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Journal of Risk and Financial Management

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Suggested Citation: Yu, Su-Chen; Shih, Kuang-Hsun (2021) : Financial market reaction to patent lawsuits against integrated circuit design companies, Journal of Risk and Financial Management, ISSN 1911-8074, MDPI, Basel, Vol. 14, Iss. 9, pp. 1-15, <https://doi.org/10.3390/jrfm14090433>

This Version is available at:

<https://hdl.handle.net/10419/258537>

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Article

Financial Market Reaction to Patent Lawsuits against Integrated Circuit Design Companies

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Abstract: With the rapid advancement in technology, Taiwan's integrated circuit (IC) design companies have made a mark in the international semiconductor industry but are unable to independently develop the key core technologies they need. Therefore, strategic alliances, competition and co-operation have become a means for enterprises to quickly obtain patents and capture the market. However, listed companies upstream and downstream of Taiwan's supply chain have been facing patent infringement lawsuits in recent years. This research mainly aims to provide investors with investment strategies when companies face patent litigation, analyze the abnormal returns on the underlying stocks through the event research method, and use the cross-sectional multiple regression model to explore the changes in different factors based on the results. The empirical results show that positive abnormal returns are generated before and after a company faces patent litigation and the cumulative abnormal rewards are all positive and significant after the incident, which indicates that the company may still have an opportunity to make a profit when facing patent litigation, which can be used as a reference for investors.

Keywords: IC design; market reaction; patent lawsuits; patent plaintiffs; patent defendants



Citation: Yu, Su-Chen, and Kuang-Hsun Shih. 2021. Financial Market Reaction to Patent Lawsuits against Integrated Circuit Design Companies. *Journal of Risk and Financial Management* 14: 433. <https://doi.org/10.3390/jrfm14090433>

Academic Editor: Marc Deloof

Received: 20 July 2021

Accepted: 3 September 2021

Published: 9 September 2021

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1. Introduction

Taiwan's information industry has the most complete industrial chain in the world. With a highly flexible build-to-order production model and integrated operations capacity, Taiwan's information industry, constructed by independent firms supplying raw materials in the upstream sector, manufacturing and assembling in the midstream sector, and conducting operations and distribution in the downstream sector, forms a complete supply chain system with the advantages of rapid product development and mass production capabilities. The information industry supports research and development, design, the supply of components, original equipment manufacturer (OEM) contract assembly, and the operations and the global distribution of technological products, such as laptops, tablets, smartphones, and television (TV) panels, and meets changing market demands by accelerating the conversion of raw materials into final goods (Beamon 1998).

Currently, Taiwan's information industry provides the following services: the design and production of more than 90% of laptops, 70% of wafer foundry, and 50% of semiconductor packaging and testing services globally. This indicates its vital role in the global production and supply chain system of the high-tech information industry.

The semiconductor industry is the most important key part of Taiwan's electronics industry. It is the core component of electronics products and is one of the major constituents of the country's overall economy. Bloomberg's 2020 report about the country-specific market share of semiconductor suppliers showed that the United States ranked first, with 42.9%, followed by Taiwan, at 19.7%, and South Korea, at 15.9%.

According to the overview of the value chain of Taiwan's semiconductor industry, the country has achieved its current position in the global semiconductor sector due to industrial clusters, vertical integration, complete specialized division of labor, and

intensive technology, and its output value has kept hitting new highs. There are the upstream, midstream, and downstream sectors, namely upstream integrated circuit (IC) design/intellectual property (IP) (silicon intellectual property), midstream wafer fabrication, and downstream packaging and testing. Among them, IC design can be further subdivided into analog IC and digital IC.

In recent years, Taiwan's IC designers have emerged in the international semiconductor industry. According to statistics produced by Gartner (Tu 2021), a market research institution, among the top 10 global IC design houses in 2020, the Taiwanese manufacturers MediaTek, Novatek Microelectronics, and Realtek Semiconductor ranked fourth, eighth, and ninth, respectively.

The major listed IC design houses are MediaTek, Realtek Semiconductor, PixArt Imaging, ELAN Microelectronics, and Novatek Microelectronics. Spurred on by the Sino-U.S. trade and technology war, new applications, such as electric vehicles and 5G, as well as postpandemic telecommuting and distance education have pushed overall revenue and stock prices to new highs. Information asymmetry and powerful propaganda by the network media always attract some investors to blindly make investments and buy stocks with an aim of making profits (Bhagat and Romano 2002a; Koku et al. 2001). High stock returns can bring high risk premiums but also imply high risks.

