Technology Portfolio, Patent Litigation Probability and Firm Performance

Michael Lee, Hsin-Ning Su
Graduate Institute of Technology Management, National Chung Hsing University, Taichung, Taiwan

Abstract--**This paper investigates if technology portfolio and patent litigation probability affect firms' short and long-term performances, which in past literature have mostly been associated with economic indicators or financial models. The patent data used in this paper are downloaded from the USPTO patent database and patent litigation probabilities are obtained from previous study. To measure firm performance, the Return on Asset (ROA) and the market value are calculated as the short-term and long-term performances, respectively. The correlation coefficient is then employed to approach the ROA and the market value to evaluate if technology portfolio and patent litigation probability correlates with the short-term and long-term performances of firms. The result of this paper sheds light for firms to make strategic decision based on their technology portfolio and to provide a novel way to identify firm performance.**

I. INTRODUCTION

Technology portfolio assessment has generally been regarded as an effective way to realize the company's whole picture of its R&D and innovation capabilities. For R&D intensive firms, patent portfolio most closely resembles the technology portfolio of the firms. For commercial success, a firm's patent portfolio usually complements substantial investments in sales, marketing, manufacturing and licensing programs. Nevertheless, it is clear that a well-developed patent portfolio can deliver competitive advantage to a firm since it can create barriers of entry, and help to carve out areas of exclusivity in the marketplace [1]. Due to this function, patent portfolio has garnered increased recognitions in the high-tech industry. Many high-tech corporations have their own plan of patent portfolio and adopt it as the way to strengthen the competency of the firms.

The competency of a firm is directly related to its performance. Firms that are knowledge-intensive require the effective collection and commercialization of intellectual property assets by its management in order to make full use of the companies' intangible assets.[2][3][4] Firms that have competitive advantage in a particular industry profit considerably higher than average firms in the same industry. Firm performance has been discussed in previous literature in terms of economic indicators and financial models [5][6]. Various indicators have been designed to measure firm performances, including: revenues, sales, Tobin's Q ratio, etc. previous literatures have linked various patent indicators and activity to these firm performance indicators to find the relationship between patent and firm performance. Ernst [7] conducted a research on the relationship between firm's patenting strategies and performance in German's mechanical engineering industry. Narin [8] found that the number of citation received by a patent is positively correlated to its financial performance in the pharmaceutical industry. Several authors have also conducted similar studies with biotechnology companies utilizing their financial and patent data [9][10]. The relationship between patent litigation and its impact on the strength of the patent portfolio of a company have been studied in previous literature and a relationship has been found between patent litigation and patent portfolio strength[11]. However, no literatures in the past have dealt with the relationship between patent litigation probability and patent portfolio strength, as well as its impact on firm performance.

Patent litigation is most commonly seen between R&D intensive firms and the amount of which has been gradually increasing over the past years[12][13]. Patents that are litigated are known to be of higher value than non-litigated patents. [14] Previous literatures have discussed the value of litigated patents in the context of the strength of the patent portfolio of a company. A consensus was reached by researchers that patents under litigations or had been litigated are of higher importance to the overall strength of the patent portfolio. However, patent litigation probability was rarely discussed in past literatures. Su [15] developed a patent litigation precaution model to forecast patent litigation probability. This model provides a premise for further investigating into the topic of patent litigations.

II. RESEARCH FRAMEWORK

In order to find out the relationship between patent portfolio, patent litigation probability and firm performances, **the survey on the strength of patent** portfolio is important, in other words the value of patents need to be considered. Different indicators have been chosen to measure the value of patent portfolio [16]. Here we hypothesizes that if a company's patent portfolio is of higher value, its patent portfolio will be relatively stronger, thus the company's performance will be greater. It is also hypothesized that if a company patent portfolio is at a higher risk of being litigated, then the company's performance will also be stronger. Figure 1 illustrates the basic structure of this research.

Firm Performance is measured in short-term and long-term, the short-term performance is measured by calculating the company's ROA (Return on Asset) and the long-term performance is obtained by its overall market value.

Numerous past literatures have worked with market value on a variety of topics. Market value had been used to examine the relationship between innovativeness, quality, growth and profitability at the firm level and acts as a mediator on these

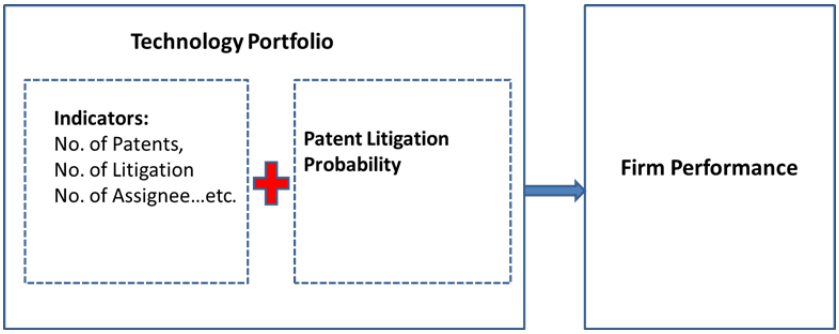

Figure 1 Research Framework

factors [17]. Patent citation has also been tested for its importance on a company's market value, of which it was found that for every extra citation a patent received, the market value will be boosted by 3% [18]. Bundell, Griffith and Van Reenen [19] had conducted a study on market share, market value and innovation of British manufacturing firms and found that the impact of innovation on market value is larger for firms with higher market shares. Patent quality was also investigated for its relationship with market value and was found that patent quality is positively associated with stock market value of firms [20]. Corporate global environmental standards, social responsibility, customer satisfaction, quality awards and even foreign currency derivatives are all parts of researches involving the use of market value either as a mediators of the factors involved or as a financial indicator for performance.[21]–[24]

