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## Keskusteluaiheita – Discussion papers

No. 1048

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# PATENT CITATIONS INDICATING PRESENT VALUE OF THE BIOTECHNOLOGY BUSINESS****

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**** The authors express their gratitude to Mika Pajarinen for his valuable assistance in the data processing. The financial support from the Ministry of Trade and Industry and the European Social Fund through the Ministry of Education is gratefully acknowledged.

ISSN 0781-6847 25.10.2006

**NIKULAINEN,** Tuomo – **HERMANS,** Raine – **KULVIK,** Martti**, PATENT CITATIONS INDICATING PRESENT VALUE OF THE BIOTECHNOLOGY BUSINESS,** ETLA, The Research Institute of the Finnish Economy, Elinkeinoelämän Tutkimuslaitos, 2006, 21 p. (Keskusteluaiheita, Discussion Papers, ISSN 0781-6847; No. 1048).

**ABSTRACT:** Patents form a central pathway for capturing the value of intangible assets in a knowledge-intensive business. Patents can potentially generate and support earnings in two ways: they can be traded or licensed out, and they can provide critical protection for core production technologies or products that are to be traded. Recent patent valuation literature relates backward citations to the basicness of an innovation, and forward citation counts to the economic value of an innovation. In our data covering all Finnish biotechnology patents, we found indications of only the first relation. This might reflect either an excess of a technology-orientated attitude of the companies, or a well-argued value creation mechanism that remains hidden from our research methods. The results imply that a usage of patent citation measures might provide important measures for innovation policies, technology management, and valuation of knowledge-intensive industries.

**KEY WORDS:** Patents, Patent Citations, Biotechnology

**JEL Classification:** O30, M21, L25

## 1. Introduction

This study is a first attempt to see how the economic value and technological significance of the Finnish biotechnology industry is developing through patent statistics. It encourages us to see the potential in using patent data in other contexts as well.

Qualitative studies have indicated a strong tendency of the Finnish biotechnology sector to emphasize scientific competence, even at the cost of business competence (Hussi *et al*. 2006). This places a special demand on investors to employ valuation methods that are transparent and quantitative to overcome the inherent risk of information asymmetry and biased valuations as a result thereof.

Patenting provides an essential form of structural capital for an infant knowledge-intensive company. A patent verifies that the company possesses critical knowledge and, just as importantly, that the company is capable of converting the tacit knowledge of innovators into reproducible codified knowledge. An appropriate patenting procedure signals the technological feasibility of the company's knowledge, and serves as an externally acknowledged form of intangible assets. The intangible assets, in turn, generate expectations of positive cash flows in the future. Consequently, the resources are typically steered towards applying for patents as they are crucial for obtaining further financing.

From a venture capitalist's point of view, patents signify the innovativeness and future profitability of a company. Moreover, patents can be licensed out and used in cross-licensing agreements. Therefore patents are used not only to protect intellectual capital, but can also serve as a tradable commodity.

In patenting the invention goes through a rigorous and objective verification process as laid down by the regulations. Patenting reduces the level of asymmetric information between inventors and investors and provides collaterals for the company; both are important means of controlling investors' risk. This gives, especially for smaller companies, an opportunity to obtain financing at reasonable terms.

A patent provides a basis for claiming markets, but not without a trade-off. The patenting procedure itself requires additional resources. A patent can also be challenged by competitors: in high-technology areas, it is rare that new inventions are not patented by other innovators, and hence opposition to patents is relatively common. Furthermore, due to high costs associated with prompt protection, a company does not necessarily possess sufficient resources to protect its patent portfolio from larger competitors' infringements.

This paper provides insight into the technological significance and economic value of biotechnology patents in two ways. First, we quantitatively analyze the patenting activities of the Finnish biotechnology industry. Second, we assess the quality of the patenting activities over the past few decades by the use of citation indices. We focus especially on the closeness to science and appropriability of the company patent portfolios and relate the biotechnology industry to other comparable Finnish industry segments. As the current value of science-based start-ups should be able to be linked to the commercial potential of its patent portfolio, our aim is to provide an alternative approach to the valuation of the Finnish biotechnology industry.

The remainder of this paper is organized as follows. Section two reviews the literature concerning the use of patent statistics. Section three presents the data used for this study. Estimations and results are presented and interpreted in Section four, and finally we conclude this paper with a brief discussion of the results, as well as suggestions for future research.

## 2. Analytical Background

*2.1 Patents as indicators of innovation*

For proper use of patents in economic analysis we must first define the terms 'invention' and 'innovation'. An invention is typically defined as a new idea, while an innovation is defined as a commercialized invention. This definition dates back to the seminal writings of Schumpeter (1911/1968). However, the line between these two definitions is often blurred. Sometimes an invention, and even a patent, can have great economic value despite being commercialized as such, and a commercialized patent can build on several inventions.

There are two categories for inventions; process and product. Process inventions often rely on non-patent methods of protecting intellectual property rights, such as secrecy or tacit knowledge. For product inventions the use of these strategic/non-patent options is much more difficult, because, for example, once the product enters the market, it becomes vulnerable to reverse engineering.

Patents are recognized among economic researchers as an implicit indicator of innovation activity. Although there are other legal means to protect intellectual property, patents are the most common. They also provide valuable information about the protected property. In addition to data concerning the actual invention, patents disclose information about the related inventors, companies, and other parties involved and, most notably with respect to our study, the references to related patents.

The patent system aims at facilitating the appropriability of inventions[1]. A patent provides exclusive rights over an invention for a maximum of 20 years with some variation between countries. The owner of the patent must pay an increasing renewal fee in order to uphold the patent.

[1] Appropriability is defined as the ability of inventors to capture financial and other benefits stemming from their inventions.

In case of illegal reproduction or other infringing activities, it is the patent owner's responsibility to take action. No other party can enforce the patent rights, and disputes are settled in a court of law.

A patent grants exclusive rights for the inventor, while at the same time compensates society through disclosure of the invention in the patent application. This disclosure provides a basis for rapid technological development, new inventions, and technology diffusion.

A patent can be granted for an invention that is novel and nontrivial, and which potentially has commercial applications. All inventions are not granted patent protection, due to any of the following reasons:

1. The invention does not meet the novelty criteria set by governing patent offices. Since the inventor usually does not have a complete insight into the patent pool, the invention or something very close to it might have already been patented.
2. The invention might be considered trivial. The invention can already be in common use, or it can simply be too trivial to be patentable.
3. The invention is not reproducible in a commercial sense. The invention must have a stated commercial application: it has to be a technical solution to a specific problem.

Cohen, Nelson, and Walsh (2000) found that distinct industries rely on a variety of mechanisms to protect their intellectual property. They showed that patenting is especially common in the chemical and pharmaceutical industries. They also claim that this preponderance to patent stems from the fact that research and development projects related to drugs and chemicals are often relatively large investments, which is why companies prefer the juridical protection of their investments. We assume that the same logic applies to the biotechnology environment.