IC design is an intelligence-intensive industry. The patents and silicon intellectual property (IP) owned by design houses, due to their exclusivity, have gradually become the core, highly valued commercial intangible assets of research and development. After obtaining patents for research and development technology, firms can not only build entry barriers and prevent competitors from bargaining to steadily expand sales, increase market shares, and gain more operating profits, but also improve their leading positions in the industry and win the recognition of the end customers (Arora et al. 2008).

In today's IC industry, the key and core technologies needed cannot be developed independently. Therefore, strategic alliances, as well as competitive and cooperative relationships, have become the methods for firms to quickly obtain patents and market layout (Yang 2012).

Taiwan's upstream and downstream listed firms in the supply chain have recently been facing patent infringement lawsuits, forcing defendants to respond in a panic and to be caught in years of patent lawsuits (Zhou 2006).

Patent infringement lawsuits are complex and expensive because in the process of patent lawsuits, firms generally go through legal arguments or technical descriptions of patent priority, serial cases, and priority claims or undergo long judicial proceedings on previous cases. Moreover, legal costs are high. Therefore, international firms use their vast resources to file patent infringement lawsuits at random in order to force Taiwanese firms that lack key patents or patent portfolios to compensate for potential sales and royalty losses or to take advantage of judicial proceedings to delay the introduction of products into markets, impacting the research, development, and design of key components and processes, resulting in forced reconciliations with competitors and acceptance of hostile mergers and acquisitions (Lanjouw and Schankerman 2001; Agostini et al. 2015).

Relevant studies show that the financial market reaction to patent lawsuits, such as the result of patent infringement, is settlement or withdrawal. In some studies, it was found that an abnormal remuneration was generated for the company at the time of the lawsuit despite the fact that the company's own reports did not contain details about any abnormal remuneration (Schliessler 2015; Cohen et al. 2019; Kafouros et al. 2021).

When a company faces an accusation or a complaint, the news impacts the psychology of the investors. This produces hidden worries and uncertain responses to the company's future operations, causing fluctuations in the company's stock price. The information value of infringement lawsuits brings negative investment information to the investors. If a company owns a specific patent, using the patent portfolio to target other markets will become the key to litigation (Koku et al. 2001; Bhagat and Romano 2002b; Raghu et al. 2008).

Transnational patent infringement lawsuits are expensive, and so firms must have strong financial resources to face potential revenue losses and market risks, indicating that the judicial proceedings of patent infringement lawsuits are complex, time consuming, and resource consuming, irrespective of whether the final judgment is a loss, a win, or a settlement. Therefore, the quality and quantity of patent protections and the systematic advance deployment of international patents are important for firms' operations, business expansion, revenue growth, and ability to research and develop technologies (Su 2002).

Taiwan's information and communication technology (ICT) often faces market reactions to patent lawsuits. Volatility is estimated to have less of an impact on the rate of returns on underlying stocks. The investigation and distribution of technology research and development and key patents are often passive. Therefore, suppliers in the supply chain lack the dynamic risk structures associated with patent infringement lawsuits (Fisher and Statman 2000; Liu 2015).

In recent years, patent infringement news has become common. Patent infringement litigation affects company stock prices; however, information relating to litigation occurs, along with information on patent infringement news release, how the market reacts, and the value of the company facing patent infringement litigation is also relatively lacking.

Therefore, the purpose of this study is as follows: when a litigation event occurs, we explore the market's reaction in terms of stock return before and after the patent litigation. We use the event research method to filter patent litigation cases and establish market share price models, perform data collection and sampling, and conduct statistical variable estimation verification to analyze Taiwan's IC design companies. The goal is to establish empirical results that investors can use as an important point of reference in order to construct investment portfolios.

The problem addressed in this study can be stated through the following questions: (1) Is Taiwan's IC design industry receiving abnormal rewards from patent litigation? (2) How will the differences between the influencing factors impact Taiwan's IC design industry during periods when it faces patent litigation?

This study is structured as follows: Section 1 contains the introduction; Section 2 consists of a literature review; Section 3 explains the research method and materials, including the event study, market model, abnormal returns, and cross-sectional multiple regression; Section 4 discusses our empirical results; and Section 5 contains the conclusions of our study.