Based on our research premises, the indicators used to measure patent value also play an important role. According to previous literature, litigated patents are of higher value than non-litigated patents; therefore, the litigation probability of a patent is directly related to the value of the patent. Su, Chen and Lee [15] calculated patent value with the following indicators: number of litigation, number of assignee, number of inventor, number of inventor country, number of patent reference, number of patent citation received, number of IPC, number of UPC, number of claim, number of non-patent reference, and number of foreign patent. The litigation probability prediction model is shown below:

z = -4.9309 – 0.3009*(No. of Assignee) -0.3308*(No. of Assignee Country)-0.0761*(No. of Inventor)+0.1036*(No. of Inventor Country) + 0.00311*(No. of patent Reference)+0.0142*(No. of Patent Citation Received)+0.0262*(No. of IPC)+ 0.00728*(No. of UPC) + 0.0148*(No. of Claim) + 0.0021*(No. of Non-Patent Reference) - 0.00608*(No. of Foreign Patent)

This research will select patent count, average citation per year and patent litigation probability as the indicators. The number of patents can be used to quantify a company's degree of technological activities engagement; hence it will be used as one of the indicators to assess a company's patent value.

Since the indicators can be used to assess the value of patents, and the value of patents will influence the strength of patent portfolio, here are the hypotheses:

- There is correlation between patent portfolio, patent litigation probability and firm performance.
  1. Since there is positive correlation between no. of patents and values of patents, no. of patents have positive correlation with strength of patent portfolio and firm performance.
  2. Since there is positive correlation between average citations and values of patents, average citations have positive correlation with strength of patent portfolio and firm performance.
  3. Since there is positive correlation between patent litigation probability and values of patents, patent litigation probability has positive correlation with strength of patent portfolio and firm performance.
- If the companies' values of patents are higher, their patent portfolio will be relatively stronger, and the market share of company will be larger, and vice versa (see Figure 2).

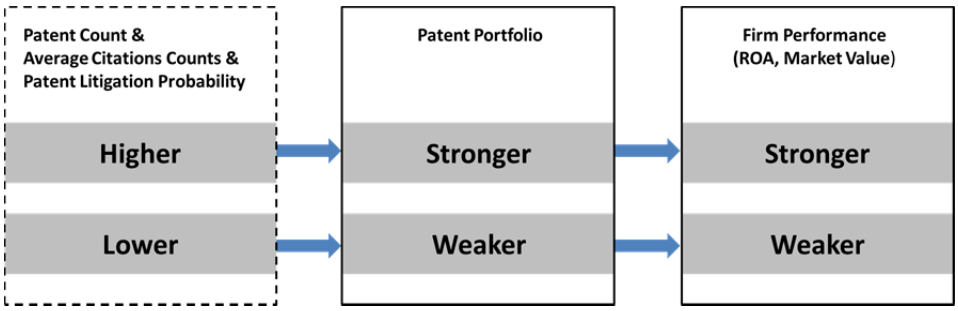

Figure 2 Effect among values of patents, strength of patent portfolio, and firm performance

III. METHODOLOGY

This research utilizes our homemade database that consists of 4,388,043 patents downloaded from the USPTO (United States Patent and Trademark Office) from the year of 1976 to 2010. Nine companies in the pharmaceutical industry are chosen for this paper. The nine companies are chosen based on its financial and patent data availability and if it is well-known around the world. The financial data are collected from S&P 500's COMPUSTAT database. Due to the availability of the financial data, some companies have shorter sample time span than other companies in this paper; however, this will not affect the result of this paper as the companies are investigated on an individual basis.

Number of patents and average patent citation are chosen for its accessibility and its simple and straight forward representation of all of the patent indicators that are available. It is easier to visualize the number of patents and average patent citations and get a sense of what the number actually represent in figures and tables.

Least squared linear regression approach is taken to measure the correlation coefficient between:

1) Patent Count vs. ROA
2) Patent Count vs. Market Value
3) Average Citations Count vs. ROA
4) Average Citations Count vs. Market Value
5) Patent Litigation Probability vs. ROA
6) Patent Litigation Probability vs. Market Value

The use of the method of least squared liner regression is fairly simple and straight forward. Discussions were made by researchers on how and when to utilize the correlation coefficient [25][26]. The method of correlation coefficient was used in many studies involving multiple disciplines [27][28]. If "X" and "Y" are strongly correlated, the coefficient should be close to ± 1:

- For "Y" increasing with "X", the correlation coefficient should be near + 1
- For "Y" decreasing with "X", the correlation coefficient should be near – 1
- If there is little correlation between "X" and "Y", the correlation coefficient should be near zero.