### *2.2 Patents as Indicators of Economic Value*

We approach the valuation of patents by using patent citations collected from the patent publication. The citations in the patent document are indications of prior art, the existing body of knowledge. These citations are made by the applicant, but verified and possibly amended by the patent examiner. The role of these citations is to limit the scope of protection and indicate which inventions are related to the patented invention. Backward citations position the new invention technologically with respect to previous patents (Figure 1.1). Citations by other patents (forward citations, vesting with time) are considered to reflect the patent's technological significance, the applicability as well as the "appropriability", that is, the ability of the inventors to benefit from their inventions (Narin 1993, Trajtenberg, Henderson, and Jaffe 1997).

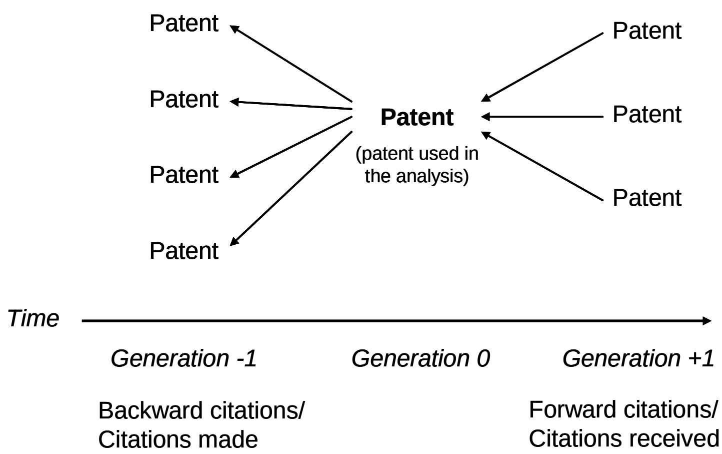



Figure 1. Patent citations

There are several studies describing the validity of using patent citations in economic research. This research can be divided into two categories: studies that focus on the validation of the patent related indicators of innovation, including patent citations, and studies that use patent citations as an indicator of economic value and technological significance.

The publications by Lanjouw (1999) and Reitzig (2004) are examples of validation studies. Both studies describe the use of multiple patent related indicators, such as citations, claims, opposition, and family size. The results show that patent citations are not the best available indicator for patent ”quality”, but they are readily available at an earlier stage than the other indicators.

Albert *et al*. (1991) conducted a survey among inventors to verify the existence of a linkage between forward citations and the significance of a patent. They studied how the inventors evaluated inventions and how this was connected to the number of forward citations. They found a connection between the number of forward citations and the technological significance of inventions (based on inventor surveys). Trajtenberg (1990) used forward patent citations in analyzing a possible connection between the number of citations and consumer welfare related to CT (computerized tomography) scanners. He argued that the number of forward citations is connected to the value of a patent. Harhoff *et al.* (1999) also used forward citations to estimate the economic potential of inventions in their study of the US and German patents. They found that the higher an invention’s economic value estimate was, the more the patent was cited.

Hall *et al* (2005) used patent citation weighted patent counts to estimate the market value of U.S. companies listed on the stock exchange. They found that patent citations could provide a more accurate picture of the company’s intangible assets. In particular, the value potential captured seemed to be enhanced in settings where the forward citations are made by the inventor (self-citation). A study by Narin *et al* (1987) used U.S. pharmaceutical patents in an attempt to connect patent citations to financial characteristics of the companies: some of the company specific financial characteristics could be explained by using patent statistics.

Citations to previous patents (backward citations) position the new invention within its application area and are linked especially to the "basicness" of a patent (Trajtenberg, Henderson and Jaffe 1997). The term 'basicness' refers to such fundamental features as closeness to science and originality, closely connected to choices and efforts of R&D. The originality of a patent is measured through an index based on patent classifications (Trajtenberg *et al*, 1997). Backward citations have also been used as a predictor of a patent's technological significance and thus economic value (Harhoff, Scherer, and Vopel 2003, Lanjouw and Schankerman 2001, Lanjouw 1999, Carpenter, Narin, and Woolf 1980).

The downside of using forward citations in evaluating the technological significance and the economic value is that they are not available until a substantial time period after the granting of a patent. However, unlike forward citations, backward citations do not reflect a realized interest in the technology; they merely look into the past. Consequently, backward citations show more noisiness in estimations compared to other estimators (e.g. forward citations), but using them in economic analysis also has some strong advantages: backward citations are available early in the life-time of the patent (at the time of publication) and they are readily available through online services. The backward citations provide comparable information upon publication of the patent document; consequently, they provide comprehensive results earlier.

## 3. Data

Patents usually have a highly skewed value distribution: few patents have a very high economic value, whereas most patents have a low economic value or none at all (Harhoff, Scherer, and Vopel 2003). In order to collect data on patents that should have the highest possible economic value, we have selected patents granted in USPTO (United States Patent and Trademark Office) and EPO (European Patent Office) only, as the costly patenting process in these patent offices should sift out inventions with a low economic potential (Moed, Glanzel, and Schmoch 2004).

### *3.1. Sources of Data*

The data we use in this paper consist of patents granted in USPTO (Unites States Patent and Trademark Office) and EPO (European Patent Office) between 1 January 1991 and 31 December 2004. Patent data was collected from publicly available sources (USPTO and EPO websites) and from an online patent database (Delphion). In addition, we collected the patent applications for EPO using the same selection criteria; in this way we aimed at ensuring that we also take into account the most recent available information of patenting activity in our target industry.

USPTO started to publish the patent applications as late as 2000. In order to achieve sufficient time-series we used only EPO patent application data. The granted patents and patent applications were selected using the IPC (International Patent Classification) classes with Finland as priority country and through company names identified in Finnish Bioindustries' Index of Biotechnology Companies.

All selected patents were also assessed individually to verify that they can be considered biotechnology related patents. We additionally divided the patents into pure biotechnology and biotechnology related (such as laboratory technology) classes. Even after this rigorous screening process, only one patent out of three hundred was clearly outside the intended target sample.

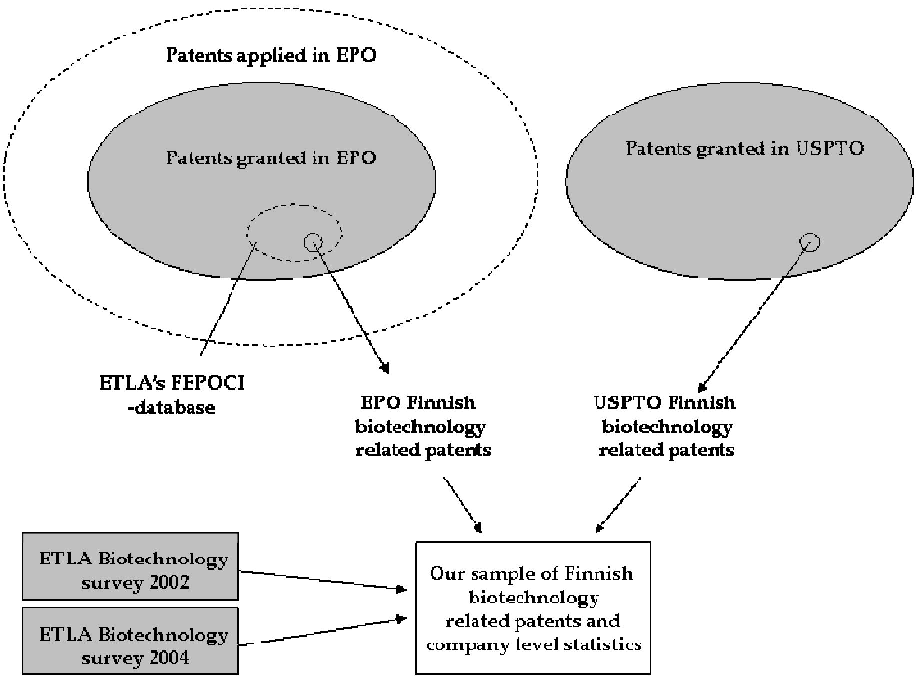



Figure 2. Data construction

In Figure 2. the structure of the data collected is visualized. ETLA's FEPOCI database (Finnish European patent office citation database) consists of patents granted to Finnish assignees and/or patents that have at least one Finnish inventor. The database contains very detailed information about the patents, inventors, and patent citations (see Nikulainen *et al* 2005 for a more detailed description of the database). From this database we collected citation information for EPO granted patents. Hence, our data covers all Finnish biotechnology patents in EPO.

