The Relationships between the Patent Deployment Strategy and Patent Value

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***Abstract*--In addition to patent basic characteristics, such as claims and citations, patent value embodies in company strategy as well. We apply two variables to measure company strategy: patent family depth and earn plan ratio. Patent family depth presents the degree in which certain fields and markets are valued by its company. Earn plan ratio indicates the degree that a patent family could be cited by later innovators and contenders. This study applies logistic regression model to analyze sample of LED industry. The results demonstrate that patent value has positive relationship with patent number of patent claims, number of backward citations, patent family depth, and earn plan ratio.**

I. INTRODUCTION

LED is a semiconductor which converts electric energy to light energy. It is applied in a large technological range including substrate, epitaxial, chip, encapsulation, application etc. As technology is the core competitiveness for LED companies, thus patent application is believed as an effective mechanism to protect it. Patent, therefore as an intangible asset, can either exclude contenders of the same technological field or enhance company competitiveness and value. Patent litigation is also treated as an important strategic tool and whether it will be filed or not is largely depends on patent value [16].

There are two options for patentees to deal with infringement; one is to settle out of court, another is to bring a lawsuit. The cost of prosecution is much higher than reaching a settlement. It involves not only excessive legal expenses, but also a generally speaking long length trial time. This would surely stretch company's human resources and capital allocation accompanying a series of uncertainties. Therefore patent litigation becomes a negative effect for company operation. For these reasons a patent litigation would not be considered if such patent is not worth enough. That is why patent litigation can be used as a standard to measure whether a patent has value or not [1].

Before litigation, patentee and non-patentee would hold different expectations on the possibility of winning. A win for the patentee could mean continues profits and also damages from the patent. If the patentee lost in court, the loss of exclusive for the patent technology will result in lower profitability and subsequent huge legal fees. In order to avoid such infringement litigation, patentees authorize contenders to use the patent through license. Both patentees and non-patentees will evaluate whether a lawsuit is worthwhile. Their expectations of winning determine whether litigation would take place or not. When the winning expectation of both sides tend to be very close, they are more likely to reach a settlement [7].

As profit margin are highly related to patent value, a patent with higher value can bring larger profits to company. Patent value has positive impact on the incentive of patent litigation [12, 14]. Higher patent value means higher probability of infringement and litigation, instead of settlement. Patent litigation can in turn impact patent value. If a patent litigation is likely to lose, the prospect of losing can minimize the patent value. On the other side, patent value increase if the protects is winning and maintain company's market share [9]. As the development of globalization of commercial activities, companies take advantages of such patent's legal value and implement legitimate commercial strategy to prevent potential contenders from entering market. From a legal perspective, patent litigation becomes a measurement of patent value [17].

In prior literature, patent value is often measured by number of patent claims and number of backward citations. Patents with more claims and backward citations have higher value [1, 2]. However, patent value can also reflect in company's strategy such as patent family. Patent family is a cluster of applications for a same patent in different countries, including its continuation, continuation-in-part and divisional applications. It indicates company's emphasis on certain fields and technologies. Patent citations show the appealing to the following innovators and contenders, which can to some extent, reflect patent value. A patent often cited by others implicates that the technological knowledge involved in it is the foundation or core technology of the following patents, which has contributed to many later innovations [19]. Thus patents with high patents citations have higher appeal and greater market value. According to these evidences, we derivate patent family depth and earn plan ratio to investigate company's emphasis of market and accuracy of its strategies.

The structure of this paper is as follows: Section 2 would outline the literature review and hypothesis development; Section 3 described the methodology and measurement of this paper; Section 4 would discuss the empirical results; the final section was conclusions and implications of this study.

II. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

A. Patent value determinants

Aiming at identifying the determinants of patent value and finding the most valuable patents, former researchers have developed various models, mainly categorizing independent variables into four different classes, including patent

characteristics (number of forward citations, backward patent citations, International Patent Classifications (IPCs) and inventors etc.), patent ownerships (co-applicants, cross-border ownership, portfolio size, market size etc.), insider information (patenting motives and invention context) and filing strategies (number of priorities and claims etc.) [20]. From these variables, we can extract much valuable information about patents such as the technological importance [4], the existing technological background, the linkage between the innovation and basic research [3], the technological scope [13], the research efforts [8], the legal breadth of the protection [18] and so on.

As for the indicators of patent value, they can be divided into two categories: market-based indicators and patent-based indicators [20]. The most famous market-based indicators are Tobin's q and stock market values at the firm level [10] and royalties, valuation by inventors and managers and buy-outs at the patent level. Patent-based indicators are much more diverse and can be clustered into five categories: technological importance (forward citations), geographical importance (family size), length (renewals), grant decisions (patent granted) and legal disputes (litigation incidences, opposition incidences). These five categories of indicators are found positively relevant to patent value [20].

