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INNOVATION INDICATORS DERIVED FROM PATENT DATA

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Abstract

The patent system is one of the oldest institutions of market societies and it is designed to promote and diffuse innovation.

A patent gives the inventor exclusive rights over the commercial exploitation of the invention for a limited period in return for publication of the invention.

Patents provide a very valuable source of information on the temporal, geographical, sectoral and technological distribution of inventions.

In the article the following patent indicators are discussed:

Number of patents, patent growth percent in area, percent of company patents in area , cites per patent, current impact index, technology strength, technology cycle time, science linkage, science strenght.

Keywords: patents, patent number, patent citation, patent information, innovation.

Intangibles, which include Intellectual Property Rights and innovation parameters such as research and development (R&D) or patents, also including items such reputation, trust and confidence, are now widely recognised as a major source of competitive advantage for companies.

Intellectual assets contribute far more value to businesses than all the corporate bricks and mortar combined.

Technological change and innovation are important factors for productivity and competitiveness and have thus become a central topic of economic analysis. Within the innovation process, science and technology (SmT) activities are decisive, although the influence of other elements like marketing, design and human skills have become increasingly evident. S&T activities comprise R&D and other activities such as collecting S&T information, testing and standardization, etc.

One major concern of analysts is to describe S&T activities in quantitative as well as qualitative terms. The general problem is that S&T can only be measured indirectly, using input, output or impact indicators which, OECD has suggested, should be called S&T resource, results and impact indicators.

Furthermore, in both theory and practice, it is harder to determine the results of S&T activities than to record the resources.

One solution is to use indicators which are proxies rather than direct measures and it is in this context that patent indicators are currently used for measuring the output of S&T activities.

Fig. 1, is a simplified model which shows the linkages of S&T indicators to innovation. It demonstrates that the innovation process can be subdivided into stages that may follow a typical sequence, but will not do so in all cases: for example, the technical concept and its industrial development may come before the theoretical clarification (SCHMOCH, 1993).

Furthermore, innovation can be viewed from the R&D. As a general rule individual types of R&D are not linked to particular stages of innovation, but are found at all stages, often in parallel. Even when a product has been brought to market, R&D and other innovative activities will continue. Similarly, patents cannot be tied to a single stage of innovation; they are generated throughout almost the whole of the technological life cycle.

At the same time, patents are a typical output of application-oriented types of R&D, formal and informal, i.e. applied research and experimental development, and sometimes oriented basic research as well.

Although patent indicators do reflect an important part of the overall innovation process, for a number of reasons they should not be used in isolation. They show only one aspect of innovation so that a consistent picture of technological change can only be achieved by combining several indicators. (SIRILLI, 1992 and GRUPP, 1990).