ETLA has also collected biotechnology related survey data conducted in 2002 and 2004 among Finnish biotechnology companies. The data collected through the surveys was extensive (see Hermans and Luukkonen 2003 and Hermans *et al* 2005 for a more detailed description). These surveys provided us with a list of companies operating in the Finnish biotechnology sector, and in addition company specific information regarding, for example, sales, personnel, and finances.

Patents are often applied for in several locations and hence our data is partly overlapping; the same inventions are patented both in USPTO and EPO thus belonging to the same patent family. As the citations are assigned somewhat differently in USPTO and EPO, we conducted our analysis by separately analyzing the granted patents of each office (Moed *et al*, 2004). The main focus is, however, on EPO patents since they provide more comprehensive data for our comparative analysis with respect to other technology areas.

### *3.2. Description of the Data*

Our search strategy provided patents that include both pure biotechnology patents and patents related to biotechnology, such as laboratory equipment. The patenting activities within the Finnish biotechnology industry are presented in Table 2, using the aforementioned classification.

Table 2. Patenting in biotechnology

| | Granted patents | Pure biotechnology patents | Biotechnology related patents | Patent applications |
|---|---|---|---|---|
| EPO | 128 | 92 | 36 | 549 |
| USPTO | 172 | 118 | 54 | n.a. |
| Total | 300 | 210 | 90 | 549 |

The patenting has followed an anticipated path, with activity in the early 1990s being relatively low, but showing a rapid increase in the late 1990s and early 2000s. Figure 3 shows the time-series of granted Finnish biotechnology patents in EPO and USPTO.

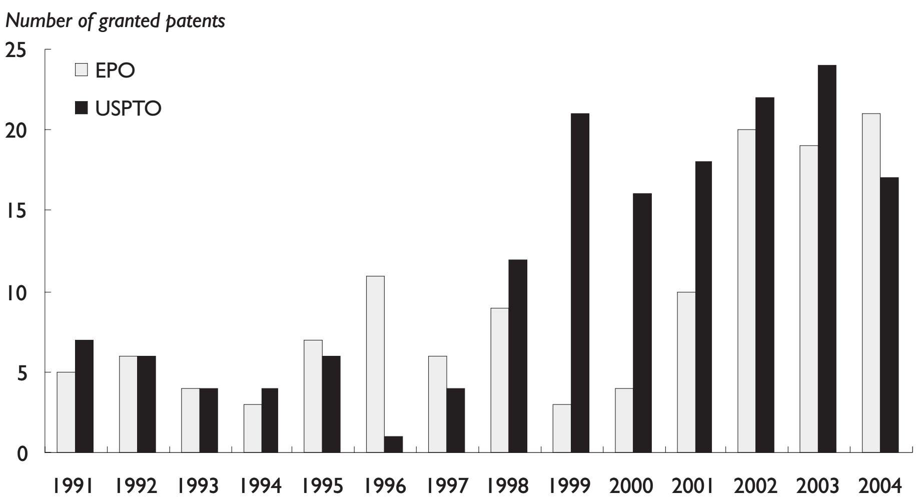



Figure 3. Number of granted patents in EPO and USPTO

As there is a time lag between the original application and the actual grant date, we have also included patent applications published in EPO to show the most recent recorded activities in biotechnology related patenting. The search criteria for retrieving the patent applications were exactly the same as for the granted patents.

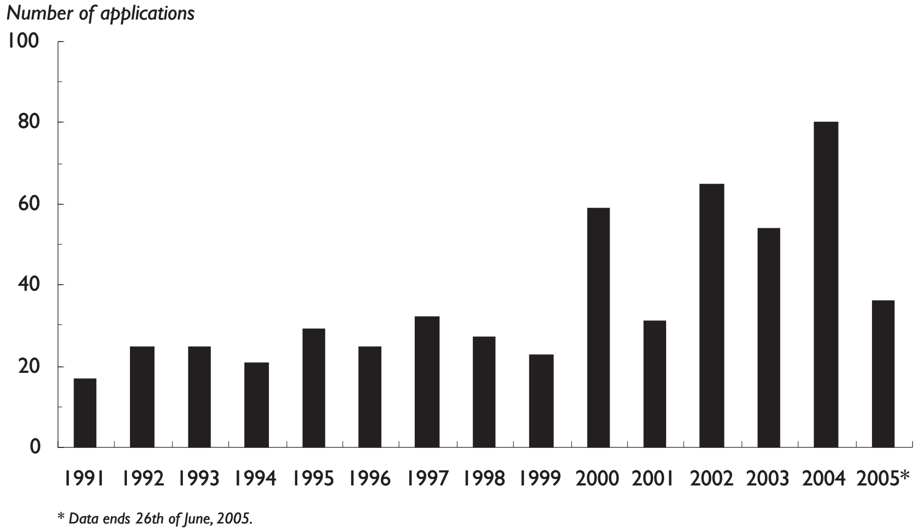
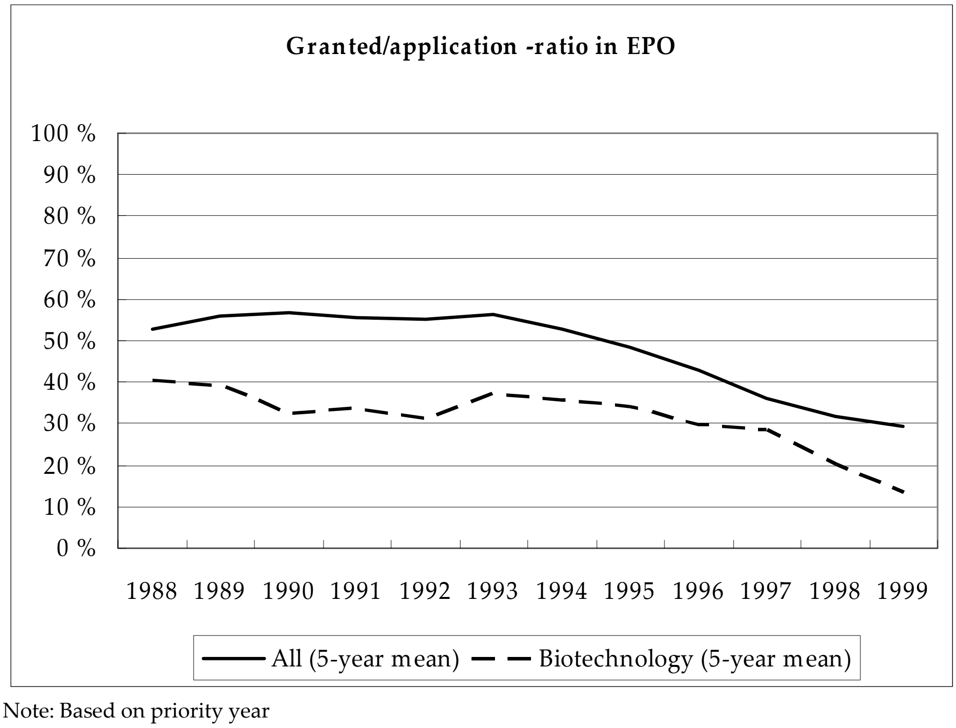