2. Literature Review

A firm's research, development, and design layouts are often closely related to its capital market efficiency, which not only directly affects its corporate value but also directly reflects investor confidence and investment propensity. Therefore, the allocation and application of appropriate quantitative methods to measure different types of patent risk structures has become crucial.

According to the statistical data of the International Strategic Development Institute of Industrial Science and Technology (ISTI) and the Taiwan Semiconductor Industry Association (TSIA), the annual output value of Taiwan's IC industry was NT 3.22 trillion in 2020. Due to the postpandemic stay-at-home economy and the international order transfer effect that arose in 2020, semiconductor products have been in short supply. It is estimated that in 2021, the industry's annual output value will increase by 8.6%, to NT 3.5 trillion.

The output value of the IC design industry will increase by 10.9%, to NT 945.9 billion. Derived from new application trends, such as data centers, high performance computing (HPC), 5G, automotive electronics, and artificial intelligence (AI), the IC market is continuing to grow rapidly and expand steadily, thus strengthening Taiwan's key position in the global semiconductor market.

The industrial chain for semiconductors roughly consists of the following upstream, midstream, and downstream sections: (1) IC design; (2) wafer fabrication/foundry; (3) packaging; and (4) testing. IC design is at the top of the whole industry chain. IC design manufacturers have two business models: integrated design and manufacture (IDM) and fables. Most of Taiwan's IC design houses adopt the fables model, mainly focusing on the design, research, development, market, and sales of integrated circuit products. In addition to direct accounts, the resources, channels, and client tiers of distributors, dealers, and agents are adopted for market development and sales.

The efficient market hypothesis (EMH) proposed by [Das et al. \(1998\)](#), also known as the efficient market theory, is one of the main representative theories in the school of traditional financial theory. In a market where information flows without any barriers, security prices can be real time and accurate and fully reflect any relevant information, regardless of the investment or trading strategies used by investors. In accordance with the efficient market hypothesis, it is difficult for investors to beat the market with any investment strategy. However, whether the efficient market hypothesis is true is controversial in the field of investment.

The efficient market hypothesis is questioned in the school of behavioral finance. According to [Thaler \(1999\)](#), in practice, limited by some conditions, prices corrected by market arbitrage cannot fully exercise their expected power. [Hong and Stein \(1999\)](#) argued that, at a specific point in time, stock prices show a sustained or reverse movement. Stock prices move sustainably due to their underreaction to public information, then move in the reverse direction due to their overreaction, but eventually return to their mean value.

With the help of communities and the network media, the competitive information channels between enterprises cause polarized reactions in the market. Investors' decision changes and competitors on both sides are influenced by the stock market sentiments induced by a negative volume, resulting in reactions that cannot be explained by traditional financial theories ([Corea 2015](#); [Bukovina 2016](#); [Chauvet et al. 2016](#); [Reed 2016](#); [Piñeiro-Chousa et al. 2017](#)).

Therefore, how we analyze and link the patent risk structures of different enterprises that are competing with each other can not only give us feedback on the competitive positions of the enterprises in the industrial chain but also help strengthen the strategic combination of patents. Moreover, it can also help enhance research and development energy in key resources, further reinforcing the competitive wheel profile strategy and global market layout of Taiwanese enterprises competing in the international market ([Sakakibara and Branstetter 2001](#); [Arora et al. 2008](#); [Krammer 2015](#)).

With the rapid demand for and growth of various new applications in the semiconductor industry in recent years, many types of IC design have been developed, leading to the emergence of business opportunities related to silicon intellectual property (IP). Therefore, under increasingly fierce international competition, in order to protect innovation design and technology from being counterfeited and stolen, governments and well-known domestic and foreign IC design houses have changed from being conservative to being proactive in the exercise of intellectual property rights, patent layout, and protection.

Intellectual property rights, generally referring to patents, trademark rights, copyrights, and business secrets, provide firms with legal and exclusive rights to prevent or restrict the unauthorized use of their intangible assets.

Relevant studies have focused on different issues derived from litigation cases to study the impact of litigation on stock prices and shareholder wealth ([Hsu et al. 2021](#); [Leiponen and Delcamp 2019](#); [Bai and Tian 2020](#); [Chang et al. 2019](#)).