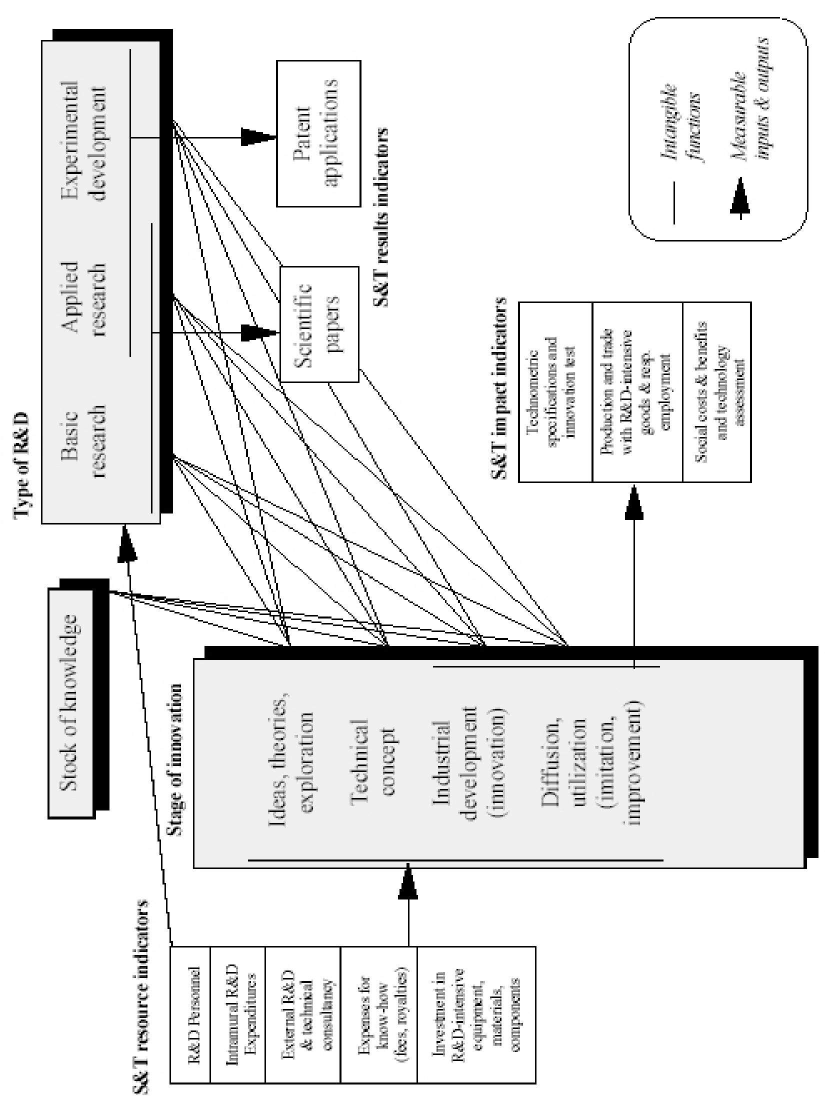
The patent system is one of the oldest institutions of market societies and it is designed to promote and diffuse innovation.

A patent gives the inventor exclusive rights over the commercial exploitation of the invention for a limited period in return for publication of the invention. The patent system is therefore a contract between the state and the individual: the former grants to the latter a legal and temporary monopoly on a certain invention against the disclosure of information which the inventor might otherwise keep secret.

A patent must provide enough detail to allow a person skilled in the art to duplicate the invention. The monopoly protection afforded by a patent is restricted to the country in which it is granted.

The owner of an invention may apply separately for a patent in each country in which protection is sought. There are international patent conventions, for example, the 1973 European Patent Convention (EPC) and the 1970 Patent Cooperation Treaty (PCT) to assist applicants in obtaining patents in more than one country. The 1883 International Convention for the Protection of Industrial Property gives priority to the patentor in any other member country within 12 months of the filing date. Hungary is a member of all the mentioned conventions.

As Scherer has indicated patents are of interest to economists, industrialists and policy makers for three main reasons: they help stimulate investment in innovation, they contribute to monopoly power, and they are a rich sorce of qualitative and quantitative information on technological change. Patent systems were developed in order to provide an incentive to inventive and innovative activity by granting inventors exclusive rights. Patents provide means by which the inventor can generate income from the invention, either through retaining exclusive use of the invention or through selling the right to use the invention by issuing a patent licence. (SCHERER, 1992)



Source: SCHMOCH (1993)

Fig. 1. Assigment of indicators to the innovation process

The granting of these exclusive rights over invention, is a form of monopoly. The rapidity and scope of competitive imitation hinges upon the presence and strength of barriers to imitation. Exclusive patent rights are an archetypal barrier. By precluding or slowing down imitation, patent rights permit innovators to capture a larger share of their innovations' profit potential. It is through this barrier to imitation effect that patents can be said to contribute to monopoly power.

In return for being granted right to exclusive use of their inventions, with the possibility of developing some monopoly power, inventors must disclose detailed information about their inventions. This information is disclosed earlier if inventors relied on secrecy as a barrier to imitation. Thus, patent specifications are a rich source of qualitative information for people interested in developing a particular technical field. The quantitative information obtainable from patents counts also has a variety of potential uses. Firms can use it to assess the technical performance of their competitors. Science and technology researchers and policy makers can use it to assess the relative technical performance of firms, industries and countries. Patent statistics provide comprehensive technical and temporal coverage. Nevertheless caution must be exercised when interpreting patent statistics due to considerable variations in the propensity to patent, across time, firms, industries and countries. (OECD, Patent Manual 1994.)