Figure 4. Number of patent applications of the Finnish biotechnology industry in EPO

The increase in patenting activity in the 2000s is illustrated in Figure 4. This indicates an increase in granted patents in EPO within the last few years. A comparison between the number of patents granted and applied for shows that few applications actually meet the patentability criteria (Figure 5).




Note: Based on priority year

Figure 5. Ratio of moving average of granted patents and patent applications in EPO

The downward trend comes from the processing lags in EPO. The percentage of patents granted in biotechnology is approximately 30% of applications. For all Finnish patents the ratio is approximately 45%, which is very close to the overall average of 47% in EPO. This is an indication of biotechnology patent applications being of lower quality (for a further discussion and measures of patent quality, see *e.g.* Ernst 2003). One rationale for this could be that companies are reviewed based on their patenting activity, which might lead to an increase in [low quality] applications.

This aspect of company behavior might have important implications for the valuation practices because patents are usually valued as a key asset in the biotechnology business. One could ask whether the biotechnology industry deliberately submits a high number of patent applications in order to convince the investors about a promising future, or the rejection rate is relatively high for other reasons, such as technical complexity. The linkage between the low overall approval rate of biotechnology patent applications and a valuation of biotechnology ventures requires further research.

## 4. Empirical Results

The values in Table 3 are the mean number of backward/forward citations for each sub-sample. The first column contains all the patents in our sample. The next column includes patents granted to SMEs only. Column three contains the pure biotechnology granted patents (other related patents, such as laboratory equipment, are excluded), and finally in column four we have the pure biotechnology patents granted to SMEs.

Table 3. Biotechnology patenting by size and technology (backward citations)

| | All patents | SME patents | All pure biotech. | SME pure biotech. |
|---|---|---|---|---|
| Backward citations | 3.79 | 4.00 | 3.30 | 3.46 |
| Forward citations | 6.07 | 5.73 | 5.88 | 6.37 |

We can see from Table 3 that SMEs have a slightly higher number of citations made (backward citations) than the larger firms. This is also true when only pure biotechnology patents are observed. A similar trend appears for pure biotechnology patents with the citations received (forward citations). Thus, SMEs seem to patent technologically more significant inventions than larger firms, which might relate to the patenting strategies of companies. Larger firms have the ability and resources to patent even ‘insignificant’ inventions, whereas the smaller companies must focus on acquiring protection only for the most ‘significant’ inventions.

### *4.1. Comparison to Other Technology Fields*

By comparing our data with similar data for other technologies we can position the Finnish biotechnology sector with respect to other technologies (Table 4). The selected comparison groups are: electrical engineering, instruments, chemicals and pharmaceuticals, process engineering, mechanical engineering, consumer goods, and civil engineering. However, the citation counts are to be used only in comparison to other counts; they provide little information about the actual economic value or technological significance *per se*.

Table 4. Comparison to other technologies (backward citations)

| | Biotechnology | Electrical eng. | Instruments | Chemicals | Process eng. | Mechanical eng. | Cons.goods & civil eng. |
|---|---|---|---|---|---|---|---|
| 1991 | 5.20 | - | 5.60 | **2.86*** ** | 5.04 | 5.24 | 4.50 |
| 1992 | 3.33 | 4.00 | **5.00** ** | 4.25* | **4.87*** ** | 4.03* | **4.92** ** |
| 1993 | 2.00 | **3.18** ** | **4.16*** ** | **3.86*** ** | **4.40*** ** | **4.29*** ** | **5.00*** ** |
| 1994 | 3.33 | 3.64 | 3.67 | 3.64 | **4.11*** ** | **4.21*** ** | **4.43** ** |
| 1995 | 5.14 | **3.54*** ** | **3.43*** ** | **4.10*** ** | **4.05*** ** | 4.75 | 4.33 |
| 1996 | 3.00 | 3.26 | **4.67*** ** | 3.33 | **3.93*** ** | **4.24*** ** | **4.00** ** |
| 1997 | 3.17 | 3.34 | 3.17 | 3.50 | **4.01*** ** | **4.46*** ** | **4.69*** ** |
| 1998 | 3.56 | 3.82 | 3.94 | 3.34 | **4.57*** ** | **4.56*** ** | 3.85 |
| 1999 | 3.00 | **3.48*** ** | **4.31*** ** | **3.89** ** | **4.06*** ** | **3.90*** ** | **4.35** ** |
| 2000 | 3.50 | 3.82* | 4.86 | **4.93** ** | **4.19** ** | **4.41*** ** | **4.97*** ** |
| 2001 | 3.60 | **4.11*** ** | **5.06*** ** | 3.74 | **4.60*** ** | **4.21** ** | **4.67*** ** |
| 2002 | 3.90 | 3.96 | **4.62** ** | 3.87 | 4.19 | **4.42*** ** | 4.10 |
| 2003 | 3.95 | 4.04 | **5.03*** ** | 4.35* | 3.99 | **4.46*** ** | 3.95 |
| 2004 | 6.43 | **3.96*** ** | **4.91*** ** | **4.78*** ** | **4.16*** ** | **4.62*** ** | **5.37** ** |
| Average | 3.79 | 3.83 | **4.49*** ** | **4.02** ** | **4.23*** ** | **4.40*** ** | **4.49*** ** |

Notes 1: The following comparisons to other technologies are based on data from EPO granted patents.
Notes 2: 1991 data on electrical engineering has been excluded due to the small number of patents.
Notes 3: t-test (average unequals the average of citations made in biotechnology patents).

*** Statistically significant at 1 % level (bolded)
** Statistically significant at 5 % level (bolded)
* Statistically significant at 10 % level

We can see that there is some volatility between the biotechnology patents and patents in other fields of technology (Table 4). Overall, biotechnology patents perform below other technology fields when backward citations are observed, with the exception of years 1995 and 2004. A relatively low number of backward citations might suggest a low basicness or novelty of the patents of the Finnish biotechnology industry compared to other fields. Another interpretation could be that the technological area in the patented biotechnology application is less competitive and less developed and consequently the total pool of patents that can be cited is smaller.

The situation changes when we look at forward citations: as shown in Table 5, the average number of citations received is now higher in biotechnology than in comparable sectors. Furthermore, biotechnology, electrical engineering, instruments, and chemicals all receive more citations on average than the other technologies over several years. As stated in the analytical background, forward citations reflect both the technological significance, applicability, and the appropriability of an innovation.