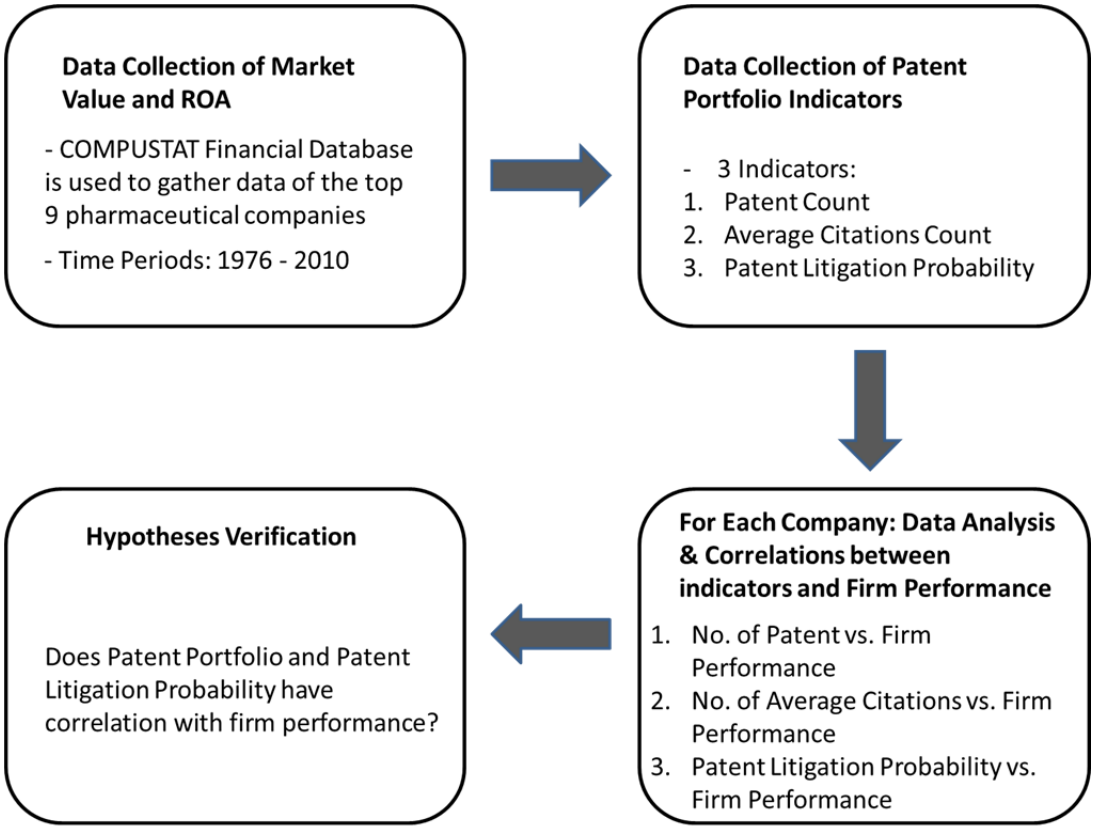

Figure 3 Research Process

IV. RESULTS

Table 1 sum up the basic patent and financial data of the 9 companies. Even though the financial and patent data from each company are collected from different time spans, the average of each financial and patent indicator is calculated to give a fair number for each of the indicator.

It can be seen from Fig. 4 that until the year 2000, Merck's market value, average citation and patent count are growing every year. After 2000 the market value drops significantly while patent count, average citation and ROA remain steady for the following years. The sharp drop in market value is possibly caused by one of its products called "Vioxx", used for treating arthritis, which in 1999 was approved by the FDA but was under the controversy that it causes increased risk of heart attacks and other possible cardiovascular risks. In 2004, Merck voluntarily withdrew Vioxx from the market with around 50,000 people suing Merck for compensation, which believed to have caused the sharp drop in market value for Merck after 2000.

TABLE 1 SUMMARY OF THE PATENT AND FINANCIAL DATA OF THE 9 COMPANIES

	Total Patent Count	Average Citation	Average ROA	Average Market Value	Average Patent Litigation Probability	Year
Merck	6929	1.055852	14.89	68758.31	0.00691	1979-2009
Pfizer	3273	2.784601	10.27616	85359.24	0.008526	1979-2009
Roche	837	2.46595	5.083625	36905.77	0.008429	1995-2002
Novartis	1646	2.1348724	10.26236	126388.43	0.0074898	1997-2010
GSK	118	9.5762712	15.2868	129247.67	0.0062306	2001-2010
Sanofi	506	1.312253	7.77375	96451.2	0.005633	2002-2009
AstraZeneca	830	2.710843	14.757	72402.19	0.006484	2000-2009
Bayer	133	6.105263	2.189286	42560.3	0.006295	2003-2009
Eli lilly	3209	3.051418	11.86422	38217.26	0.007694	1979-2010