Expenditures and personnel for R&D are the first indicators constructed ad hoc for measuring scientific and technological activities. The first attempts at measurement in the field of statistics on R&D date back to the 1930's in the Soviet Union and the 1940's in the United Statetes. Hoewer, it was only in the 1950' s that the National Science Foundation (NSF) of the US embarked on a regular survey of R&D in the United States. The vast experience acquired by the NSF exerted a decisive influence on the activities of the OECD, which in 1963 led to the adoption of the Frascaty Manual on the measurement of S&T activities. Over the years this manual has been revised several times.

EUROSTAT has prepared a Manual on statistical indicators for regional activities on R&D and innovation.

1. Indicators Derived from Patent Data

Patents are the most widely availble indicator of output of technological activities.

Patents provide a very valuable source of information on the temporal, geographical, sectoral and technological distribution of inventions.

Patents represent the outcome of the inventive process and more specifically of those inventions which are expected to have commercial impact. They are a particularly appropriate indicator to capture the proprietary and competitive dimension of technological change.

A patent document contains the following information: the title, abstract and full description of the invention, the year of invention (priority year), the name, address and nationality of the owner of the invention, the technological classes to which the patent belongs, and the citations to both the relevant scientific literature and previous patents.

As patent data become more available in machine-readable form, an increasing number of researchers has begun to use measures based on patents and their citations as indicators of technological output and information flow.

As regards to the source of data on patents, three types of data providers can be distinguished: individual patent offices, international organisations, and commercial companies providing data.

Among international agencies, the World Intellectual Property Organisation (WIPO) has published statistics on patent applications and patents granted all over the world since 1979.

The European Patent Office has published data on patent applications since 1978.

A variety of national sources has also been used. In particular patents granted in the United States have been used for cross-industry and cross-country comparisons.

The Inpadoc (International Patent Documentation Centre) has built up a data base with more than ten million patents granted by 51 countries which identifies the patent families, i.e. groups of patents taken in various countries to protect the same invention (when a first application in a country – the priority – is then extended to other offices).

Derwent Publications Ltd., a private firm whose main activity is the publication of patent abstracts, has built up an electronic system to process statistics on series of data, including qualitative data, contained in patent documents.

CHI Research, Inc. has built up a data base, called Tech-Line®, on patents and patent citations at the level of individual countries and companies.

As any other available indicator patent data also have advantages and disadvantages. Problems naturally arise when information which patent offices collect for administrative reasons are used to investigate technological activity.

The main advantages can be summarized as follows:

- the availability of data from patent offices in most countries across the world, generally in very long time series,
- the patent data cover virtually every field of technology, with the exceptions of software, which is generally protected by copyright and can be patented only when it is integrated in a technical process or product,
- the detailed information available about the type of technology, the inventor, and relevant markets,
- the wide range of computerised databases developed by institutions and commercial entities which facilitate access and data manipulation,
- the very detailed classification in patent documents, which allows almost unlimited choice of aggregation levels from broad fields of technology down to single products,
- the statistical processing of patent data is largely free of errors, because patents are legal documents in which the details mentioned are very carefully recorded.

The weakness lie in:

- not all inventions are patented, sometimes firms protect their innovations with alternative methods like secrecy, rapid launching, low prices and so on.
- institutional factors, including aspects of patent law and procedures which can vary from one country or institution to another,
- the particular role of patenting in the complex process of invention and innovation, and its role in firms' strategies,
- differences in patenting behavior across sectors, patent institutions, markets, types of inventors and firms,
- the 'quality' and 'value' of patents varies greatly, due to 'home advantage' bias as countries take more patents in their domestic market than in other regions.

Tech-Line, the database of CHI Research, uses the following three standard patent indicators and six advanced citation indicators. (NARIN, 1999)

1.1. Number of Patents

A count of a company's patents issued in the U.S. patent system. Because the U.S. is such a large market, even non-US companies seek the protection of a U.S. patent for their most important innovations. By tracking number of patents, growth in patenting and distribution across technology areas, we can monitor and compare the evolution of companies' R&D activity by technology area. The number of patents tracks R&D spending but can be disaggregated across technologies whereas R&D spending usually cannot.

