THE INFLUENCES OF PATENT COUNTS, DEFENDANT COUNTS OF PATENT LITIGATION, AND PATENT SHARE ON FIRM PERFORMANCE

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Abstract—This study used artificial neural networks to explore the influences of patent counts, defendant counts of patent litigation, and patent share on firm performance in the American semiconductor industry. The patent data were collected from the United States Patent and Trademark Office (USPTO), legal information was collected from the database of Westlaw and the financial data were collected from the database of COMPUSTAT. The results showed that patent counts and defendant counts of patent litigation have a positive effect on corporate performance in the American semiconductor industry. However, patent share has a negative effect on corporate performance in the American semiconductor industry. Accordingly, this paper suggests that we can apply the three indicators, patent counts, defendant counts of patent litigation, and patent share, to assess firm performance of American semiconductor companies.

1. INTRODUCTION

Compared to traditional industries, tangible assets are no longer considered more as a competitive driver than the intangible ones for high-tech industries. Although the patents are intangible and cannot be accurately appraised, the patents still allow the owner of the patent to increase the company's value. Breitzman & Thomas [1] found that there is a lack of patent citations as an indicator of the value when assessing the intangible assets. Trajtenberg [2] proved that R&D in a particular technological field is proportional to technological change, measured by simple patent counts. Prior researches pointed out that patent information can provide abundant information to complement financial data when evaluating corporate performance [3].

In previous studies, there have been many patent indicators including quality and quantity used to...
measure performance [4]. Chen and Chang [5] posited that corporate R & D and patent quality are related to business performance and market value. Many studies have extensively discussed the relationship between patent indicators and firm performance indicators, but few studies had further investigated the impacts of the number of patents and patent share on market value. Therefore, this study took market value as a firm performance indicator.

When companies expand the scale of development, they are likely to be involved in business litigation. In high-tech industries, most litigation projects focus on patent litigation. The development of high-tech industries and patent litigation are inseparable. Especially now that patent litigation is almost ubiquitous, it is a serious problem for the high-tech industry. In previous studies, researchers explored the impact of patent litigation on firm performance [6]. Most of the studies only studied patent lawsuits, litigation announcement dates, litigation announcements, and other variables and their effects on firm performance. This study wanted to comprehensively investigate the influence of patent litigation on firm performance, such as the effect of defendant counts of patent litigation on market value. Therefore, this study took market value as a firm performance indicator.

In machine learning and cognitive science, artificial neural networks (ANN) are inspired by biological neural networks [7]. However, there are few articles using ANN in the field of patent analysis [8]. Therefore, this study used neural network intelligence to explore the effects of patent counts, defendant counts of patent litigation, and patent value on market value. This study collected a lot of patent information, litigation, and financial information to analyze the results for decision making.

II. Theory and Development of the proposition

Patent indicators can evaluate patent quality of the company and organization as well as the innovation competitiveness with a quantitative method [8]. Patent indicators mainly assess their technical capacity, information of technology patent assets, and intangible assets. Patent counts are based on the earliest priority date, the inventor's country of residence, and fractional counts. If a county has more patents, it may have more innovative technologies, and thus is more competitive [3]. When the firm has more patents, the firm’s R&D capabilities and innovative capacity are higher, thus leading to higher market value. Therefore, we hypothesized:

Hypothesis 1 (H1). The patent counts are positively related to firm performance.

In past research, the news of patent infringement litigation has shown indirect or direct financial costs on the defendants, and thus generate the risk of bankruptcy [9]. Raghu et al. [10] researched the IT industry, and pointed out that the news of patent infringement litigation was unfavorably accepted in the stock market for the defendants. There are many studies focusing on the declaration of litigations, but we focused on the defendant counts of patent litigation. Therefore, we proposed that defendant counts of patent litigation have different outcomes on performance. Lanjouw and Schankerman [11] pointed out that the probabilities of litigation differ very substantially, and are systematically related to patent characteristics associated with their economic value and the characteristics of their owners. Therefore, we posited when the number of defendant counts of patent litigation rise, there will be more patent trolls coveting the critical technology. Thus, when a company’s defendant counts of patent litigation increase it means the company has a
significant R&D advantage in the market. Therefore we hypothesized:

**Hypothesis 2 (H₂).** Defendant counts of patent litigation are positively related to firm performance.

Prahalad and Hamel [12] posited that core competencies are the collective learning in the organization, especially the capacity to coordinate diverse production skills and integrate streams of technologies. They argued that top management should develop a corporate strategy for acquiring and deploying core competencies. Barney [13] noted that firms can earn above-normal profits and sustainable competitive advantage by developing core competencies. In this study, the patent indicators are mainly the core competencies of technology. Therefore, we used patent share for patent valuation. Patent share is defined as the number of the patents in the company's most important technological fields divided by the number of total patents owned by the company. Patent share represents the core competencies accumulated in the technology field. Therefore, we hypothesized:

**Hypothesis 3 (H₃).** Patent share is positively related to firm performance.

### III. Methodology

Artificial neural networks are proposed by McCulloch and Pitts [14] proposed a computational tool, based on the properties of biological neural systems. Recently there has been a growing interest in combining both these approaches, and as a result, neuro-fuzzy computing techniques have evolved. This approach has been tested and evaluated in the field of signal processing and other related areas. The input layer consisted of patent counts, defendant counts of patent litigation, and patent share. The output layer consisted of market value. This study used market value as the proxy of firm performance. The data of this study was in a period of fourteen years from 1999 to 2012. This study gathered 28 US semiconductor companies in the USPTO, COMPUSTAT database, and Westlaw database as the research sample, and the sample size is 392 in total. A training data set was used to estimate model parameters. The testing data set was used and applied in the same 28 firms. This study used information obtained above, the analysis of the total number of patents, and the patent number of the defendant on the market value of the share. In this study, ANN was used to analyze the influences of patent counts, defendant counts of patent litigation, and patent share upon corporate market value. A firm’s market capitalization is defined as a firm's stock value multiplied by its total number of shares outstanding. The firm’s market value in this study was acquired from COMPUSTAT from 1999 to 2012. Patent counts are the readily available indicator to measure the extent to which the companies are engaged in technical activities. The defendant counts of patent litigation refer to the number of times the company was sued with respect to patent litigation during a period. The legal information was collected from the database of Westlaw. This study defined patent share as the number of patents in the company's most important technological fields divided by the number of total patents owned by the company. Patent share represents the core competencies accumulated in the technology field.

### IV. Results

This study reports the descriptive statistics in Table 1. The obtained temperature results were used to train the back propagation neural network by means of the QNET software. With a change on the hidden layers
and combining different equations, a different structure was created for artificial neural networks which the optimum structure was selected from. In step 1, a learning algorithm used the training data to generate a classification model during the training step. In step 2, the learned model was tested using the test set to obtain the classification accuracy during the testing step. Back propagation neural networks were created by approximating the non-linear relationship between the input and the output by adjusting the weight values internally. The input layer consisted of three independent variables including patent counts, defendant counts of patent litigation, and patent share. The output layer consisted of one dependent variable, that is, market value.

Table 1. Mean, Standard Deviation

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
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<tbody>
<tr>
<td>Patent Counts</td>
<td>723.34</td>
<td>1874.142</td>
</tr>
<tr>
<td>Defendant counts of</td>
<td>1.327</td>
<td>2.935</td>
</tr>
<tr>
<td>patent litigation</td>
<td>0.355</td>
<td>0.195</td>
</tr>
<tr>
<td>Patent Share</td>
<td>10324</td>
<td>30130.6</td>
</tr>
<tr>
<td>Market Value</td>
<td></td>
<td></td>
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Note: * p<0.05, ** p<0.01

This study used a ratio of 80/20 for training and testing the sample. To deal with a recurrent network is simply to consider only a finite number of iterations. The algorithm must run on a webserver so we put in a measure to stop training when it looked like it was not going anywhere. This was set to 15,000 training iterations. A root mean squared error (RMSE) in this study is convergent well. Since the RMSE for the test set was much lower than that of the training set, it fit the data. The trained neural network model was acceptable, as shown in Fig 3.

The empirical results of this study are presented in Figures 1, 2, and 3. As Figure 1 shows, the market value has a positive effect on market value. When patent counts increase, the company's market value grows faster. When patent counts increase to a certain stage the market value will slow down, however. Therefore, in order to enhance the market value of the company, the firm has to increase the ratio of R&D spending on patent applications. Eventually, patent counts enhance the market value of the firm, and therefore, hypothesis 1 is supported.