Based on the different selections of patent value indicators and patent value determinants, various empirical studies have been conducted to predict the potential patent value. Forward citation counts, patent families, renewals, legal disputes and filing strategy indicators are consistently found positive related to patent value, nevertheless, the relationship of other determinants and patent value are ambiguous [20]. The phenomenon calls forth the need for further study into the determinants of patent value from a new perspective.

B. The main effect of the patent claims

To evaluate patent value, patent documents can provide some basic indicators, such as patent claims, backward citations, forward citations and patent families. Reference [1] found that valuable patents have more patent claims, forward citations and backward citations than others. Reference [15] suggested that the more claims the greater value of intellectual property.

Patent claim is one or a set of claims proposed under certain conditions, describing the technological characteristics of patents and stating the patent protection based on patent application form. It functions as criteria to clarify the protection range and judge of infringement. As for patentees, more patent claims mean wider range of patent protection. However, maximizing of patent protection is more than protection to patentees and motivation of invention and creation, but obstacles for technology spread and application, which in turn leads to more infringement cases. Reference [12] found that every 10% rise in the number of claims implies a 1.4% increase in the sample litigation. Hence, this study proposes the following hypothesis:

Hypothesis 1 (H_1): The number of claims is positively associated with the probability of patent litigation.

C. The main effect of the backward citations

Backward citations are citations of existing and relevant patent/non-patent references, reflecting the technology foundation [5]. Reference [12] found that each one unit increase in the ratio of forward citation and claims is associated with a 22% rise in possibility of litigation. Reference [1] showed that litigated patents cite more backward citations and are more likely be cited by others. Generally, cite pattern reveals diversity of technology sources. The more complicated of cite pattern, the more diversified of technology sources. Therefore, patents which own a great number of backward citations are those which are developed or improved on the basis of existing technology, namely substantial technology, great value and high possibility of litigation.

Moreover, backward citations reveal activeness of company in certain technology fields. Narrow technology fields refer to high rate of infringements and litigations. This can also happen where other companies recombine existing technologies and thus simulate the invention by studying the patent technology. Hence, this study proposes the following hypothesis:

Hypothesis 2 (H2): The number of backward citations is positively associated with the probability of patent litigation.

D. The main effect of the patent deployment strategy

Besides patents' own characteristics, patent value can either reflect in companies' strategic deployment. Patent family is the basic indicator of companies' patent strategy [11]. By applying a same patent technology over several countries, companies are able to obtain enough protection and prevent their competitive advantages and market share from being eroded. Nevertheless, the more patents applied the higher fees and costs, thus company will not invest in a patent family unless it can surely be payback [20]. Reference [6] suggested the deployment of patent family reveals potential markets, thus the size of patent family represent the importance of such technology and direction of future market.

Patent citation shows the appealing to follow innovators and contenders. It measures the knowledge spillover effect and company market value. Patent with large forward citations means the patent technology is unique enough to influence following innovators and appealing to contenders. Reference [6] suggested that patent forward citation is an important indicator to inspect whether the technology is important and appealing to competitors.

According to the function of patent family and patent forward citations, this study derives two indicators to measure company strategic deployment. The first one is Patent Family Depth (PFD), defined as the ratio of patent family size to the no. of countries that patent family has applied in. It shows average patent family of each patent

family country, reflecting the degree in which certain fields and markets are valued by company. The greater of patent family depth the more company has valued, which in the meantime, implying a high expect return from investing in such fields and markets and great value of this patent. Hence, this study proposes the following hypothesis:

Hypothesis 3 (H3): The patent family depth is positively associated with the probability of patent litigation.

The second indicator is Earn Plan Ratio (EPR), defined as the ratio of no. of patent forward citations to patent family size. It shows the degree that a patent family could be cited by later innovators and contenders. A higher earn plan ratio implies more accuracy of company strategy, as it stands for rational capital allocation by investing in patents with greater competitiveness and values. Hence, this study proposes the following hypothesis:

Hypothesis 4 (H4): The earn plan ratio is positively associated with the probability of patent litigation.

III. METHODOLOGY AND MEASUREMENT

A. Sample and data collection

The patent data used in this study were collected from Thomson Innovation database. It includes the US authorized patent information up to May 31st 2011. Technologies that retrieved include epitaxial, LED chip and LED encapsulation technology, exclude application of terminal products. Primary searches obtained 40,330 patents, and then 7164 patents within the scope of this study remained after carefully manual screening. To locate the exact technological fields of LED industry, we interviewed 10 leading experts of LED industry; all of them have at least ten years experiences in program R&D. we used the Westlaw patent litigation database to verify litigated patents. Finally we obtained a set of samples with 7164patents (64 litigated patents).