For the patent counts only regular (Type I) U.S. utility patents are considered. Other categories of U.S. patents such as plant patents, design patents, reissues, continuations, and so forth, are not counted, in order to keep the focus of the database on the key category of patents which contributes to corporate technological strengths.

It is important to note that, propensity to patent varies from technology-to-technology; comparisons of patent counts should be made only within similar technology areas.

1.2. Patent Growth Percent in Area

The change in the number of patents from one time period to another, expressed as a percentage. This identifies technologies receiving increasing emphasis and those in which innovation is slackening off. It also identifies companies increasing their technological development.

Patent Growth Percent in Area, from one period to the next, is just the number of patents in the current period minus the number of patents in the previous period, divided by the number of patents in the previous period.

1.3. *Percent of Company Patents in Area*

The number of patents in a technology area divided by the total number of patents for that company, expressed as a percentage. This tells us which technologies form the core of a company's intellectual property portfolio.

1.4. *Patent Citation Indicators*

Four Tech-Line indicators are derived by analyzing the references on the front pages of patents, or 'patent citations'. References are placed on patents to help establish the novelty of the invention. Inventions must be novel to be awarded a patent. To enable the patent office examiner to assess the novelty of the invention, a patent document lists 'prior art' in the form of references to previous patents in the same area. Patent citations also play an important role in patent infringement litigation by delineating the domain of the patent.

1.5. *Cites Per Patent*

A count of the citations received by a company's patents from subsequent patents. This allows you to assess the technological impact of patents.

In patent citation analysis, high citation counts are often associated with economically and technically important inventions, ones that are fundamental to future inventions. Companies with highly cited patents may be more advanced than their competitors, with more valuable patent portfolios.

It is also important to note that Patent Citation frequency varies from technology-to-technology, so comparisons should be made only within similar technology categories.

After four or five years, the average U.S. patent is cited 5 or 6 times.

1.6. *Current Impact Index (CII)*

A fundamental indicator of technological impact is how frequently a patent is cited by later patents, demonstaring patent portfolio quality. When a patent is heavily cited by later patents, this is a sign that the cited patent represents an important technological advance.

In simple terms, the CII measures how often a particular company's patents are cited, compared with the average for the overall patent system. A company with many highly cited patents is regarded as being in a strong position technologically.

In more formal terms, the current CII for a particular company is calculated based upon the number of times patents issued this year cite the patents issued to the chosen company in each of the previous five years. The number of citations is then divided by the number of patents issued to the company in each of those five years, in order to produce an average citation rate. This rate is then divided by the average citation rate for all U.S. patents issued in each year during the same time period, in order to derive

A value of 1.0 represents average citation frequency; a value of 2.0 represents twice average citation frequency; and 0.25 represents 25% of average citation frequency. We can benchmark a company's technological quality against other companies and against the average for the technology. (CII's vary by technology. For example, they are high in semiconductors, biotechnology, and pharmaceuticals, and low in glass, clay & cement, and textiles). CII has been found to be predictive of a company's stock market performance.

The key characteristic of the Current Impact Index is that is a synchronous indicator, looking backwards from the current year to the previous five years. As a result, it moves with financial indicators, and it is sensitive to a company's current technology. Essentially, the Current Impact Index is the weighted sum of the citation ratios for each of the past five year's company patents, as cited by all patents in the current year

The basic idea behind technology indicators is that they are a necessary, but not sufficient condition for company success. While it is not sufficient for a company's success for it to have a strong, creative technological and inventive capability, it is certainly necessary, if the company is going to be competitive in any of the technology driven fields. A company either has to have or develop that technology in-house or to license it in, or else it will be a strong competitive disadvantage.

1.7. Technology Strength (TS)

Quality-weighted portfolio size, defined as the number of patents multiplied by current impact index, that is, patent portfolio size inflated or deflated by patent quality.

Using Technology Strength we may find that although one company has more patents, a second may be technologically more powerful because its patents are of better quality.

1.8. Technology Cycle Time (TCT)

It indicates speed of innovation or how fast the technology is turning over, defined as the median age in years of the U.S. patent references cited on the front page of the company's patents. Companies with shorter cycle times than their competitors are advancing more quickly from prior technology to current technology. The average cycle time is 8 years. In fast moving technologies, TCT allows you to identify companies that may gain advantage by innovating more quickly.

