful.

4. Sources and Ways of Knowledge Procuring

The electronic sources of information are at present the most effective resources of knowledge, technical or technological as well as economic or business type. The consortium acting as one of the largest providers of scientific and technical information is

known under the name STN-International. The American publisher of the Chemical Information Service (Chemical Abstract Service) and the German Institute of Scientific-Technical Information (Fachinformationszentrum Karlsruhe) compose the consortium. Japanese Institute of Chemical Scientific and Technical Information (Japan Association for International Chemical Information), and Japanese Agency of Science and Technology (Japan Science and Technology Agency) co-operate with them closely.

The consortium possesses many representatives in the various countries of Europe, and also in other areas of the world. Many manufacturers of the databases cooperate with STN, what in the present moment gives as the result above 200 thematic databases covering various fields of science, technique and business being accessible in the net. The thematic range covers: life sciences, biotechnology, pharmacology, chemistry, physics, energetics, engineering, materials science, the medicine and toxicology, agriculture and the protection of crops, and also environment protection. Bibliographic data, and the full texts of documents published in various sources are accessible. Contained are also bases of numeric data giving the various properties of materials, substances, thermodynamic characteristics. From the viewpoint of technical and technological innovations the particularly important position is Derwent Patent Index assuring access to the huge number of patents. Patent bases and a number of other databases, such as COMPENDEX, INSPEC, CAS, DERWENT PATENT INDEX, and many others can be searched simultaneously, what makes possible detection of correlations of information contained in various bases. The access to databases is assured by means of several types of tools – the software facilitating connection and formulation of a query. The following belong to the mentioned:

- ***STN Express*** -the program that should be installed on the user's computer to enable the search the databases and elaboration of the results
- ***STN on the Web*** -the internet window lets the access to about 180 bases and enables formulation of a query using instructions and functions of the language MESSENGER that facilitates formulation of advanced query and offers many auxiliary tools.
- ***STN Easy*** - the internet form letting access to the limited number of bases (about 80) -allowing to write down the key words of query to the individual columns of the form.

STN offers auxiliary programs, such as ***STN AnaVist*** enabling the analysis of the group of the results in order to reveal regularities, or ***STN ® Viewer ™*** facilitating preview and the analysis of the patents of retrieved by means of suitable query.

The similar set of services, and the own searching tools offers ***ISI WEB of Knowledge*** that administers a set of databases produced by Institute for Scientific Information, being the part of the Thomson Reuters Corporation. ***Science Citation Index Expanded*** and ***Social Science Citation Index*** are the most important databases available from this institution. These databases deliver the number of citations of the investigated document that appear in the documents written by various authors as well as give the details of publications, in which the citation appears. This creates the possibility of the judgment of the popularity of a given publication and following the flow of ideas contained in the specified publication. It also makes a possibility to examine nets of connections between centers creating scientific conceptions. This becomes one of the essential methods of the s. c. bibliometric analysis. The databases also make possible estimation of the speed of the increase of the number of publications as a function of time, what informs about the degree of development of the given field of science, or even of development of relatively narrow scientific conception. Bibliometric analyses also lead to the quantification of the efficiency indices of both

individual scholars, and scientific organizations. Among the providers of information it is not possible to skip the database ***Science@Direct*** and related scientific search engine ***Scirus*** (< http://www.scirus.com>) led by the publishing house Elsevier. The search engine serves both: documents accumulated in the database and those accessible in the Internet. One should also remember Cambridge Scientific Abstracts (***CSA***) collecting great amount of the summaries of scientific documents from many fields of the science from humanities, through natural, to technical sciences. The option ***ProQuest Deep Indexing,*** enlarging the potential of searches is indeed accessible in some CSA-databases. Unusually useful, although not unique, in searching in the resources of the Internet, especially when searching for the institution, or a commercial offer is **Google** search engine, and also for scientific information, is the search engine **Google Scholar** directed towards scientific searches. Important possibility, especially valuable for technical sciences and engineering, is search for data collected in databases by many governmental, as well industrial institutions. Those databases, although accessible to the public, are not indexed by usual Internet search engines. Helpful tool for finding such information resources is the COMPLETE PLANET search engine (http://aip.completeplanet.com/) which is specialized in s. c. deep web searching and also contains catalog of many resources.

The tools mentioned above do not make up the exhausting review of the possibility, particularly in the face of rapid development of the already existing, and appearance of new sources of information. More detailed description is given in the book [8]. Perspectives of the development of the semantic web create a chance for development of new tools for the search of information.

The transformation of information into knowledge is important task of both the broker of knowledge and the scientist or engineer through making analyses, and also syntheses of data coming from various sources, the drawing conclusions regarding trends, making prognoses, and also evaluation of collected data. Considerable part of documents placed in the professional databases, in electronic periodicals (on-line), digital libraries is subjected to the review by reviewers well-chosen by the publisher. This reduces risk of publishing incorrect, or the dishonest opinion, but does not eliminate it entirely. However in the case of internet window, the owner can put any contents and nobody beyond the recipient makes the verification of these contents. User of such resources has to be prepared, that he will be responsible for the sense of chosen content and responsible not only morally, but also financially.