[Nam et al. \(2015\)](#) used the event research method to detect whether corporate litigation could change the company's wealth. The empirical results show that a firm in a vantage position in a patent lawsuit experiences a positive stock price return when it sues a rival firm for patent infringement, but one that does not have a vantage position in a patent lawsuit experiences a negative stock price return when sued by a rival firm. Therefore,

patent litigation has a positive wealth effect on the value of a plaintiff firm and a negative wealth effect on the value of a defendant firm.

In an efficient market, the following questions thus arise: what are the effects of announcements of patent infringement lawsuits on plaintiffs, defendants, shareholders' equity, stock returns, overall market volatility, and corporate performance and do information effects of announcements influence investors' decisions? By the event study method, this study analyzes the situations before or after the occurrence date or disclosure date of different specific major announcements and within a certain time series or period, and thereby considers whether the market reaction produces significantly abnormal (cumulative) returns on the research targets employed.

For both plaintiffs and defendants, information disclosure may change shareholder wealth or make investors suspicious and affect corporate performance (Nicholas et al. 1998). Lawsuit announcements cause significantly abnormal returns. Favorable judgments result in abnormal returns, while adverse judgments result in negative abnormal returns (Lee et al. 2013).

The market prices of firms' stocks are the market values formed by all market traders based on the collection of all kinds of information, creating market fluctuations (Grossman and Shiller 1981). Lawsuits against firms affect stock prices, brand images, goodwill, and overall corporate performance (Keller and Aaker 1992; Keller and Lehmann 2003). In the case of positive information in the market, firms are likely to obtain high abnormal returns on stock prices (Keller and Lehmann 2003) and market values. On the contrary, in the case of negative information, the firms' reputations, equity, returns on stock prices, and market values could suffer great losses (Keller and Lehmann 2003; Luo and Bhattacharya 2006). Hence, the stock price changes caused by lawsuits affect corporate performance and lead firms to adjust major decisions (Fama 1970).

Patent lawsuits between competing firms are competitive strategies that often directly impact their business value and operational utility (Hillman et al. 2004). Patent laws, after being enacted by legislative institutions and negotiated through international treaties, are adopted and enforced by government agencies and courts in most countries. Therefore, firms may try to change or influence patent preferences or patent laws by lobbying and other influential public activities (Somaya and McDaniel 2012). Moreover, key patents are acquired to limit competitors' access to research and development technology so as to reduce the capability of competitors to acquire patents (Reitzig and Wagner 2010; Mayer et al. 2012; Kim et al. 2016). Therefore, the key patents owned by firms can meet the current industry demands and future dynamic patent competition, laying the foundation for today's market competition.

With patents, uncertainties in technical, commercial, and legal preconditions may be resolved promptly. Firms, through the real options given by patents, can enforce patents according to the judgments made and obtain potential abnormal returns, but they also face lawsuit risks and potential losses caused by invalid patents (Marco 2005; Nerkar et al. 2007; Fang et al. 2017).

Patent lawsuits take place to stop infringing firms from using patented inventions or require them to pay the necessary licensing fees via legal enforcement. In addition to different issues arising from infringement lawsuits (Lanjouw and Schankerman 2001; Raghuram et al. 2008; Lee et al. 2013), current studies have examined stock market reactions to the lawsuits of competing firms (Bessen and Meurer 2006; Raghuram et al. 2008; Nam et al. 2015). If firms face judicial proceedings because they own specific patents or must prepare patent strategies, then it is not that there is no inducement for investment but rather that market investors are concerned about the profitability of the patents (Langinier and Marcoul 2009; Park and Yoon 2014).

According to [Somaya \(2012\)](#), if firms cannot predict how patents will be used, then defensive strategies are necessary. Firms often prelicense patents, announce the launch of new technologies externally, obtain patents for the research and development of key technologies, challenge the validity and enforceability of competitors' patents, or build defensive portfolios for their own patents so as to prevent the threat of patent lawsuits from hindering future product development ([Conner 1991](#); [Chen et al. 2016](#)).

In patent infringement lawsuits, defensive patent portfolios can help to submit evidence of counter-lawsuits quickly and to make settlements much more likely ([Graham and Somaya 2004](#)). In addition, if firms lack experience in patent lawsuits and capital expenditure, then defensive strategies regarding the transfer of research and development abilities and operation activities to the technological fields involving less litigation may be taken ([Lerner 1995](#); [Fang et al. 2017](#)).