Table 5. Comparison to other technologies (forward citations)

| | Biotechnology | Electrical eng. | Instruments | Chemicals | Process eng. | Mechanical eng. | Cons. goods & civil eng. |
|---|---|---|---|---|---|---|---|
| 1991 | 4.60 | - | 10.60 | 4.14 | 3.77*** | 2.28*** | 0.83*** |
| 1992 | 10.50 | 2.83*** | 9.82 | 6.88** | 3.89*** | 3.29*** | 4.46*** |
| 1993 | 8.25 | 2.18*** | 5.42** | 5.82** | 2.93*** | 2.37*** | 3.11*** |
| 1994 | 3.67 | 4.80 | 7.63 | 3.67 | 3.22*** | 2.97*** | 2.19*** |
| 1995 | 10.43 | 5.02*** | 2.82*** | 7.66** | 3.29*** | 2.42*** | 2.78*** |
| 1996 | 6.00 | 7.28 | 5.83 | 4.86 | 3.81*** | 2.46*** | 2.08*** |
| 1997 | 5.00 | 5.98 | 6.13 | 5.91 | 3.20*** | 1.72*** | 2.87*** |
| 1998 | 3.89 | 5.44*** | 5.18 | 4.11 | 2.52*** | 2.79* | 2.88 |
| 1999 | 10.00 | 5.67*** | 4.50*** | 6.72** | 3.14*** | 2.34*** | 1.87*** |
| 2000 | 8.75 | 4.69*** | 6.10** | 6.26** | 3.18*** | 3.37*** | 2.57*** |
| 2001 | 6.44 | 6.21 | 9.06 | 6.00 | 2.75*** | 1.49*** | 1.25*** |
| 2002 | 3.30 | 5.58*** | 3.26 | 2.73 | 2.21*** | 1.52*** | 1.38*** |
| 2003 | 2.32 | 5.07*** | 2.61 | 3.50** | 1.52*** | 1.12*** | 1.24*** |
| 2004 | 1.81 | 5.30*** | 1.42* | 2.82* | 1.33*** | 0.82*** | 0.58*** |
| Average | 6.07 | 5.44*** | 4.60*** | 4.67*** | 2.64*** | 1.97*** | 2.00*** |

Notes 1: The following comparisons to other technologies are based on data from EPO granted patents.
Notes 2: 1991 data on electrical engineering has been excluded due to the small number of patents.
Notes 3: *** Statistically significant at 1 % level
** Statistically significant at 5 % level
* Statistically significant at 10 % level

Most of the forward citations are made by claimants independent of the patent holder, and also reflect a realized interest for the cited patent; consequently, the empirical literature shows a clear association of economic value and technological significance with forward citations. The high number of forward citations in Table 6 indicates that the Finnish biotechnology sector has promising future prospects arising from a well-based technological foundation.

### *4.2. Regression analysis*

Patent citations have been observed to mirror the economic value in some respects. In order to assess how the backward and forward citations, respectively, predict the present value of anticipated future sales, we performed a regression analysis.

#### 4.2.1. Dependent variables

In our regression model the dependent variable is the present value of current and anticipated future sales revenues. The present value of current and anticipated sales (PVsales) of a single company is formed as follows:

(1) $$PVsales = \sum_{i=0}^{t-1} \frac{\left(\frac{t-i}{n}\right)S_c + \left(\frac{i}{n}\right)S_f}{(1+r)^i} + \frac{S_f}{r(1+r)^t},$$

where $S_c$ denotes the current sales and $S_f$ the anticipated future sales (by the end of $t$ years) of a single company. The variables of current and anticipated future sales are based on estimations disclosed by the companies themselves in year 2003 and year 2008, respectively (ETLA survey 2004), thus $t = 5$. The term $r$ stands for a discount rate which includes a risk factor of the biotechnology industry. It is set at 20% in the basic models and within the range of 2-100% in the sensitivity analyses below.

According to Equation 1, the PVsales of the company is a sum of discounted values of two factors. The first factor is a sum of linear combinations of the current ($t=0$) and anticipated future sales ($t=5$), defined by the first term on the right-hand-side in Equation 1. The second factor is the perpetuity value of the anticipated future sales which is assumed to be fixed at the level in Year 5, defined by the second term.

4.2.2. Independent variables

The independent variables in the regression analysis include application area dummies, size and age indicators, and other variables related to R&D activity and patents. We employ the five following application area dummies: drug discovery, diagnostics, biomaterials, equipment, and enzymes. The size and age control variables are expressed as a number of personnel (log) and the company's age in years (log), respectively. R&D intensity is measured as a ratio of R&D expenditure to total costs. The patent-based indicators contain the number of patents (log), number of cited patents (standardized), number of citing patents (standardized), and originality index. Our sample consists of 30 companies.

The backward citations were standardized by defining:

$$(2)\quad BC_{adj} = \frac{BC_i - \bar{x}_{bcit}}{s_{bcit}}$$

and the forward citations by defining:

$$(3)\quad FC_{adj} = \frac{FC_i - \bar{x}_{t\_fcit}}{s_{t\_fcit}}$$

where $BC_{adj}$ indicates the standardized backward citations, $BC_i$ are the citations of the patent, $\bar{x}_{bcit}$ is the average of all backward citations, and $s_{bcit}$ the standard deviation of all backward citations. In a similar manner, $FC_{adj}$ indicates the standardized forward citations, $FC_i$ the number of forward citations per patent, $\bar{x}_{t\_fcit}$ indicates the average number of forward citations for a given year and is used in order to limit the changes over time, and the $s_{t\_fcit}$ denotes the standard deviation for a given year.

In order to illustrate the basicness of the patent, we applied the originality index (Trajtenberg et al, 1997):

$$(4)\ ORIG_{adj} = \left[ \left( 1 - \sum_{k=1}^{N_i} \left( \frac{NCITED_{ik}}{NCITED_i} \right) \right) - Average_{orig} \right] / s_{orig}$$

where $ORIG_{adj}$ is the standardized originality index for a given patent, $NCITED_{ik}$ is the number backward citations in a given technological class *k* (IPC), $NCITED_i$ is the total number of backward citations, $Average_{orig}$ is the over all mean of the originality index, and the $s_{orig}$ is the standard deviation of the over all originality index.

### *4.2.3 Regression estimations*

The estimation models used are OLS (Ordinary Least Squares) and 2SLS (two-stage least squares regression). OLS provides a rough idea of the significance, whereas the more complex 2SLS gives a opportunity to use an instrument variable to take into account a potentially reversal causality between dependent and independent variables. In the 2SLS model, the control variable is the R&D expenditure estimated in the first stage by the number of Ph.D.s, and the estimates are then used as a new variable for the second stage.

R&D activity, or the R&D expenses, is determined endogenously in the OLS model for the following reasons; 1) R&D activity can be financed primarily by internal sources, such as earnings from sales. According to the conventional financial pecking order, the company prefers internal sources of financing, such as sales earnings, to external (Myers and Majluf 1984). 2) R&D activity usually creates earnings potential to be realized only in the distant future.

Because current sales have a great impact on the present value calculations related to our dependent variable in the regression model, we have to recognize the possible severe reversal causality between the R&D expenditure and current sales earnings (as the main source of financing). Hence, the educational degree of personnel (the number of personnel with a Doctoral degree) is chosen as an instrument predicting R&D expenditure. The educational degree was available for 26 out of 30 companies. The prediction points are used in creation of a new variable for the second stage of the 2SLS model. The educational degree is assumed to be independent of the present value of sales.