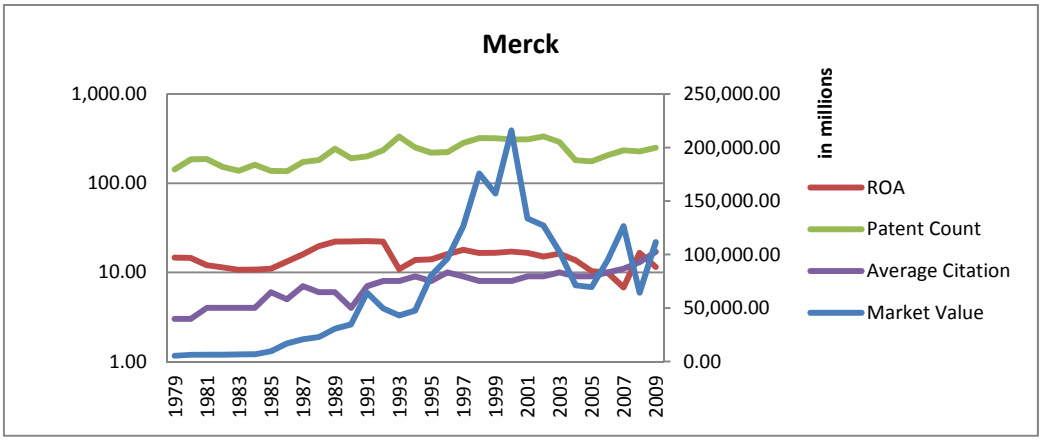

Figure 4 Patent and Financial Data for Merck by Year

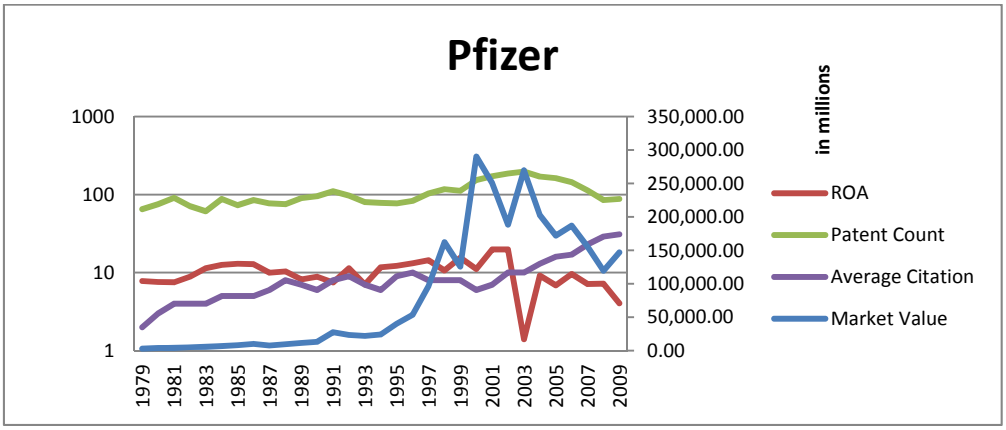

Figure 5 Patent and Financial data for Pfizer by Year

It can be observed from Fig. 5 that a trend of growth can be seen for Pfizer's market value, patent count and average citation from 1979 to 2009. Indicating a positive relationship is present among the three indicators. ROA can be seen as steady until 2003 when a sharp drop is present. This is possibly due to the acquisition of Pharmacia. After acquiring Pharmacia, Pfizer commenced with a massive restructuring causing multiple site closures and loss of jobs. These factors are believed to have caused the sharp drop in ROA in 2003.

A sharp drop in market value can be observed in Fig. 6 for Roche while patent count, average citation and ROA remain relatively steady. The sharp drop in 1997 can be directed to Roche's vitamin price fixing scandal during that period of time. During 1990 and 1999, Roche was the worldwide market leader in vitamins, with a market share of 40%. In 1999, Roche was fined US$500 million in the US and €462 million in 2001 in Europe.

Novartis showed consistent growth in its market value, patent count and average citation from 1997 to 2010. It can be further observed that two instances where an increase in average citation also resulted in an increase in its market value, as it can be seen from 2004 to 2005 and from 2007 to 2009.