Fast moving technologies such as electronics have cycle times as short as three to four years.

Technology Cycle Time, captures some elements of the rapidity with which a company is inventing since it measures, in essence, the time between the previous patents upon which the current patent is improving, and the current patent.

Another particularly interesting aspect of Technology Cycle Time is that it sometimes can be used, along with the rate of increase of patents, to identify areas in which a company is really intensively active. If a company is increasing its patenting, and at the forefront of a technological area, then it will tend to have a short Technology Cycle Time. It was found that the companies which are relatively slow overall in their inventive cycles will be very fast in one area, and that is often the area in which they are known to be technology leaders.

As with many of the other indicators the computation of TCT is not totally straightforward.

For one, CHI uses the median rather than the average age of the cited references because there are, very often, one or two old classic references used in a patent, and if the average is used these one or two very old references would distort the data.

1.9. Science Linkage Indicators

Two indicators are derived by analyzing the front page of patents. Patent documents must cite relevant prior art. Increasingly, patents are citing non-patent documents as prior art, and many of these are papers in scientific journals. Tech-Line's Science Linkage and Science Strength indicators are based on counts of patent references to scientific papers. Patents that reference many scientific journal articles are different from patents that reference none. For example, a patent on a genetically engineered seed, or on a neural network based process control may reference 10 or more scientific articles. In contrast, an improved design for a part of a motor may reference none.

1.10. Science Linkage (SL)

Science Linkage measures the average number of citations that a company's patents make to scientific papers and similar research publications. Science Linkage is therefore an indicator of how closely a company's patents are linked to cutting-edge scientific research.

At the forefront of a technology companies tend to have higher science linkage than their competitors. This type or referencing is growing rapidly. The average is roughly 1 per patent: drug & medicine patents often have 5 or more, leading edge biotechnology patents 15 or more, and Genentech's patents 25 or more. The areas which are the least science linked are just those areas one would expect, miscellaneous machinery, motor vehicles and parts, and other transport, each which have less than one-tenth of a science reference per patent on average.

High science linkage indicates that a company is building its technology based on advances in science. High-tech companies tend to have higher science linkage than their competitors. Science Linkage enables you to pick out the high-tech players in even traditional areas such as agriculture or textiles. Science Linkage has been found to be predictive of a company's stock market performance.

1.11. Science Strength (SS)

The number of patents multiplied by science linkage, effected, the patent portfolio size inflated or deflated by extent of science linkage. This is a count of the total number of science links in the company patent portfolio.

It indicates the total amount of a company's science linkage activity. Science strength reminds us that although a small biotech firm may use science very intensively, a big pharmaceutical firm in fact has a greater reliance on science because it makes use of research across a much larger R&D effort.

1.12. Industry-normalized Indicators

The industry-normalized versions of the indicators are computed by taking the indicator value for each company and dividing by the industry average for the company's industry. For example, suppose that there are 30 companies in the chemical industry with an average Science Linkage of 3.7, then the normalized Science Linkage for each chemical company will be that company's Science Linkage divided by 3.7. In this way, the industry effects can be removed from each company's indicators so that our portfolio will pick the best performing companies within each industry. The industry-normalized indicators are:

1. Industry Normalized Number of Patents
2. Industry Normalized % Patent Growth 1 Year
3. Industry Normalized Technology Cycle Time
4. Industry Normalized Science Linkage
5. Industry Normalized Current Impact Index

(US 6,175,824 patent, 2001)

Consequently, publicly available information on firms' science and technology is inadequate for assessing the capabilities of firms to innovate and the impact of such innovations on future corporate performance. Patent data analysis provides a potentially important tool for overcoming many of these data inadequacy problems.

The extensive documentation accompanying patent applications includes a wealth of information from which various aspects of the quality of firms' science and technology can be learned. The references cited in the patent documents are of particyular relevance, which identify earlier inventions ('prior art'), in the form of previous patents or scientific papers and articles relevant to the patent application.

Economists have examined in recent years the usefulness of patent citations as output measures of firms' innovative activities, supplementing R&D expenditures, which are an input measure

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