The results of these estimations are presented in Table 6. These models include a robustness check (robust standard errors) controlling for any heterogenousity in the standard errors.

Table 6. Estimation results
Dependent variable: ln (PVsales)

| | OLS I | OLS II | 2SLS I | 2SLS II |
|---|---|---|---|---|
| *# of observations* | 30 | 30 | 26 | 26 |
| *Probability (F-test)* | 0.000 | 0.001 | 0.000 | 0.000 |
| *R-squared* | 0.710 | 0.741 | 0.724 | 0.742 |
| | | | | |
| *Drug discovery* | 0.836 | 0.539 | -0.083 | -0.044 |
| | (0.798) | (0.804) | (1.002) | (1.011) |
| *Diagnostics* | 0.351 | 0.461 | 0.691 | 0.568 |
| | (1.025) | (0.986) | (0.891) | (0.932) |
| *Biomaterials* | -0.643 | -0.564 | -1.125 | -1.122 |
| | (1.193) | (1.292) | (1.322) | (1.463) |
| *Equipment* | -0.966 | -1.479 | -1.820 | -2.022 |
| | (1.611) | (1.510) | (1.446) | (1.422) |
| *Enzymes* | 0.765 | 0.859 | 0.934 | 0.913 |
| | (1.276) | (1.259) | (1.504) | (1.553) |
| *Forward citations* | 0.273 | 0.335 | 0.153 | 0.320 |
| | (0.489) | (0.481) | (0.365) | (0.460) |
| *Backward citations* | 0.571 | 0.901* | 0.713 | 0.977* |
| | (0.399) | (0.486) | (0.457) | (0.522) |
| *Ln patents* | 0.215 | 0.348 | 0.064 | 0.181 |
| | (0.641) | (0.636) | (0.843) | (0.880) |
| *Ln age* | -0.021 | 0.210 | -0.123 | 0.032 |
| | (0.585) | (0.556) | (0.593) | (0.637) |
| *Ln labor* | 0.828*** | 0.843*** | 0.720** | 0.690 |
| | (0.262) | (0.241) | (0.293) | (0.285) |
| *R&D intensity* | -0.228 | 0.353 | -- | -- |
| | (1.676) | (1.498) | | |
| *Originality* | -- | -0.670 | -- | -0.546 |
| | | (0.451) | | (0.570) |
| *R&D exp est* | -- | -- | 0.502 | 0.492 |
| | | | (0.411) | (0.386) |
| *Constant* | 14.511*** | 13.502*** | 15.603*** | 15.188*** |
| | (2.357) | (2.337) | (2.197) | (2.392) |

Notes: *** statistically significant at 1%; ** at 5%; * at 10%, (robust standard errors)

Both OLS models yield a positive dependency solely for company size (labor employed) with the PVsales as the dependent variable. Our second empirical model is similar to the OLS regression model, but we have added a variable for originality. This originality variable represents the basicness of the company patent portfolio, which in other terms could be interpreted to indicate how original the patenting activity is in the company. This regression shows a statistical significance between the number of backward citations and the PVsales, other things being equal with the first model.

Consequently, the introduction of an originality index altered the results implying that our model might carry a problem of multicollinearity. This could be explained by the originality index employing backward citations, and thus introducing correlation.

4.2.4 Sensitivity analysis

We used a relatively high discount rate (20%) as the R&D projects in biotechnology are risky. We also conducted sensitivity tests to ensure that our results are valid with different risk levels. In these analyses we used very low (2%) and very high (100%) discount rates depicting low risk and extremely high risk of the projects. The low discount rate reflects solid future sales and the high discount rate current sales and highly speculative future earnings. Both of the models showed that the size is the most powerful predictor of the current and future sales. The number of backward citations was significantly close to 10 percent risk level in OLS and 2SLS models, but the results were unchanged in the component score-based model.

The results, however, do not seem to be robust in all aspects. There is some variation within the significance of backward citations depending on the model we choose. Moreover, the results seem to vary depending on the number of variables set into the model. This may imply a severe problem of multicollinearity between the application areas and other independent variables. In order to overcome the problem, the next section constructs principal components that are uncorrelated to each other.

*4.3. Principal component analysis*

We included the variables of the regression models in the principal component analysis. Table 8 below presents the principal component matrix, depicting five distinctive components.

Table 7. Principal component matrix results

| | **Comp. 1** "Well-established giants" | **Comp. 2** "Patented enzymes and equipment" | **Comp. 3** "Originality of biomaterials" | **Comp. 4** "Diagnose and cure profitably" | **Comp. 5** "Applicable research" |
|---|---|---|---|---|---|
| RD staff / pers | **-0.733** | -0.021 | -0.101 | 0.206 | **0.452** |
| PV sales | **0.671** | -0.098 | 0.263 | **0.534** | 0.161 |
| Patents | **0.651** | **0.525** | -0.256 | -0.017 | 0.165 |
| Employees | **0.641** | -0.268 | **0.416** | 0.126 | 0.233 |
| Enzymes | **0.610** | 0.346 | 0.167 | -0.242 | 0.335 |
| Age of comp. | **0.602** | **-0.452** | 0.318 | -0.064 | -0.242 |
| Biomaterials | **-0.540** | 0.333 | **0.430** | -0.217 | -0.182 |
| Bwd citations | -0.211 | **0.568** | **0.556** | **0.403** | -0.217 |
| Equipment | **0.436** | **0.568** | **-0.478** | 0.000 | -0.141 |
| Diagnostics | 0.047 | 0.537 | **-0.435** | **0.445** | -0.145 |
| Originality | -0.084 | **0.455** | **0.683** | 0.128 | -0.116 |
| Drug discovery | -0.230 | -0.254 | -0.101 | **0.789** | 0.268 |
| Fwd citations | -0.157 | 0.326 | 0.197 | -0.306 | **0.734** |

In our interpretations of the principal component results, we include only variables with loadings greater than 0.4. This corresponds roughly to a level of a statistically significant correlation coefficient related to the size of our data. Component 1 "Well-established giants" represents relatively large and relatively old companies which have a low number of patents and are active in application areas other than diagnostic equipment. Component 2 "Patented enzymes and equipment" discloses a high number of patents related to enzyme and diagnostic applications. Component 3 "Originality of biomaterials" relates the backward citations and originality of innovations to the branch of biomaterials. The index of originality is technically derived in part from the number of backward citations, and we can see that the linkage between these two variables seen in Component 3 is fairly straightforward. We have, however, chosen to include both of these variables to be able to compare the behavior of these non-identical variables.

Component 4 "Diagnose and cure profitably" relates some drug development activities with scientific expertise. These companies have a high number of backward citations. Here the behavior of the originality index differs from the loading of the backward citations, with only backward citations exceeding the 0.4 limit. Component 5 "Applicable research" shows that few of the drug discovery companies are large and their technologies are applicable or appropriable in terms of a number of forward citations, that is, their patents are highly cited by other patents.

In the following phase we have contrasted the derived principal component loadings with the current value of sales, allowing a comparison to our results from the regression analysis. The benefit of this procedure is that the model allows multicollinearity among the variables; it provides us with a richer outcome than the separate analyses above.