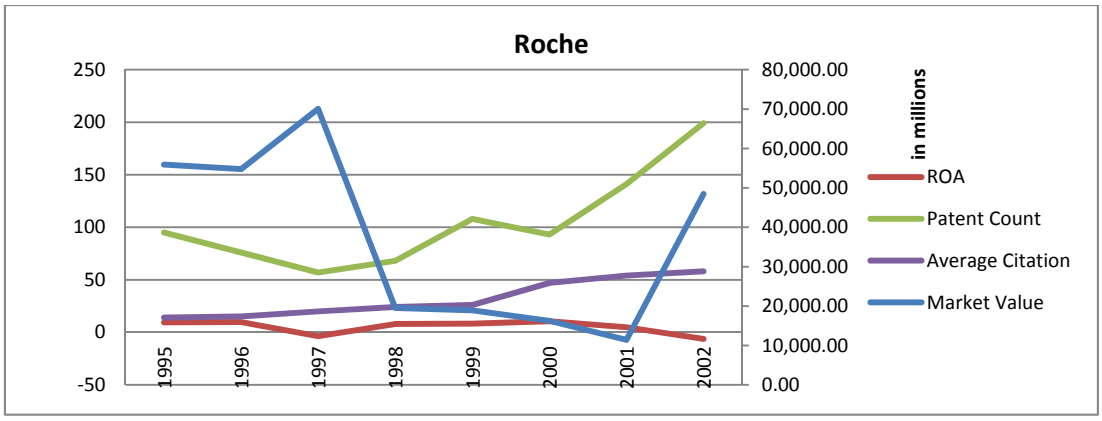

Figure 6 Patent and Financial Data for Rohe by Year

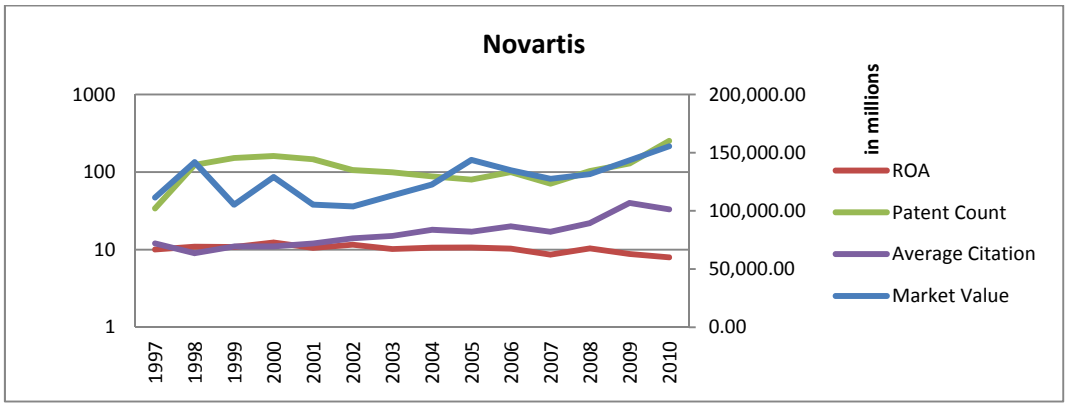

Figure 7 Patent and Financial Data for Novartis by Year

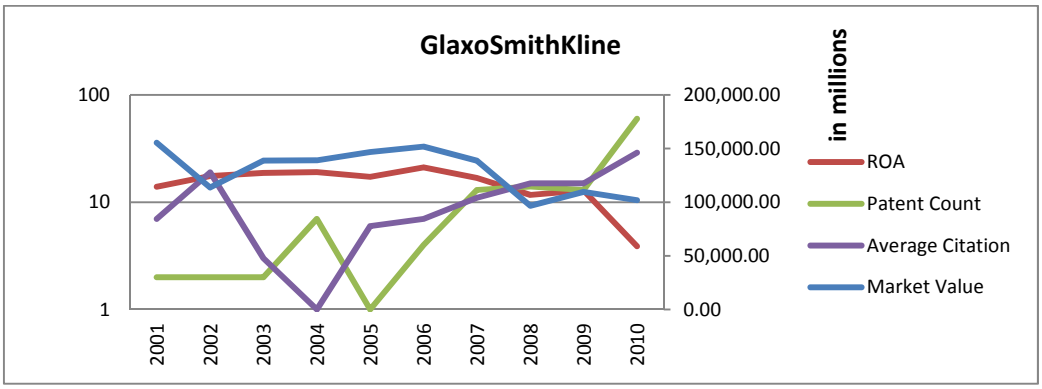

Figure 8 Patent and Financial Data for GlaxoSmithKline by Year

The patent and financial data for GlaxoSmithKline (GSK) is relatively irregular compared to other pharmaceutical companies. This is possibly due to its shorter time span (2001 to 2010) than most other sample companies. If data for a longer time span is available, a more impartial analysis can be given. However, it can still be observed that from 2005 to 2006, GSK's market value, patent count, average citation and ROA have all increased in similar pattern, indicating positive relationship among all indicators.

Sanofi experienced a divergence between its market value and its patent count, ROA from 2003 to 2004, while average citation remains relatively constant throughout the years. The divergence is most likely due to Sanofi's acquisition of Aventis, which cost around € 54.5 billion. This merger increased Sanofi's market value; however, the amount of capital is consequently less for R&D expenditures. The cost of restructuring also affects the ROA since there are costs for restructuring the newly formed Sanofi-Aventis.

AstraZeneca's market value experienced fluctuations throughout the time span (2000 to 2009) used for this paper. This is possibly due to its rapid acquisition of various companies during that time span. The patent count and average citations showed similar trend in growth while ROA remain relatively steady.

