PATENT QUALITY AND COMPANY PERFORMANCE

A sample from the US biotechnology and pharmaceutical industry

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Patent quality and company performance: A sample from the US biotechnology and pharmaceutical industry

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This article presents the patent quality relation to firm performance for a sample from the US Biotechnology and Pharmaceutical Industry. Innovation value (INNV/PAT), innovation importance (INNV/PAT) and overall quality (q) are used as measurement of patent quality and book to market ratio (B/M), firm value (FV), and market capitalization (MCP) are used as measurements of performance. The sample consists of a yearly average of 600 companies, and 285,000 patents from year 1999 up to 2009. The results show that total revenue is related to patenting and R&D intensity changes, but is not related to innovation value. B/M, FV and MCAP results suggest a possible 10% increase on innovation rates. MCAP and FV relate to innovation value with average growth of 10.3% for the whole sample. B/M relates to quality (q) with average growth of 2.5%. The 3800 SIC coded group results imply; MCAP, B/M, and FV relate to quality (q) with average growth of 9.4%. These results imply that innovation outputs are perceived and valued differently by stakeholders, and markets. These effects suggest that the qualitative indexes are useful for understanding stock market activity and firm valuation for specific industrial sectors.

Keywords: Patent quality, market value, innovation, innovation value, total revenue

INTRODUCTION

Research and development (R&D) strengthen companies’ competitive advantage. Innovative technologies increase the number of patents and reduce R&D expenditures. R&D spending relates to acquiring and protecting knowledge (Chen and Miller, 2007). According to Bloch (2005), knowledge acquisition and protection contributes to companies’ competitive advantages and R&D increases companies’ opportunities to influence external fundraising.

Given ample R&D cycles and relatively low scientific success rates for individual projects, the effect of capital costs on investment decisions can be particularly high for the pharmaceutical, biotechnology, and medical device sectors. Firms in these sectors are mainly financed by equity (Harrington, 2009). Technological capital and the value of patents relates to investments and economic growth (Shane and Klock, 1997). Patents relate increasingly with knowledge-based economies in relation to firms’ sources of information, technology development, industrial trends and profitability growth (Cheng and Gao, 2009).

Stakeholders continuously assess the value of R&D intensive companies. Investors evaluate companies’ performances using different market value indices and different tools to measure innovation value and knowledge assets (Lev 2001; Oriani and Sobrero 2002; Ballardini et al., 2005; and Chichirau 2007). There is an increasing interest in using the accumulation of knowledge as a measure to evaluate company performance. Single patent count is not a reliable way of describing the relationship between R&D expenditure and a company’s performance and value. Therefore, single patent counts are considered as inadequate proxies for innovation value (Griliches1984, 1988; Hall, Jaffe and Trajtemberg 2000, 2001, 2005; Hall, Thoma and Torrissi 2006; and Chichirau, 2007).
In relating patent quality to a company's performance and value, this article is organized as follows: The following section describes the R&D and innovation valuation. Based on this theoretical background, the third section discusses the hypotheses and research methodology applicable to R&D and innovation value. The fourth section presents the main findings and analysis, as well as the limitations of the research and suggestions for further research.

**R&D and innovation valuation**

The continuous innovation research process creates innovative scenarios relevant to science related policies, technology, and global innovation performance (OSLO Manual, p. 25). Proposed importance demands adequate disclosures to assess R&D spending, and stakeholder's capital, and economics effects (Xu Magnan and Andre 2007; Oliver, 2003). As in Hall et al. (2000), this article uses indices related to innovation and corporate value implications. The related indices value and importance of a patent can have market implications for a company's performance, business sustainability, and companies' strategic positions.

According to Chichirau (2007), further analyses using finance and economic factors are needed to determine the implications of the qualitative value of patents. These factors include industry-specific samples, particularly in the pharmaceutical and biotechnology sectors. Data provided by the World Intellectual Property Organization (WIPO) support the theory that patent trend information can be a valuable tool in evaluating the economic performance of selected countries and industrial sectors within selected time frames (http://www.wipo.int/ipstats/en/statistics/pct/) (figures 1 and 2).