Product commercialization requires various proprietary technologies. Hence, firms need defensive patent strategies against potential mandatory risks by competitors ([Hall and Ziedonis 2001](#); [Somaya et al. 2011](#)). The rights used by competitors can be excluded with various defensive strategies, such as patent portfolios, (defensive) blockade and occupation, (defensive) patent coverage, and validity challenges. Patent holders, with court injunctions, can threaten their competitors or file infringement lawsuits against competing firms to claim huge indemnities ([Lemley and Shapiro 2007](#)). In addition, defensive patent portfolios can lead firms to make large investments ([Ziedonis 2004](#)).

In spite of this, defensive strategies are limited. As consumer behavior patterns change, if there is no innovation in products, then the patent holder will continue to have this patent, while licensing will become a weak defensive strategy if the holder's patents are no longer in the firm's patent portfolio. However, patent trolls, which have received a lot of attention in recent years, are challenging for firms owning a large portfolio of technologies ([Reitzig et al. 2010](#); [Chen et al. 2016](#)).

A firm can benefit through leverage strategies and must effectively implement them in order to acquire patents in advance when its competitors are using (or will use) the strategies or bear significant research and development costs for key patents, which can enhance its ability to negotiate and bargain in the face of the threat of patent lawsuits from competitors ([Wang et al. 2017](#)). During proceedings, sudden injunctions can directly threaten the overall operations and performance of competitors ([Lanjouw and Lerner 2001](#)), forcing competitors to make concessions in negotiations. In addition, companies with key licensed patents can earn licensing fees, damage awards, or negotiated royalties meeting technical standards for firms by taking advantage of indirect patent leverage.

Some types of firms use patents not as a means of commercializing technologies but as leverage strategies, similar to patent trolls. By such strategies, patent systems and infringement lawsuits are used to acquire benefits, large damages, and huge conversion costs from patent infringers through injunctions against defendants ([Reitzig et al. 2007](#)); moreover, competitors usually do not have too many bargaining chips. As a result, most firms using such patent strategies can successfully receive damages from target firms ([Reitzig et al. 2010](#)). Some of those held by some firms may not be key patents anymore but still have commercial value for their competitors or other firms.

Therefore, corporate patent leverage strategies can offer advantages over negotiation and bargaining through patent exclusivity, so firms are willing to obtain opportunities directly and gain profits indirectly. Many firms holding patents can have more direct opportunities to obtain licensing fees by the bargaining power arising from their patents—that is, firms that fully engage in cross-licensing their entire patent portfolios can obtain more powerful or more commercially valuable patents ([Arora and Fosfuri 2003](#)).

Studies on the market's reaction stock return before and after a patent litigation are also relatively lacking. However, the relevant literature can be used as an important foundation for the development of this research structure and research methods.

This study focuses on the period from 2010 to 2020, and the research targets are the semiconductor IC design companies in Taiwan. The stock prices of the sample companies need to be obtained from the TEJ database. When a patent infringement lawsuit occurs, the indicator definition event stock return is evaluated. The impact of returns and the resulting risks, such as the rise and fall of stock prices, are empirically discussed and analyzed using event research methods and cross-sectional multiple regression. The research results will serve as an important reference for the shareholders and investors.

3. Research Method and Materials

Taiwan's listed semiconductor IC design houses in the upstream sector are taken as the research subjects in this study. The data compiled in this study contain the following: (1) upstream IC design house samples selected from the industrial value information platform; (2) news about relevant events selected from the infringement lawsuits of plaintiffs; and (3) defendants of Taiwan's listed semiconductor IC design houses from 2010 to 2020 on Unified Patent.

The event study method has been widely used for different events and in various fields (Chen et al. 2014), such as electronic commerce (Subramani and Walden 2001) and strategic alliance (Das et al. 1998). The event study method, first proposed by Demirer et al. (2010), has been used in finance in recent years, such as for major investments and lawsuit announcements. The study by Son et al. (2015) provides investors with an assessment on the effects of information on stock price changes. Their study tests whether event occurrences cause abnormal changes in a firm's stock price and then generate abnormal returns, so as to understand whether stock prices can quickly and directly reflect event information and to discuss whether the market is efficient (Demirer et al. 2010; Fama et al. 1969).