B. Measurement

The definitions and measurements of the variables were further defined as follows:

Dependent variable:

Litigated/Non-litigated patents: The dependent variable is a categorical variable and is coded as 1 if a patent has ever been litigated and 0 if a patent has never been litigated. This study used "litigated patent" as the proxy variable for a "valuable patent" and collected information from Westlaw to ensure whether each patent in the sample used to be litigated.

Independent variables:

Number of patent claims: The sum of independent claims and dependent claims. The variable is a discrete variable, which is defined as an integer greater than or equal to 1. The study used Patent Full-Text and Image Database provided by United States Patent and Trademark Office (USPTO) .

Number of backward citation: The sum of patent references and non-patent references, where the number of patent references consists of the number of US patent references and foreign patent references. The variable is a discrete variable, which is defined as an integer greater than or equal to 0. The study used Patent Full-Text and Image Database provided by USPTO.

Patent family depth: the ratio of patent family size to the number of countries that patent family has applied in. The variable is a continuous variable, which is defined greater than or equal to 1. The study used patent database from International Patent Documentation Center (INPADOC) in European patent office website esp@cenet.

Earn Plan Ratio: the ratio of number of patent forward citations to patent family size. The variable is a continuous variable, which is defined greater than or equal to 0.The study used Patent Full-Text and Image Database provided by USPTO and patent database from INPADOC in European patent office website esp@cenet.

IV. RESULTS

A. Descriptive statistics and T-test

The descriptive statistics and correlations matrix are shown in Table 1. T-test is conducted to verify the variables in samples of litigated and non-litigated patents. The results shown in Table 2 indicate significant differences between variables in both samples with P value smaller than 0.01. The mean of patent claims, backward citations, patent family depth and earn plan ratio of litigated patents are significantly higher than that of non-litigated patents, which is consistent with the four aforementioned hypotheses. Patent claims and backward citations are usually considered as measurement of patent value, patent family depth and earn plan ratio reflect company strategy, in which patent value embodied. As litigated patents are more valuable, thus they have higher mean of those four variables.

TABLE 1: DESCRIPTIVE STATISTICS

	Variables	Min	Max	Mean	S. D.
1.	Litigated/Non-Litigated patents	0	1	0.0089	0.0941
2.	No. of Patent Claims	1	228	16.8675	13.8459
3.	No. of Backward Citations	0	747	20.2154	37.5089
4.	Patent Family Depth	0.5	53	1.8290	2.3972
5.	Earn Plan Ratio	0	241	3.7964	11.2474

TABLE 2: CHARACTERISTICS OF LITIGATED PATENTS AND NON-LITIGATED PATENTS

	Variables	Litigated patent	Non-Litigated patent	t-value	p-value
1.	No. of Patent Claims	23.50	16.81	-3.8531	0.0001
2.	No. of Backward Citations	38.27	20.05	-3.8709	0.0001
3.	Patent Family Depth	3.3428	1.8153	-5.0833	0.0000
4.	Earn Plan Ratio	7.5756	3.7623	-2.7014	0.0069

B. Results of logistics regression analysis

This study applied logistic regression analysis, set dependent variable as whether a patent is litigated, independent variables as number patent claims, number of backward citations, patent family depth and earn plan ratio. The results presented in Table 3 support the hypothesis in this study that all the independent variables have positive influences on the dependent variable.

Patent family depth and earn plan ratio have positive influences on the probability of patent litigation with P value of 1%, number of patent claims and number of backward citations have positive influences on the probability of patent litigation with P value of 5%. Patent family depth and earn plan ratio play more of a role than number of patent claims and number of backward citations on the probability of patent litigation.

V. CONCLUSIONS AND DISCUSSION

Using samples of LED industry, this study collected the US granted patent information up to May 31st 2011 from Thomson Innovation database. It found a significant difference between non-litigated and litigated patents on number of patent claims, number of backward citations, patent family depth and earn plan ratio. This study applied logistic regression to test the relationship between the aforementioned four variables and the probability of patent litigation.

According to the results of positive correlation between number of patent claims, number of backward citations and the probability of patent litigation, it is suggested that when applying for patents, companies should specialize patent claims, increase number of patent claims and cite as more backward citations as possible to increase patent value.

Patent family depth and earn plan ratio measure company strategies and the results in this study shows positive influences on the probability of patent litigation. Patent family depth presents the degree in which certain fields and markets are valued by its company. The greater of patent family depth the higher return company can gain from investing in that market. Therefore, it is suggested that companies apply patents or continuation patents which have lager shares in markets and higher return.