Approaches focused on both theoretical and empirical
innovation have shown tangible R&D effects; this article intends to assess R&D spending and intensity, and related outputs by considering the implications between the quality value of a patent in terms of its backward and forward citations, the quality importance of a patent as reflected in its claims and references, and corporate profitability. Also, variables such as book-to-market value (B/M), firm value (FV), and market value are used.

RESEARCH METHODOLOGY

Chichirau (2007) states that a company’s economic and business performance relates to fine-tuned R&D patent portfolios and references. Following definitions of Lanjouw and Shankerman (2004), devised methods apply the following indices:
- Patent counts (PATS) are the sum of patents a company applies in any given year.
- Patent claims (CLAIMS) are a section that alternate inventors request as part of the applied patent.
- Forward references (FREF) are following patents that cite a given patent in their own applications.
- Backward references (BREF) are patents cited previously in the application.
- Family patents (FAMPATS) are parallel patents created in alternate countries.
- R&D spending (R&D) is the logical costs needed to create a stock of knowledge.
- R&D intensity (RD/OI) is the ratio of R&D spending to operating income (OI).
- Return on Equity (ROE) gauges stockholders’ profitability as a percentage of the corporation’s net worth.

Hall et al. (2001) present methods intended to correct Forward References truncation, a technique used to improve forward references indices reliability. Hall et al. (2001) state that forward references life spans may extend up to 30 years. Additionally, larger time periods help to prevent patent and citation-grant lags because just -granted patents get forward references. The output of revised truncation correction regression models explains at least 20% of the variance. Complementary tests may be necessary to refine correction models that determine references truncation.

The financial variables used in this article include R&D expenses (R&D), total revenues; operating income (OI), return on equity (ROE), stockholders equity, total assets, market capitalization (MCAP), book-to-market (B/M), firm value (FV), and cash. The knowledge data indices are obtained from the “Delphion Patent Database”. This database includes USPTO, EPO, OECD, and WIPO data. The retrieved capital indices and financial variables are obtained from “Mergent Online”. The sample includes both biotechnology and pharmaceutical firms acting publicly and patenting in the United States between 1999 and 2009.

Based on data collected from US biotechnology and pharmaceutical companies concerning the link between R&D and a company’s performance, analysts must consider the following research questions:
(H1): How does R&D spending (R&D/IOI) relate to companies’ total revenue?
(H2): How do a patent’s innovation value (INNV) and importance (INNP) relate to the book-to-market ratio and firm value?
(H3): How do patent quality indices (q) relate to the book-to-market ratio and firm value?

To obtain the final sample, the following criteria were used: (1) only firms included within SIC codes 2800 and 3800 are considered. These two classifications comprise corporations involved in basic organic manufacturing, medicinal and botanical manufacturing, pharmaceutical preparations, in-vitro and other biological substance preparations. As well, all companies in the final sample operate in the United States and have at least three years of financial and patent data.

The following companies are excluded from the final sample: 66 firms that are not acting locally, 24 American firms acting in China, 18 Canadian firms, 12 Israeli firms, and 12 European firms. Two thousand two hundred thirty-seven (2,237) other firms do not belong to the selected SIC codes and are, therefore, excluded from the sample. The final sample consists of 1,231 SIC-coded firms acting in the United States between 1999 and 2009.

The collected data in this sample are not normally distributed. Common statistical analysis demands data from normal populations (Norusis, 2012, p. 463). Two main factors prevent the selected sample from achieving normality. First, SIC codes are the only grouping tool. Added discrimination measures will help to convey results trends within groups. Previous factors led to wider ranges of both standard deviations, and variances. Secondly, some cases have negative profitability indices. Data with negatives usually normalizes by adding a constant number to the entire sample, but in this case, adding a constant to the sample might weaken or eliminate significant or mild correlations.

Therefore, nonparametric models are used to analyze the data. The benefits of these methods depend on nonrestrictive assumptions such as parametric tests, and devised data ranking procedures avoid multi collinearity and heteroskedasticity (Andy Field, 2009, p. 540). This methodology designs a patent qualitative indices factor model based on the principles of Hall et al., (2001 and 2007), and Lanjouw and Schankerman.
REFERENCES, 14,595, with an average of 63 forward references and a standard deviation of 505 forward references. Backward references range from 1 to 63,349, averaging 328 with a standard deviation of 2455 backward references per patent applied. Figures 3 and 4 displays the time series of constructed indices.