![Fig. 1 The relationship between patent counts and market value](image_url)

As Figure 2 shows, the defendant counts of patent litigation have a positive effect on market value. When defendant counts of patent litigation increase at an early stage, they have no effect on the company's market value. However, when defendant counts of patent litigation increase at a later stage, the company's market value grows faster. When the company’s defendant counts of patent litigation increase, there will be more patent trolls coveting the critical technology. Thus, when the company’s defendant counts of patent litigation increase, it implies that they possess higher technological capabilities in the market. Therefore, hypothesis 2 is supported.
Fig. 2 The relationship between defendant counts of patent litigation and market value

As Figure 3 shows, patent share has a negative effect on market value. When patent share increases, it goes against the market value. Therefore, hypothesis 3 was not supported. The semiconductor industry has to diversify its patented layout to improve firm performance. Therefore, this study suggests that the US semiconductor companies must have the core technology, but do not over-rely on such core technology. With the rapid development of technology, semiconductor companies have to pursue diversified patent portfolios in order to improve firm performance.

Fig. 3 The relationship between patent share and market value

V. Conclusion and Discussion

This study used litigation and patent analysis to explore firm performance of American semiconductor companies. The data were obtained for each year during 1999–2012 from 28 US semiconductor companies. The data of this study was obtained from the COMPUSTAT database, the United States Patent and Trademark Office (USPTO), and Westlaw. This study used artificial neural networks to explore the influences of patent counts, defendant counts of patent litigation, and patent share on firm performance of the American semiconductor companies. The results showed that patent counts have a positive effect on the market value in the American semiconductor industry. Therefore, hypothesis 1 is supported. The defendant counts of patent litigation also have a positive effect on the market value in the American semiconductor industry, which supported hypothesis 2. Patent share has a negative effect on market value, so hypothesis 3 is not supported.

Patent counts are positively related to market value. If a firm has more patent counts, its market value will increase. As most technology-intensive industries, the semiconductor industry invests in high-technology with innovation and R&D investment. A firm can transform its patents into core competences, and thus improve competitive advantage and market value. Patent counts are one of the most commonly used patent indicators, often regarded as the indicators of innovation. Therefore, patent counts can be used to analyze the company's ability to innovate and its competitiveness.

Defendant counts of patent litigation are positively related to market value. This study found that at an early stage, the increase in defendant counts of patent litigation has no effect on the company's market value. When defendant counts of patent litigation increases at a later stage, however, the company's market value grows faster. Bhagat, Brickley, and
Coles (1994) examined the market reaction to lawsuit filings and settlements for a much larger sample of 550 inter-firm disputes. They observed combined wealth losses stemming from lawsuit filings and noted that these leakages are a result of increased probability of financial distress for the defendant. They found that defendant firms gain upon the announcement of a settlement. However, this study found that it is not always negative for the defendant. The defendant may have more core technologies and thus face a higher risk of lawsuits from patent trolls. Therefore, in the semiconductor industry, the number of defendants can have different interpretations. Take the patent war between Apple and Samsung about mobile devices for example. Although Samsung’s defendant counts of patent litigation increased, but it received further attention and the company's value also increased. Samsung’s lead over Apple in smartphone sales has continued to widen since 2010. In the first quarter of 2013 Samsung sold 70.7 million phones, a 61% hike over its sales from a year ago and more phones than the next four competitors combined. In addition, Apple brought the patent wars to the smartphone market by its desire to "go thermonuclear" on Google's competing Android operating system for mobile devices. Apple's patent lawsuit number was the highest among all the cell phone companies in 2013, but its market value is still the highest in the world. Therefore, when the company has a competitive advantage of core technology, the company can gain excessive profits and rapidly expand the scale. As patent breaches increase in scale and frequency, businesses must prepare in advance for defense in lawsuits filed by patent trolls.

Although hypothesis 3 was not supported, it is clear that the semiconductor industry has to diversify its patented layout. Therefore, this study suggests that the US semiconductor companies must have the core technology, and develop a large patent portfolio. With the rapid development of technology, the semiconductor companies have to pursue diversified patent portfolios in order to improve firm performance. In this industry, the short product life cycles and new substitutes are quite a contentment phenomenon. When the company is unable to meet the consumers’ need by the introduction of new technologies and products, the company will quickly be eliminated. Therefore a firm should develop its core technology, and cultivate a wide variety of technical fields to enhance firm performance.

VI. References

Litigations. World Academy of Science, Engineering and Technology, 3(6), 1315-1321.