3.1. Event Study

According to the advice of Peterson (1989) on the estimated period in the event study method, the expected model is constructed by the day and the estimated period is usually set between 100 and 300 days. The event period refers to the duration of time during which the occurrence of specific events or information has effects. Event day herein refers to the point at which the market knows that such events occur or may occur. Hence, in this study, the event day of a patent lawsuit for a firm as a defendant or a plaintiff is set as 0 and is postponed to the next trading day if it is a holiday. The observation period is 121 trading days in total, from the 105th trading day before the event day to the 15th trading day after the event day. The event period is 15 trading days before and after the event day, and the estimated period is the remaining 90 days.

3.2. Market Model

The market model proposed by Sharpe (1964) assumes that the returns of various firms are linearly related to those of investment market portfolios (Bukovina 2016). It is represented by a linear model, as shown in Equation (1):

$$R_{it} = a_i + b_i(R_{-mt}) + \mu_{it} \quad (1)$$

where R_{it} is the return of the stock in period; R_{-mt} is the stock market return in period; a_i is the fixed term of the market model; b_i is the systemic risk and is used to measure the effects of return changes in the stock market on the return on an individual stock; and μ_{it} is the random error term in period.

3.3. Abnormal Return

Abnormal return (AR) refers to the difference between the actual return and the expected return without the occurrence of any event, the main purpose being exploring whether abnormal returns are caused by some events in the sample stocks.

(1) Abnormal return

In the market model, after the stock returns are estimated, the stock returns and market returns in the observation period are substituted, as shown in Equation (2):

$$AR_{it} = r_{it} - E(r_{it}) \quad (2)$$

where AR_{it} is the abnormal return of the firm in period; and (r_{it}) is the expected return of the firm in period.

(2) Average abnormal return

The average abnormal return (AAR) is calculated by dividing the sum of daily abnormal returns of all event samples by the size of event samples, as shown in Equation (3):

$$\overline{AR}_t = \frac{1}{N} \sum_{i=1}^N AR_{it} \quad (3)$$

where \overline{AR}_t is the average abnormal return on day t and N is the sample size.

(3) Cumulative abnormal return

The cumulative abnormal return (CAR) helps us to understand the cumulative effect or the abnormal return in a specific period. In this paper, the average abnormal returns in a specific period during the observation period are summarized to obtain the average cumulative abnormal return, as shown in Equation (4):

$$CAR(T_1, T_2) = \sum_{E=T_1}^{T_2} AR_E \quad (4)$$

In this study, the average abnormal return and the average cumulative abnormal return are tested by the traditional method. The significance of AR in a specific period during the event period is tested, and the test statistics are shown in Equation (5):

$$t = \frac{\overline{AR}_t}{\frac{1}{N} \sqrt{\sum_{i=1}^N \hat{S}_i^2}} \quad (5)$$

3.4. Cross-Sectional Multiple Regression

In this study, the factors affecting abnormal returns of IC design houses in patent lawsuits are explored by cross-sectional multiple regression analysis. The effects of stock prices of upstream IC firms on patent lawsuits are analyzed. The abnormal returns are analyzed and explained after examination by the cross-sectional multiple regression analysis. In this study, the dependent variable is the average cumulative abnormal return and the independent variable is the debt ratio, which is a financial indicator used to measure corporate business performance. About control variables, the log of market value is taken as the firm size and the trading volume is used to test the market trend. They are described below.

(1) Debt ratio (DEBT)

The debt ratio measures the soundness of the financial structures of sample firms (Goyal et al. 2002). Bankruptcies may occur in the case of high debt and poor management (Bailey et al. 2006). Low risk ratios indicate good financial conditions and strong debt-paying abilities (Michaelides et al. 2015), and investors will typically put more money into such companies.

(2) Firm size (SIZE)

According to previous studies, global competition requires large amounts of resources and economies of scale, which bring more benefits. The smaller the market value, the smaller a firm in general. Since institutional legal persons rarely trade the stocks of small firms, the log of market value is taken as the firm size and the control variable in this paper.

(3) Trading volume (VOL)

Trading volume refers to the number of specific traded stocks within a specified period of time and is mainly used to observe the market trend. In general, the trend of stocks with high trading volumes and rising prices is optimistic, whereas market trading is pessimistic if the trading volume remains low, a bear market appears, or stock prices are adjusted. As a result, the trading volume is often an important basis for the stock price trend, and investors often pay close attention to stocks with abnormal trading volumes.