We found two components closely linked to the PV of sales (Figure 6).

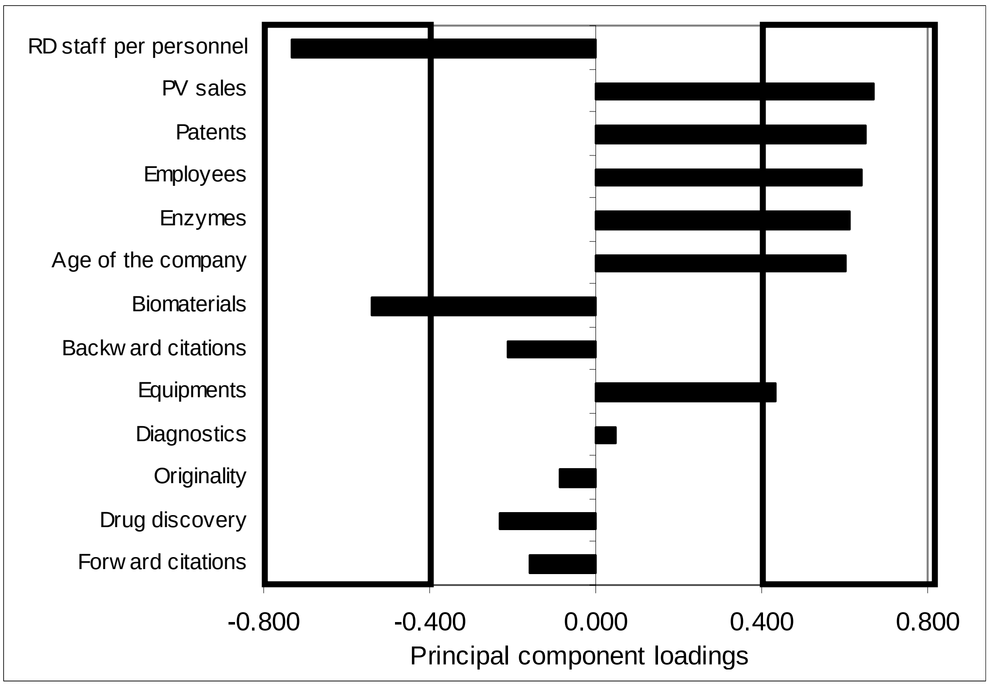



Figure 6. Principal component 1: Matured giants and high PV sales

Principal component 1, "Well-established giants", is closely connected to the company size as measured by the number of employees in the OLS and 2SLS models above; this seemed to predict significantly the present value of sales. The principal component analysis discloses an additional linkage between the size and age of the companies. Moreover, Component 1 relates the size of the patent portfolio and the age of the company to the PV of sales. This suggests that a typical giant develops enzyme and equipment applications but not biomaterials. Due to their large size, as well as their sales orientation, the giants employ relatively few R&D personnel. Neither patent citations nor the originality index show any loadings; Component 1 seems to stress the logic of "if we are big today – we will be big tomorrow".

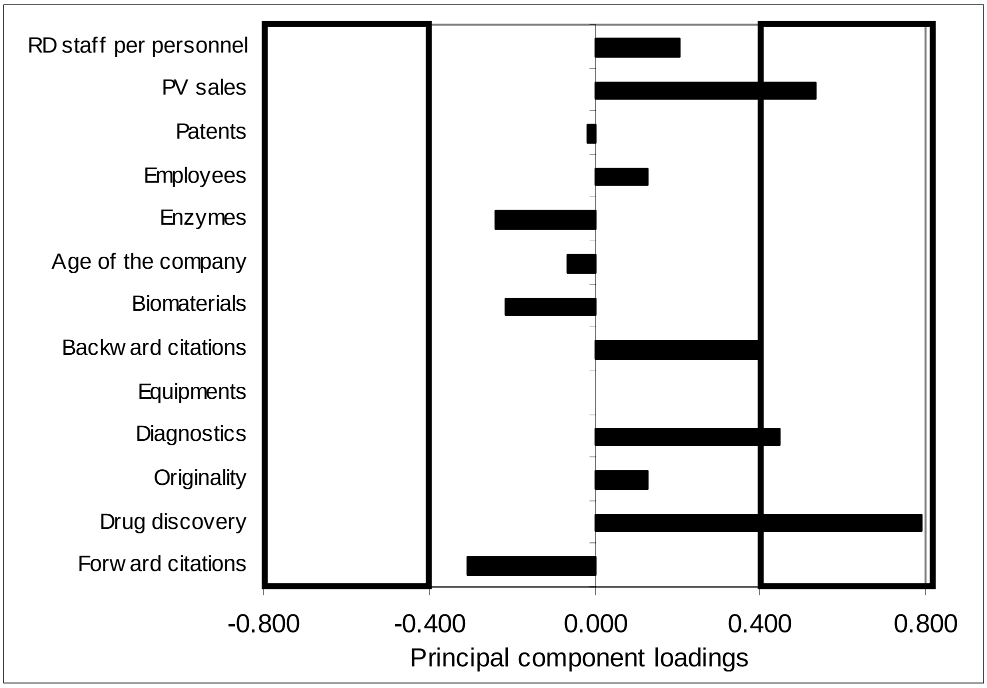



Figure 7. Principal component 4: Backward citations in drug discovery and diagnostics indicating high PV sales.

Component 4 "Diagnose and cure profitably" relates activity in drug development and diagnostics with high PVsales (Figure 7). Component 4 is also loaded with backward citations: some of the drug discovery and diagnostics companies' high expectations on future sales (PVsales) seem to be derived from the high number of backward citations in their patents; both backward citations and PVsales are strongly influenced by the companies' own judgment.

## 5. Discussion and Further Research

Industrial renewal is partially based on innovation and creation of new ideas, and patents are one of the most important instruments in the protection of these innovation activities. Therefore patenting activities can be seen as one central measure of the innovation intensity of companies. In Finnish biotechnology, the number of patents and patent applications is rising and we will most likely see a major increase in patenting within a few years due to this increase in activity.

In this work we first described the development of the Finnish biotechnology patenting citations over time. The biotechnology sector shows stability in backward citations and even a diminishment in forward citations over time. Intuitively, in an infant industry the initially low absolute number of patents in the sector can induce a confounding effect on the absolute citation counts: new patents have relatively few prior art patents to refer to (low count of backward citations), whereas the few prior art patents there are might catch an aberrant multitude of citations (high count of forward citations) due to the strongly increasing patenting activity. However, we found no indications of such an effect in our data.

In the next step we compared patent citations in distinctive fields of technology. The data showed that backward citations within the biotechnology patents in Finland is slightly below the average of all technologies during our sample period (1991-2004). On the other hand, forward citations (citations received) are higher than in the compared technologies. The literature suggests that backward citations are considered to reflect, in particular, the basicness of an innovation and forward citations both the applicability and the appropriability. Basicness refers to the technological significance, whereas applicability and appropriability reflects the economic value of the innovation. Backward citations are influenced somewhat by the applicant whereas forward citations are more independent as most of the citations are made by claimants independent of the patent holder.