The 2800 SIC code group of firms specializing in chemicals and allied products presents the following descriptive statistics. The total revenues range from $-9 million (Mergent utilizes the FASB Revenue Recognition—Milestone Method (Topic 605) No. 2010-17 April 2010. The negative numbers are the results of companies’ collaborations on R&D and innovations.) dollars up to $81,107 million dollars. Average total revenue is $1,582 million dollars with a standard deviation of $ 7,061 million dollars. Total assets range from zero dollars to $212,949 million dollars, with an average of $2,258 million dollars, with a standard deviation of $ 11,140 million dollars. This SIC code group has R&D expenses ranging from zero dollars to $12,183 million dollars. R&D expenses for this code group average $130 million dollars, with a standard deviation of $654 million dollars. The firms contained in this subsample have an average of 87 patents, ranging from one to 5,006 with a standard deviation of 394 patents per corporation. The average number of backward references for this group is 94 references, ranging from one to 63,349 with a standard deviation of 1,530 references per total patents applied. Forward references per patents within this group averaged 19 references, ranging from one to 10,018 references per patent applied, and a standard deviation of 234 references per total patents applied in group. Figures 5-8 include SIC coded sample time series of constructed innovation qualitative indices.

The SIC code group 3800 comprises firms specializing in instruments and related products, displays the following descriptive statistics. The average total revenue is $694 million dollars, ranging from $0 to $99,512 million dollars with standard deviation of $ 4,991 million dollars. The total assets average $634 million dollars with a standard deviation of $2,663 million dollars. Total assets range from $0 to $31,197 million dollars. This subsample has an average R&D expenditure of $43 million dollars, and a standard deviation of $199 million dollars. The outputs of R&D average 55 patents per corporation, ranging from one up to 2,034, and a standard deviation of 205 patents per corporation. Backward references in this group averaged 97 references. The number of backward references per patent ranges from 1 to 21,265 with a standard deviation of 797 references per total patents applied. Forward references per patent within this group ranges from 1 to 3,365 references with an average of 19 references and a standard deviation of 130 references per total patents applied in group.
In Panel A, R&D spending growth shows correlation coefficients of 0.439 ($\alpha = 0.05$) with Patent's counts, of 0.190 with backward references, and of 0.318 with forward references. Patents correlate positively with both backward ($r=0.524$) and forward references ($r=0.787$). Patents and family patents have a positive
correlation of 0.910. According to Lanjouw and Shankerman, the importance of innovation will increase proportionally as corporations apply for parallel patents in alternate countries (2004).

Panel B presents the financial implications of innovation. R&D spending growth does not associate with increased operating income. Patents applied per million dollars spent correlates with increased operating income; the sample shows a (r = 0.19) significant relationship (α = 0.05). Spending one million dollars in R&D without any further disclosures will increase revenue by nineteen. R&D spending was negatively correlated (r=-0.387) and statistically significant (α = 0.05) with patents per million dollars spent. A weak positive relation exists (r=0.051) between patent productivity (patents/R&D) and R&D spending when scaled with operating income. A significant negative correlation (r=−0.157) between patent productivity and forward references per patent may indicate that patent production is detrimental to innovation value. Chichirau (2007) got results similar to those in Panel B. However, scaling references (backward references: 0.195, forward references: 0.150) with operating income indices significantly correlates (α = 0.05) with operating income growth. Prior results may backup relative income growths to higher quality patents.

In Panel C, stakeholder’s and market’s view on innovation value, spending, and intensity, R&D scaled with stockholder’s equity percentage (RD/SE) shows significant (α = 0.05) nominal coefficients (r= 0.079) between forward references. Additional significant (α = 0.05) relationships exist between patents per million dollars, patents weighted by stockholders equity (r=0.580), and both backward references (r=0.587) and forward references (r=0.540) weighted by stockholders equity. Merely producing patents is beneficial to stakeholders, because previous perception increases as the value of patents increases and builds over higher value knowledge. Relating Book-to-market to R&D intensity produced significant positive factors. These correlations may suggest that higher value R&D intensity has practical implications to market value. Correlating book-to-market value and number of patents weighted by stockholders equity shows a significant (α = 0.05) but moderate relationship (r=0.05). Both Forward references and backward references weighted by stockholders equity seem to have a positive relationship, as shown by its correlation coefficient of 0.689.