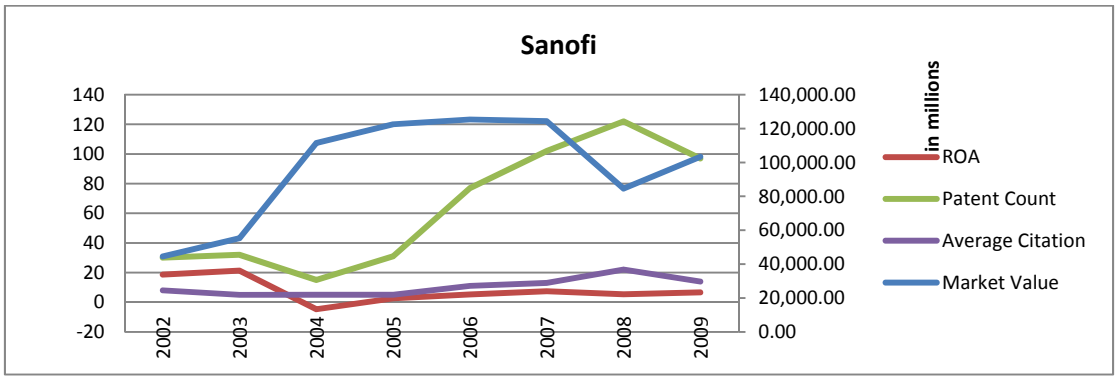

Figure 9 Patent and Financial Data for Sanofi by Year

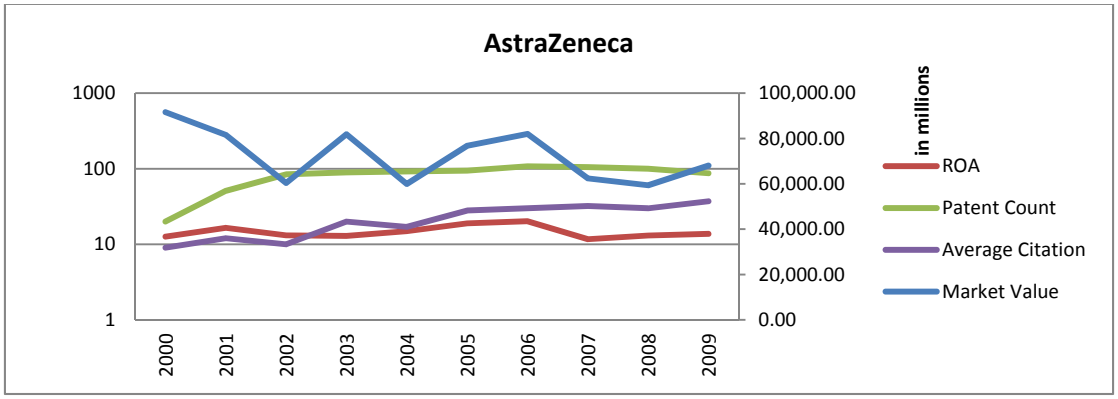

Figure 10 Patent and Financial Data for AstraZeneca by Year

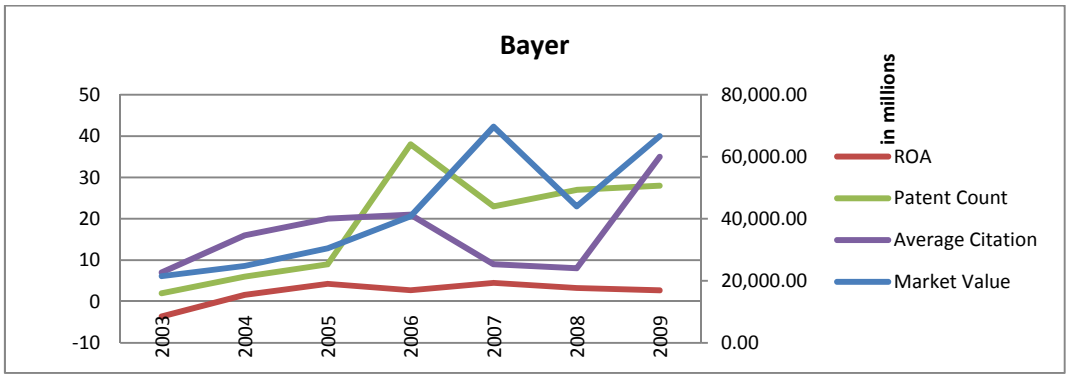

Figure 11 Patent and Financial Data for Bayer by Year

It can be observed from Fig. 11 that Bayer experienced similar trend of growth for its market value, patent count and average citation while ROA remain relatively steady.

Eli Lilly market value and patent count demonstrated a sharp growth in 1993; this is possibly due to its acquisitions of Pacific Biotech, Origin Medsystems and Heart Rhythm Technologies in 1990. These companies were later incorporated in 1992 and contributed about 20 percent of Eli Lilly's annual revenue, hence the increase in both the market value and patent count in that period of time.

Table 2 shows the correlation coefficient between: 1) ROA vs Patent Count, 2) ROA vs Average Citation, 3) ROA vs Patent Litigation Probability, 4) Market Value vs Patent Count, 5) Market Value vs Average Citation, and 6) Market Value vs Patent Litigation Probability of the 9 companies used in this paper.

In order to check if our hypotheses are valid, the correlation coefficient is looked at for each of the 9 companies.

A. Hypothesis 1 indicates that:

Since there is positive correlation between no. of patents and values of patents, no. of patents have positive correlation with strength of patent portfolio and firm performance.

To check the validity of hypothesis 1, the correlation coefficient between patent count and ROA and market value is obtained. It can be seen from Table 4.2 that companies with longer sample time span will generally have a positive correlation coefficient between its patent count and ROA and market value, while companies with shorter sample time span tend to have a negative correlation coefficient. Considering the effect of sample size on the result, smaller sample sizes tend to have errors [29]; therefore, the correlation coefficient from the companies with longer sample time span is used to test our hypotheses. It can be concluded that from the result of correlation coefficient, hypothesis 1 can be verified.