5. Knowledge Brokering

Often one can notice that the both researchers engaged at the universities, as well as in the R&D institutes do not have skills and experience in business, neither have indispensable contacts to business organizations. Their professional education, and the way of thinking, at least so far, runs away these categories from activities, which are characteristic for the business practitioners. These last, in the turn, have sufficient amount of current occupations that prevent them to observe the up to date progress of scientific investigations. This causes a gap in knowledge sharing between the both categories of actors. The filling of this gap would be the role of the broker of knowledge. This role cannot exclusively be comprehended as the working on the order. The intelligent businessman himself will find necessary device, or a new product, if he knows what he needs. Yet a businessman might often specify the functions he would expect from new and maybe still non-existing solution. The broker could, therefore, basing on his knowledge and the experience, direct

questions to the manufacturers of equipment or to the research centers, which could propose the number of solutions or to conduct investigations aimed to find appropriate solution. It can be concluded, that the broker of knowledge has to be active, he has to keep contacts with businesses, and know as well as be able to foresee their needs, he should also be in contact with research organizations, participate in the symposia, conferences, and technical fairs, and be able to notice novelties that hold promises of the perspectives use. In spite that personal contacts facilitate the meeting of the realities of the business as well as the scientific world they cannot be sufficient for professional activity of the broker of knowledge. He has also used different sources and ways of procuring information and necessary knowledge. Analysis of the literature, both technical, and business one, is one of the basic ways. A dozen or so years ago studying the literature would force to the long-lasting sojourn in libraries, today completely new possibilities creates the access to the resources existing in the electronic form. The considerable part of these resources is accessible against payment through several providers. The height of prices, in the essential way depends on the way of access, the type of the document, and also the kind of provider. Certain part of documents is accessible free of charge, but there is the no certainty of credibility of obtained documents, neither the certainty of completeness of knowledge accessible in this way.

The broker of knowledge can, therefore, establish the important link for the transfer of knowledge and the transfer of technology. One can figure out the both: activity specialized in the definite field, as well the one covering the wide spectrum of knowledge from various disciplines obtained through influence and the synergy of opinions from experts working in various fields. The activity should not be directed only on giving the answer on the concrete order – it should rather depend on permanent contacts with the scientific and business reality, building own databases enabling bibliometric analysis (cf. Narin [9], Janssens [10], Mayr P. [11], Kozłowski [12, 13]), publication of bulletins informing about the condition of knowledge in various fields. From the bibliometric analyses one can also infer about the level of the maturity of the studied scientific or technological discipline, and resulting ability to creating applicable solutions.

The way of funding the broker's office is the important question, particularly in the initial period, when there is still no grounded conviction about usefulness of such organization and the usefulness of delivered knowledge, and also about positive role of this knowledge in formation of the innovativeness of the customer in creation of its position in business surroundings. It seems, that funds supporting the innovativeness of enterprises, and also the Business Angels should take into the attention that this type of enterprises can create the fundamentals of the knowledge based economy, and create the perspective of the future development of the broker itself as well as co-operating enterprises.

The issues of the ethical nature are the next question to which one should pay an attention. The delivery of knowledge to the particular firm, especially when it is done on the order, must fulfill the requirements of the mutual confidence and discretion in the reference to the area of interests, and the range of the knowledge which the customer administers - this cannot happen to become publicly accessible. Consequently the relationships have to similar to that which arise among employer and his adviser, or the legal representative, or also between the bookkeeper and his customer, or generally among employers and consignees connected with outsourced services.

6. Conclusions

Innovation is considered to be the most important factor determining competitiveness of the manufacturing enterprises. The notion of innovation covers technical, technological aspects as well as style of management. In the most advanced cases innovation is based on completely new, fundamental scientific ideas, in other cases it may consist of a modification of already known concepts or transfer of knowledge from other sources, even from different fields of technology.

It is relatively rare, especially at small enterprises, that all needed knowledge is created inside the organization. In majority of cases at least some knowledge is transferred from outside. This obviously creates needs to establish links between providers and acceptors of knowledge. The broker of knowledge should built the platform between the research centers creating technological and organizational ideas from one side, and enterprises that can use these ideas to elevate their level of innovativeness, and market competitiveness, on the other side. Since that knowledge must cover various aspects, a professional knowledge broker should be able to analyze the state of art of technology, the availability of appropriate machinery, and eventually also suggest a possibility of cooperation at domestic and international levels. Moreover, the information should be provided discreetly, during relatively short time, and fulfill the requirement of high quality with respect to content, truth. To reach such ability a contemporary knowledge broker must be open minded, and must use several tools, especially computerized ones, already available. The most important sources of information and methods of data retrieval are reviewed in the paper. The role of knowledge broker will grow in the measure building of knowledge based economy, and in the measure of the popularization of the broker's services, as well as from the moment when the active brokers will demonstrate their usefulness for building customer's market position.

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