In Panel D, the market capitalization growth value has positive correlations with returns on assets (r=0.095), and stockholders equity growth (r=0.072). In Panel E, the indices interaction with the factor analysis outputs innovation value (INNV) and innovation importance (INNIP) were included. According to Lanjouw and Shankerman (2004), forward references indicate that the knowledge protected in the patent has contributed to future research and potential dominance in a
valuable technological area, while a large number of backward references may represent less expensive knowledge. Innovation value \((r=0.194)\), importance \((r=0.210)\) and quality \((r=0.206)\) indices relate significantly \((\alpha = 0.05)\) to R&D growth. Patenting intensity has intriguing relations to innovations value \((r=0.322)\), importance \((r=0.301)\) and quality \((r=0.297)\). Innovation importance \((r=0.360)\), innovation value \((r=0.344)\) and quality \((r=0.357)\) clearly influence stockholders equity, but the correlation of stockholder equity growth percent with innovation value \((r=0.174)\) and innovation importance \((r=0.183)\) indices indicates that stockholders may view innovation value as the most trustworthy gauge of market value. This is consistent with Putnam (1996) that family size should be directly related to the expected value of protecting a patent because applying for protection in alternate countries is expensive for the patenting firm.

The forward and backward reference indices do not show significant results \((\alpha = 0.05)\) on the test of the two year lags. Jonckheere and Terpstra (JandT) analyses added to evaluate significant Kruskal and Wallis findings show positive, mild to strong relations for all cases, and SIC coded subgroups. Explanatory and coding indices have rising means. Only backward references show no significant results for the test of the two year lag. Total revenue higher percentiles have a stronger relationship with R&D \((13.0-24.0)\). The backward references of both SIC code groups, 2800 and 3800 have no significance \((\alpha = 0.05)\) on the test of the two-year lags. Total revenue higher percentiles have a stronger relationship to R&D \((11.6 \text{ and } 10.9)\) in both SIC code groups.

All qualitative indices show positive correlation with all financial indices. The resulting innovation value \((\text{INNV/PAT})\) relationships are ordered with descending coefficients: firm value \((15.23)\), market capitalization \((15.21)\), cash \((15.20)\), and finally book-to-market value \((4.49)\). The innovation protection \((\text{INNP/PAT})\) relations are also ordered with descending coefficients: cash \((15.99)\), firm value \((15.68)\), market capitalization \((15.56)\), and finally book-to-market \((5.93)\). Overall quality \((q)\) relations are also ordered with descending coefficients: cash \((16.36)\), firm value \((16.14)\), Market capitalization \((16.11)\), and finally book to market \((6.38)\). Figure 9 presents these results graphically.

The 2800 SIC coded subgroup shows positive correlations with small coefficients. The innovation value \((\text{INNV/PAT})\) relations are ordered with descending coefficients: cash \((14.66)\), firm value \((14.37)\), market capitalization \((14.36)\), and finally book-to-market \((B/M, 4.63)\). The innovation protection \((\text{INNP/PAT})\) relations are also ordered with descending coefficients as follows: cash \((15.2)\), firm value \((14.7)\), market capitalization \((14.69)\), and finally book-to-market value \((5.01)\). Overall quality \((q)\) relations are ordered with descending coefficients: cash \((15.56)\), market capitalization \((15.15)\), firm value \((15.14)\), and finally book-to-market value \((5.39)\). Figures 10 and 11 present the results graphically.