Based on the above research variables, this paper explores the factors affecting cumulative abnormal return changes caused by new product launches to obtain Equation (6).

$$CAR_i = a + b_1DEBT + b_2SIZE + b_3VOL + \varepsilon_i \tag{6}$$

4. Empirical Results

In this study, the abnormal returns and cumulative abnormal returns of IC design houses in patent lawsuits are tested by the event study method and the date when patent lawsuits occur is set as the event day to examine the abnormal returns of IC design houses over the years.

Table 1 takes the date when patent lawsuits occur in IC design houses as the event day. After stock prices are converted into returns, the abnormal returns on Day 4 ($t = -4$) and Day 2 ($t = -2$) prior to the event day and on Day 9 ($t = 9$) after the announcement day are positive. Figure 1 shows the fluctuations in abnormal returns.

Table 1. AR of IC design houses in patent lawsuits.

	AR	p-Value		AR	p-Value
-15	0.137	0.572	1	0.199	0.413
-14	0.143	0.556	2	0.148	0.542
-13	0.160	0.510	3	0.079	0.745
-12	0.256	0.292	4	-0.191	0.431
-11	0.056	0.818	5	0.041	0.866
-10	0.380	0.118	6	0.048	0.845
-9	-0.016	0.947	7	-0.201	0.407
-8	-0.016	0.948	8	0.034	0.890
-7	0.287	0.236	9	0.405 *	0.095
-6	0.200	0.410	10	0.385	0.113
-5	0.080	0.742	11	-0.343	0.157
-4	0.408 *	0.093	12	0.134	0.580
-3	-0.151	0.535	13	0.327	0.178
-2	0.483 **	0.046	14	-0.239 *	0.325
-1	-0.183	0.451	15	-0.317	0.191
0	-0.099	0.684			

Notes: ** indicates a significance level of 5%. * indicates a significance level of 10%.

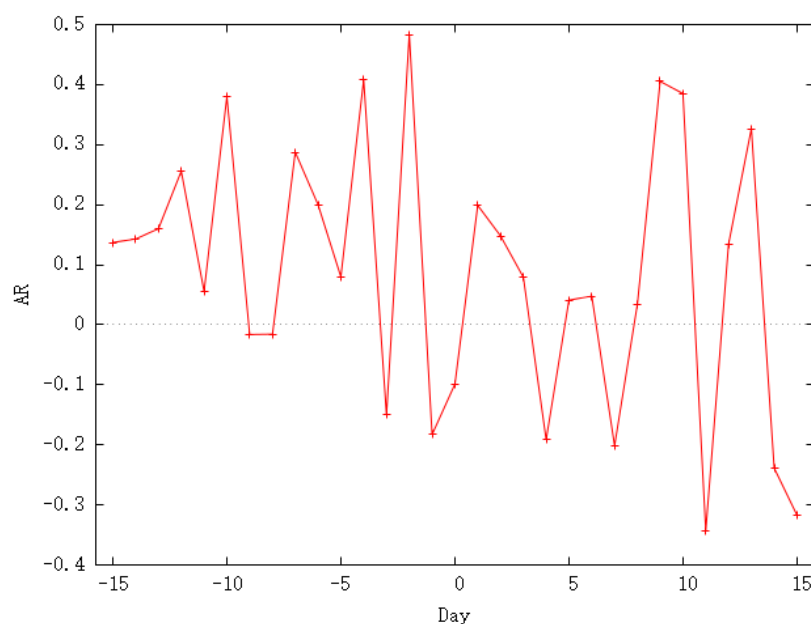


Figure 1. AR of IC design houses in patent lawsuits.

Table 1 shows the abnormal returns after mobile shopping services are imported by firms. According to the empirical results, at a significance level of 5%, the abnormal returns are significantly positive on Day 2 prior to the announcement day; at a significance level of 1%, the abnormal returns are significantly positive on Day 4 prior to the announcement day and on Day 9 after the announcement day; and the abnormal returns are significantly negative on Day 14 after the announcement day.