Earn plan ratio indicates the degree that a patent family could be cited by later innovators and contenders. A lower earn plan ratio indicates an excessive investment in patents of weaker competitiveness. In other word, patents with small earn plan ratio have less value. Accordingly, it is suggested that when applying for patents, companies take patent deployment into consideration to estimate the value of patent, such as degree of novelty and sales figure in target market.

Finally, as to competitors, only by commercializing valuable patents can they promote the value of enterprise. So they could target the potential patent according to the patent value evaluated by the model, and negotiate with the patentee to obtain the use right by patent license. What's more, competitors may as well analyze the patent deployment of two parties to seek potential opportunities of cooperation and realize development on complementary resources by cross licensing.

TABLE 3: RESULTS OF LOGISTIC REGRESSION ANALYSIS

Variables	Patent Value
Intercept	-5.299**
No. of Patent Claims	0.014*
No. of Backward Citations	0.004*
Patent Family Depth	0.066**
Earn Plan Ratio	0.014**
Log Likelihood	-353.3196
Prob > χ^2	0.0001

Note: **p<0.01, *p<0.05

REFERENCES

[1] Allison, J. R., M. A. Lemley, K. A. Moore and R. D. Trunkey, "Valuable Patents," *Georgetown Law Journal*, vol. 92, pp. 435-480, 2004.

[2] Allison, J. R., M. A. Lemley and J. Walker, "Extreme Value or Trolls on Top? The Characteristics of the Most Litigated Patents," *University of Pennsylvania Law Review, vol.* 158, pp. 101-137, 2009.

[3] Carpenter, M., M. Cooper and F. Narin, "Linkage between basic research literature and patents," *Research Management, vol.* 3, pp. 30-35, 1980.

[4] Carpenter, M., F. Narin and P. Woolf, "Citation rates to technologically important patents," *World Patent Information, vol.* 3, pp. 160-163,1981.

[5] Chang, K.-C., D.-Z. Chen and M.-H. Huang, "The Relationships between the Patent Performance and Corporation Performance," *Journal of Informetrics*, vol. 6, pp. 131-139, 2012.

[6] Chang, Y.-H., W. G. Yang and K.-K. Lai, "Valuable patent or not? Depends on the combination of internal patent family and external citation," *in* Papers presented at the Technology Management for Global Economic Growth (PICMET), Proceedings of PICMET '10, 2010.

[7] Cremers, K., "Determinants of Patent litigation in Germany", Retrieved 10/15/04 World Wide Web, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=604467##.

[8] Duguet, E. and N. lung, "R&D investment, patent life and patent value: An econometric analysis at the firm level," *Institut National de la Statistique et des Etudes Economiques, w*orking paper, 1997.

[9] Gibbs, A., "Application of multiple known determinants to evaluate legal, commercial and technical value of a patent," *Technical Representative, Patent café, working paper,* 2005.

[10] Hall, B., A. Jaffe, and M. Traitenberg, "Market value and patent citations," *The RAND Journal of Economics*, vol. 36, pp. 16-38, 2005.

[11] Harhoff, D., F. M. Schererc and K. Vopeld, "Citations, Family Size, Opposition and the Value of Patent Rights," *Research Policy*, vol. 32, pp. 1343-1363, 2003.

[12] Lanjouw, J. O. and M. Schankerman, "Characteristics of Patent Litigation: A Window on Competition," *The RAND Journal of Economics*, vol. 32, pp. 129-151, 2001.

[13] Lerner, J., "The importance if patent scope: An empirical analysis," *The RAND Journal of Economics*, vol. 25, pp. 319-333, 1994.

[14] Lin, T., "Assessment of decision-making regarding market entry/exit for technology innovation," *Quality & Quantity*, vol. 44, pp. 447-457, 2010.

[15] Nerkar, A., S. Paruchuri and M. Khaire, "Business Method Patents as Real Options: Value and Disclosure as Drivers of Litigation," *Advances in Strategic Management,* vol. 24, pp. 247-274, 2007.

[16] Su, H.-N., C. Chen and P.-C. Lee, "Patent litigation precaution method: analyzing characteristics of US litigated and non-litigated patents from 1976 to 2010," *Scientometrics*, vol. 6, pp. 202-216, 2012.

[17] Sun, C. C., "A conceptual framework for R&D strategic alliance assessment for Taiwan's biotechnology industry," *Quality & Quantity,* vol. 48, pp. 259-279, 2014.

[18] Tong, X., and J. Frame, "Measuring national technological performance with patent claims data," *Research Policy*, vol.23, pp. 133-141, 1994.

[19] Trajtenberg, M., "A penny for your quotes: Patent citations and the value of innovations," *The Rand Journal of Economics*, vol. 21, pp. 172-187, 1990.

[20] van Zeebroeck, "The puzzle of patent value indicators," *Economics of Innovation and New Technology*, vol. 20, pp. 33-62, 2011.