The 3800 SIC coded subgroup shows drastically reduced positive relations, and book to market \((B/M)\) ratio shows no significant \((\alpha = 0.05)\) negative coefficients. Harrington and Miller (2009) obtain similar results across sectors in their examination of R&D impacts on the cost of capital \((p. 3)\). Their methods control for R&D intensity, and average market betas differ significantly across sectors. Between 2001 and 2005, firms in their SIC code group 2800 had higher market betas than firms in the SIC code group 3800. Large biotech firms, on average, have large negative and significant book-to-market betas during the 2001-2005 periods, significantly lowering their estimated cost of equity capital. Previous scenario disappeared between 2006 and 2008. Device firms had higher betas than pharmaceutical firms for just two years as compared to the 2006-2008 period, but this trend did not sustain throughout the time frame. The innovation value \((\text{INNV/PAT})\) correlations are presented in descending order: firm value \((3.72)\), market capitalization \((3.52)\), cash \((2.48)\), and finally book-to-market value \((-0.95)\). Correlations with innovation protection are presented in descending order: firm value \((3.41)\), market capitalization \((3.22)\), cash \((2.59)\), and book-to-market \((-0.32)\). Overall quality \((q)\) relations are shown in descending order as follows: firm value \((3.61)\), market capitalization \((3.42)\), cash \((2.41)\), and finally book-to-market \((-0.44)\). All results are significant \((\alpha = 0.05)\) except book-to-market coefficients and the cash value on the innovation value per patent \((\text{INNV/PAT})\). Figures
10 and 11 present the results graphically.

CONCLUSION

Summary and concluding remarks

This article discusses the determinants of research innovation using panel data on manufacturing firms in the US between 1999 and 2009. The operative method used to assess patent quality is a factor model created following the guidelines of Lanjouw and Shankerman (2004). The model aims to demystify the unobserved qualitative characteristics of patents as well as examine the relationship between patent references, claims and family patents. As these factors integrate the model, three new factors emerge: Overall patent quality (q), innovation protection (INNP) and innovation value (INNV). The output proposes minimum-variance indexes built over a sample of 285,000 patents between 1999 and 2009. Patent quality indices account for a significant part of the financial variation at the sector level, but their explanatory power varies across qualitative variables.

The results of the article are consistent with Hall et al. (2005) showing that innovation measures contain noteworthy evidence on the financial trends of firms, justifying designed models validity and empirically explaining intangible assets, particularly the knowledge assets of firms. The findings confirm the importance of patents relation to firm value and economic performance, answering questions two and three. The sample time lapse trend concurs with Hall et al. (2005) and Chichirau (2007); it rationalizes the time patents need to accumulate significant information about references. Additionally, it confirms the effect of additional references per patent on finance measures.
Results produced by the model implies that firm financial improvement can be related to an improvement in patent innovation indices, not by mere changes in patenting or R&D intensities. Total revenue percentage changes range from 0.53 to 0.80. The financial measures of a firm will change proportionally as patents receive additional references or become better protected (table 1).

Table 1 reviews methods used to evaluate corporate profitability. The sample selection used in this paper did not show direct implications for risk adjusted securities valuation, unlike the findings of Chichirau (2007) which showed 5% per year both on a cumulative and risk-adjusted basis (p. 69). The findings present serious implications on cash and marketable securities with positive change percentages ranging from 9.329% to 10.780% for the whole sample. The 2800 SIC coded group cash implications range from 8.855% to 10.603%, and the 3800 SIC coded group changes range from 5.821% to 16.902%. Firm value (FV) and market capitalization (MCAP) results suggest a possible 10 percent increase on innovation rates, MCAP, firm value and cash relate to innovation value with average percentage growths of 10.288% for the whole sample and the 2800 SIC coded group. Book to market ratio relates to quality (q) with average percentage growths of 2.516%. The 3800 SIC coded group presents different implications; MCAP, book to market ratio, and firm value relate to quality (q) with average percentage growths of 9.407%. Cash relates to INNP with a growth of 16.9%. Previous results imply that innovation outputs are perceived and valued differently by stakeholders, and markets. These effects suggest that the qualitative indexes help to understanding stock market activity and firm valuation for specific industrial sectors.

Since the article relies heavily on data gathered from DELPHION (Patent) and Mergent (Finance) databases, much work remains to be done. Additional implications must assess the recently applied FASB 2010-17 (Revenue recognition milestone Method). DELPHION has not previously used variables and fully updated time frames. The indices enable national and international comparisons, including the potential to design models with two or more countries in an industry specific sample, perform spillover assessments within countries, and craft analyses of industrial segments such as pharmaceutical and biotechnology.

REFERENCES