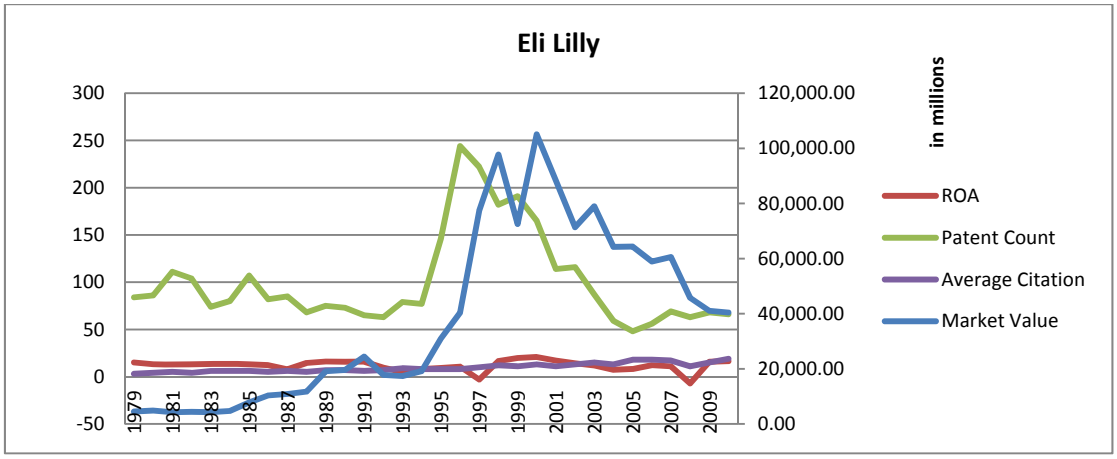

Figure 12 Patent and Financial Data for Eli Lilly by Year

TABLE 2 THE CORRELATION COEFFICIENT OF THE 9 COMPANIES

Company	ROA vs Patent Count	ROA vs Average Citation	ROA vs Patent Litigation Probability	Market Value vs Patent Count	Market Value vs Average Citation	Market Value vs Patent Litigation Probability
Merck	0.2223	-0.1102	0.1638	0.7831	0.5963	-0.2720
Pfizer	0.1137	-0.3293	-0.0141	0.8786	0.4311	-0.2993
Roche	-0.4737	-0.3867	0.3742	-0.1760	-0.4798	0.2177
Novartis	-0.1982	-0.7175	0.3083	0.3542	0.6143	-0.3668
GSK	-0.8679	-0.8075	0.3025	-0.5835	-0.7805	-0.1229
Sanofi	-0.1036	-0.1108	-0.3139	0.2695	0.0767	0.0818
AstraZeneca	0.2093	0.1551	0.1523	-0.6057	-0.2972	0.2952
Bayer	0.5331	0.2900	-0.6302	0.6530	0.3386	-0.5723
Eli Lilly	0.0362	-0.0239	0.1571	0.4141	0.7263	-0.4356

B. Hypothesis 2 indicates that:

Since there is positive correlation between average citations and values of patents, average citations have positive correlation with strength of patent portfolio and firm performance.

To check the validity of hypothesis 2, the correlation coefficient between average citation and ROA and market value is obtained. It can be seen from table 4.2 that average citation generally has a negative correlation with ROA while generating mostly positive correlation with market value. This can be explained by the fact that ROA is a measure for short-term performances where market value is a measure for long-term performance. Average citation is an accumulating unit where it gets higher with time. Therefore, the effect of average citation has on ROA will be less evident than it does on the market value of the companies.

C. Lastly, Hypothesis 3 indicates that:

Since there is positive correlation between patent litigation probability and values of patents, patent litigation probability has positive correlation with strength of patent portfolio and firm performance.

To check the validity of hypothesis 3, the correlation coefficient between patent litigation probability and ROA and market value is obtained. It can be seen from table 4.2 that patent litigation probability generally has a positive correlation with ROA while generating mostly negative correlation with market value. This can be explained by the costly nature of patent litigation. When company undergoes patent litigation lawsuits, a considerable amount of capital is spent on the lawsuits. Regardless of the results of the lawsuits, which will not be settled until years later, the legal costs will have impacts on the market value of the company; hence explains the negative correlation coefficient between patent litigation probability and market value.

V. CONCLUSION

This paper aims to find if patent portfolio indicators affect firms' performances in terms of the firm's ROA and market value. Basic patent and financial data and important events were looked at to see if trends or causes are present for each of the 9 companies in terms of relationships between the patent portfolio indicators and firm performances.

The correlation coefficients between the patent indicators (patent count, average citation, patent litigation probability) and firm performance indicators (ROA and market value) are then calculated to check the validity of the three hypotheses this paper proposed:

1. Since there is positive correlation between no. of patents and values of patents, no. of patents have positive correlation with strength of patent portfolio and firm performance.
2. Since there is positive correlation between average citations and values of patents, average citations have positive correlation with strength of patent portfolio and firm performance.
3. Since there is positive correlation between patent litigation probability and values of patents, patent litigation probability has positive correlation with strength of patent portfolio and firm performance.

From the statistical result of correlation coefficient between patent portfolio indicators and firm performance indicators, hypothesis 1 is validated, showing a positive correlation between the number of patents and firm performance. The correlation coefficient resulted from hypothesis 2 indicates that average citation has a negative correlation coefficient with ROA while having a positive correlation coefficient with market value. This is explained by the accumulative nature of average citations, which increases with time. Hence have a positive correlation coefficient with market value, the long term firm performance indicator. Lastly, hypothesis 3 showed positive correlation coefficients between patent litigation probabilities with ROA while having negative correlation coefficients with market value. This is explained by the costly nature of patent litigation lawsuits which may take tolls on the company's market value.

The result of this study should provide insights for pharmaceutical industries managements to examine the relationships between patent portfolio indicators and firm performance indicators in a novel way. When firms are performing evaluations on its patent portfolio, patent litigation probabilities should also be taken into account as it affects the company's performance.

ACKNOWLEDGMENTS

The authors would like to thank National Science Council of Taiwan, for the financial support under the contract: NSC 102-2410-H-005-029

REFERENCES

[1] S. J. Shumaker, "Building a Patent Portfolio that Supports Your Business Objectives." Shumaker & Sieffert, P.A., 2002.

[2] O. Granstrand and C. Oskarsson, "Technology diversification in MUL-TECH corporations," *IEEE Trans. Eng. Manag.*, vol. 41, no. 4, pp. 355–364, 1994.

[3] P. F. Drucker, "The discipline of innovation," *Harv. Bus. Rev.*, vol. 76, no. 6, pp. 149–157, 1998.

[4] M. Sadowski and A. Roth, "Technology leadership can pay off," *Res. Technol. Manag.*, vol. 42, no. 6, pp. 32–33, 1999.

[5] N. Bloom and J. Van Reenen, "Patents, Real Options and Firm Performance," *Econ. J.*, vol. 112, no. 478, pp. C97–C116, 2002.