The high forward citation counts compared to other industries suggest that the Finnish biotechnology sector has a high potential for creating value, but that at the same time the industry itself emphasizes the much weaker backward citations and to some extent R&D as markers for present and future earnings; but specifically not the strong forward citations. Related to the literature (Trajtenberg, Henderson and Jaffe 1997), this finding implies that the Finnish biotechnology industry seems to rely on their own technological competence as a source of the company value or their sales anticipation schemes particularly in the application segments of drug development and diagnostics.

Our regression analysis model discloses a positive dependency on company size: smaller companies seem unable to catch the value added of patents with a high basicness in contrast to the larger enterprises. Moreover, our regression models including the originality index disclose a statistically significant dependency between backward citations and present value of current and anticipated future sales (PVsales). However, neither of the models shows a dependency between forward citations and the PVsales.

Since the regression analyses did not result in unambiguous results, we also conducted principal component analysis; this was to identify any inter-linkages between the variables employed in the regression models. We found that PVsales were closely related to the variables as in the regression analyses. In addition, we found some incremental linkages on how patent citations may affect the valuation of companies.

The backward citations were related not only to PVsales, but also to the application segments of drug discovery and diagnostics.

Our findings are in line with earlier analyses on the Finnish drug development business: the segment projects higher sales expectations than other application segments (Hermans and Kauranen 2005). Our present empirical results show that the positive projections are not linked to forward citations but instead to backward citations. This indicates some problems related to the economic valuation of their own activities: Finnish drug and diagnostic companies seem to rely on their own technological superiority, but not so much on applicability and appropriateness of their innovations (see also Renko *et al*. 2005).

If the Finnish biotechnology industry cites inside their own industry but claims it has high expectations for the future, the expectations are highly technology-oriented without a strong market pull. On the other hand, if the citations are in reality outside their own technological field, they would show high originality, and the industry's interpretation is well argued. In order to elaborate further on this issue, we assessed originality indices of the patents. The results revealed that the companies did not base their PVsales on the originality of their innovations.

Our findings emphasize the importance for investors, the public sector, as well as companies themselves, to apply transparent and quantitative valuation methods in the management of the technology. This is one step to overcome the inherent risk of information asymmetry, and biased valuations as a result thereof.

## References

Albert, M. B. – Avery, D. – Narin, F. – McAllister, P. (1991). Direct Validation of Citation Counts as Indicators of Industrially Important Patents. Re-search Policy Vol. 20(3), pp. 251-259.

Carpenter, M. – Narin, F. – Woolf, P. (1980). Citation Rates to Technologically Important Patents. World Patent Information Vol. 3(4), pp. 160-163.

Cohen, W. – Nelson, R. – Walsh, J. (2000). Protecting Their Intellectual Assets: Appropriability Conditions and Why U.S. Manufacturing Firms Patent (Or Not). NBER working paper nr. 7552.

Ernst, H. (2003). Patent information for strategic technology management. World Patent Information Vol. 25, pp. 233-242.

Griliches, Z. – Schmookler, J. (1963). Inventing and Maximizing. American Economic Review Vol. 53(4), pp. 725-729.

Hall, B. – Griliches, Z. – Hausman, J. (1986). Patents And Research-And-Development – Is There A Lag. International Economic Review Vol. 27(2),
pp. 265-283.

Hall, B. – Jaffe, A. – Trajtenberg, M. (2005). Market value and patent citations. Rand Journal of Economics Vol. 36(1), pp. 16-38.

Harhoff, D. – Narin, F. – Scherer, F.M. – Vopel, K. (1999). Citation Frequency and the Value of Patented Innovation. Review of Economics and Statistics Vol. 81 (3), pp. 511-515.

Harhoff, D. – Scherer, F.M. – Vopel, K. (2003). Citations, family size, opposition and the value of patent rights. Research Policy Vol. 32(8), pp. 1343-1363.

Hermans, Raine – Kauranen, Ilkka (2005). Value Creation Potential of Intellectual Capital in Biotechnology: Empirical Evidence from Finland. R&D Management, Vol. 35, 171-185.

Hermans, R. – Kulvik, M. – Tahvanainen, A. (2005). ETLA 2004 Survey on the Finnish Biotechnology Industry. ETLA Discussion Papers No. 978.

Hermans, R. – Luukkonen, T. (2003). Findings of the ETLA survey on Finnish biotechnology firms. ETLA Discussion Papers No. 819

Hussi, T. – Hermans, R. – Kulvik, M. (2006). How do you see the future prospects of the Finnish biotechnology industry? – Interviewing 89 business leaders. In Hermans, Raine – Kulvik, Martti (eds.) (2006). Sustainable Biotechnology Development – New Insights into Finland. ETLA series B 217, pp. 47-86.

Jaffe A. – Trajtenberg M. (2002). Patents, Citations, and Innovations – A Window on the Knowledge Economy". MIT Press.

Lanjouw, J. (1999). The Quality of Ideas: Measuring Innovation with Multiple Indicators. NBER working paper nr. 7345.

Lanjouw, J. – Schankerman, M. (2001). Characteristics of patent litigation: a window on competition. RAND Journal of Economics Vol. 32 (1), pp. 129-151.

Mancusi, M. (2003). Geographical Concentration and the Dynamics of Countries' specialization in technologies. Economics of Innovation & New Technology Vol. 12, (3), pp. 269-291.

Moed, H. – Glanzel, W. – Schmoch, U. (2004). Handbook of Quantitative Science and Technology Research: The Use of Publication and Patent Statistics in Studies of S&T Systems. Kluwer Academic Publishers.

Narin, F. (1993). Patent Citation Analysis: The Strategic Application of Technology Indicators. Patent World (April), pp. 25-30.

Narin, F. – Noma, E – Perry, R. (1987). Patents as Indicators of Corporate Technological Strength. Research Policy Vol. 16, pp. 143-155.

Nikulainen, T. – Pajarinen, M. – Palmberg, C. (2005). Patents and Technological Change – A Review with Focus on the FEPOCI Database. ETLA Discussion Papers no. 984.

OECD (1994). The Measurement of Scientific and Technological Activities: Using Patent Data as Science and Technology Indicators. Patent Manual. OECD Publication.

Renko, M. – Carsrud, A. – Brannback, M. – Jalkanen, J. (2005). Building market orientation in biotechnology SMEs: balancing scientific advances. International Journal of Biotechnology Vol. 7, pp. 250-268.

Reitzig, M. (2004). Improving patent valuations for management purposes – validating new indicators by analyzing application rationales. Research Poli-cy Vol. 33(6-7), pp. 939-957.

Schumpeter, J. (1911/68). The Theory of Economic Development. English translation 1968, Cambridge: Harvard University Press.

Tahvanainen, A.-J. – Hermans, R. (2005). Funding intellectual-capital-abundant technology development: empirical evidence from the Finnnish biotechnology business. Knowledge Management Research & Practice Vol. 3, pp. 69-86.

Trajtenberg, M. (1990). A Penny for Your Quotes – Patent Citations and the Value of Innovations. Rand Journal of Economics Vol. 21(1), pp. 172-187.

Trajtenberg, M. – Henderson, R. – Jaffe, A. (1997). University versus Corporate Patents: A Window on the Basicness of Invention. Economics of Innovation and New Technology Vol. 5(1), pp. 19-50.

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