[6] L. H. P. Lang and R. M. Stulz, "Tobin's Q, Corporate Diversification and Firm Performance," National Bureau of Economic Research, Working Paper 4376, Jun. 1993.

[7] H. ERNST, "PATENTING STRATEGIES IN THE GERMAN MECHANICAL-ENGINEERING INDUSTRY AND THEIR RELATIONSHIP TO COMPANY PERFORMANCE," *Technovation*, vol. 15, no. 4, pp. 225–240, May 1995.

[8] F. Narin, E. Noma, and R. Perry, "Patents as indicators of corporate technological strength," *Res. Policy*, vol. 16, no. 2–4, pp. 143–155, Aug.

1987.
[9] D. M. DeCarolis and D. L. Deeds, "The impact of stocks and flows of organizational knowledge on firm performance: An empirical investigation of the biotechnology industry," *Strateg. Manag. J.*, vol. 20, no. 10, pp. 953–968, Oct. 1999.
[10] M. Gittelman and B. Kogut, "Does good science lead to valuable knowledge? Biotechnology firms and the evolutionary logic of citation patterns," *Manag. Sci.*, vol. 49, no. 4, pp. 366–382, Apr. 2003.
[11] V. Tang and B. Huang, "Patent litigation as a leading market indicator," *Int. J. Technol. Transf. Commer.*, vol. 1, no. 3, pp. 280–291, 2002.
[12] J. F. Merz and N. M. Pace, "Trends in patent litigation: the apparent influence of strengthened patents attributable to the Court of Appeals for the Federal Circuit," *J Pat Trademark Soc*, vol. 76, p. 579, 1994.
[13] K. A. Moore, "Judges, Juries, and Patent Cases-An Empirical Peek Inside the Black Box," *Mich Rev*, vol. 99, p. 365, 2000.
[14] J. Allison, M. Lemley, and J. Walker, "Extreme Value or Trolls on Top? The Characteristics of the Most-Litigated Patents," *Univ. Pa. Law Rev.*, vol. 158, no. 1, pp. 1–37, 2009.
[15] H.-N. Su, C. M.-L. Chen, and P.-C. Lee, "Patent litigation precaution method: analyzing characteristics of US litigated and non-litigated patents from 1976 to 2010," *Scientometrics*, vol. 92, no. 1, pp. 181–195, Apr. 2012.
[16] H. Ernst and N. Omland, "The Patent Asset Index – A new approach to benchmark patent portfolios," *World Pat. Inf.*, vol. 33, no. 1, pp. 34–41, Mar. 2011.
[17] H. J. Cho and V. Pucik, "Relationship between innovativeness, quality, growth, profitability, and market value," *Strateg. Manag. J.*, vol. 26, no. 6, pp. 555–575, Jun. 2005.
[18] B. H. Hall, A. Jaffe, and M. Trajtenberg, "Market Value and Patent Citations," *RAND J. Econ.*, vol. 36, no. 1, pp. 16–38, Apr. 2005.
[19] R. Blundell, R. Griffith, and J. van Reenen, "Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms," *Rev. Econ. Stud.*, vol. 66, no. 3, pp. 529–554, Jul. 1999.
[20] J. O. Lanjouw and M. Schankeman, "Patent quality and research productivity: Measuring innovation with multiple indicators," *Econ. J.*, vol. 114, no. 495, pp. 441–465, Apr. 2004.
[21] G. Dowell, S. Hart, and B. Yeung, "Do corporate global environmental standards create or destroy market value?," *Manag. Sci.*, vol. 46, no. 8, pp. 1059–1074, Aug. 2000.
[22] X. Luo and C. B. Bhattacharya, "Corporate social responsibility, customer satisfaction, and market value," *J. Mark.*, vol. 70, no. 4, pp. 1–18, Oct. 2006.
[23] K. B. Hendricks and V. R. Singhal, "Quality awards and the market value of the firm: An empirical investigation," *Manag. Sci.*, vol. 42, no. 3, pp. 415–436, Mar. 1996.
[24] G. Allayannis and J. P. Weston, "The use of foreign currency derivatives and firm market value," *Rev. Financ. Stud.*, vol. 14, no. 1, pp. 243–276, SPR 2001.
[25] J. L. Rodgers and W. A. Nicewander, "Thirteen Ways to Look at the Correlation Coefficient," *Am. Stat.*, vol. 42, no. 1, pp. 59–66, Feb. 1988.
[26] A. Asuero, A. Sayago, and A. González, "The Correlation Coefficient: An Overview.," *Crit. Rev. Anal. Chem.*, vol. 36, no. 1, pp. 41–59, Mar. 2006.
[27] J. L. Sevilla, V. Segura, A. Podhorski, E. Guruceaga, J. M. Mato, L. A. Martinez-Cruz, F. J. Corrales, and A. Rubio, "Correlation between gene expression and GO semantic similarity," *Ieee-Acm Trans. Comput. Biol. Bioinforma.*, vol. 2, no. 4, pp. 330–338, Dec. 2005.
[28] L. F. Masson, G. McNeill, J. O. Tomany, J. A. Simpson, H. S. Peace, L. Wei, D. A. Grubb, and C. Bolton-Smith, "Statistical approaches for assessing the relative validity of a food-frequency questionnaire: use of correlation coefficients and the kappa statistic," *Public Health Nutr.*, vol. 6, no. 3, pp. 313–321, May 2003.
[29] R. A. Fisher, "On the 'Probable Error' of a Coefficient of Correlation Deduced from a Small Sample.," 1921.