Table 2 shows the cumulative abnormal returns of IC design houses in patent lawsuits. According to the empirical results, at a significance level of 1%, the cumulative abnormal returns are significantly positive on Day 2 prior to the event day; at a significance level of 5%, the cumulative abnormal returns are significantly positive on Days 6, 5, 4, 3, and 1 prior to the announcement day; on the event day; and on Days 1, 2, 3, 4, 5, 6, 9, 10, 11, 12, 13, and 14 after the event day; and at a significance level of 10%, the cumulative abnormal returns are significantly positive on Days 7, 8, and 15 after the event day. In the samples, the cumulative abnormal returns are significantly positive. The significantly positive cumulative abnormal returns begin to appear on Day 7 prior to the announcement day, indicating that information may be disclosed early before the event or that firms disclose information in advance. The cumulative abnormal returns are also significantly positive after the event day, indicating that investors give a certain degree of support because they do not think IC design firms will necessarily lose patent lawsuits.

Table 2. CAR of IC design houses in patent lawsuits.

	CAR	p-Value		CAR	p-Value
-15	0.137	0.572	1	2.324 **	0.020
-14	0.280	0.415	2	2.472 **	0.016
-13	0.440	0.295	3	2.551 **	0.016
-12	0.696	0.152	4	2.359 **	0.030
-11	0.751	0.166	5	2.400 **	0.031
-10	1.131	0.057	6	2.448 **	0.032

Table 2. Cont.

	CAR	p-Value		CAR	p-Value
-9	1.115	0.083	7	2.247 *	0.054
-8	1.099	0.109	8	2.280 *	0.055
-7	1.386 *	0.057	9	2.686 **	0.027
-6	1.586 **	0.039	10	3.070 **	0.013
-5	1.666 **	0.038	11	2.727 **	0.031
-4	2.074 **	0.014	12	2.862 **	0.026
-3	1.923 **	0.028	13	3.188 **	0.015
-2	2.407 ***	0.008	14	2.949 **	0.027
-1	2.224 **	0.018	15	2.632 *	0.051
0	2.125 **	0.029			

Notes: *** indicates a significance level of 1%. ** indicates a significance level of 5%. * indicates a significance level of 10%.

Figure 2 integrates the AR and the CAR after being organized and analyzed and shows that the abnormal returns are stable prior to the announcement day, fluctuate increasingly as the announcement date approaches, and fluctuate extremely after the announcement day. In particular, the negative abnormal returns are the most significant on Day 2 ($t = -2$).

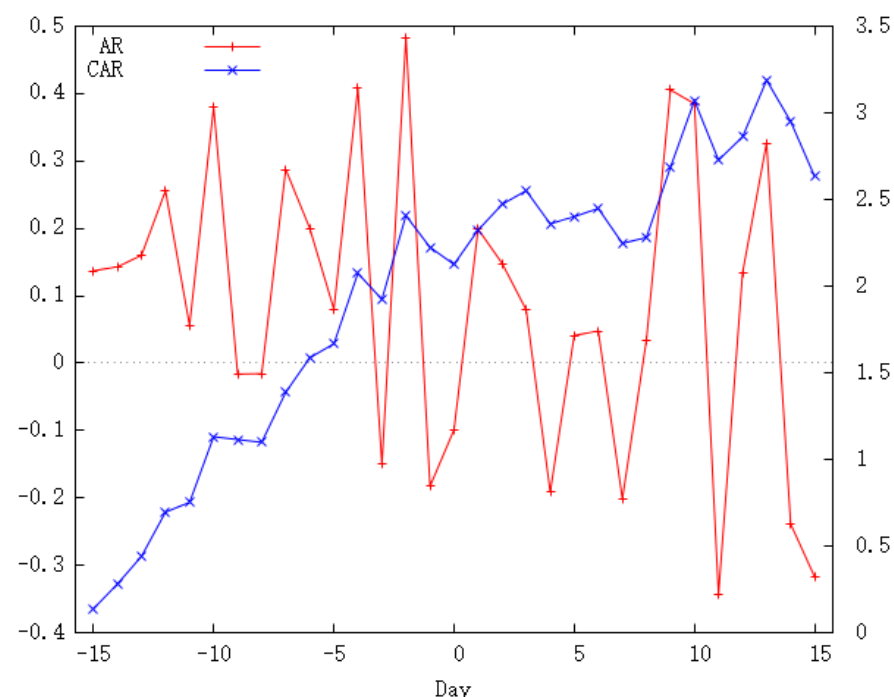


Figure 2. Abnormal returns and cumulative abnormal returns of IC design houses in patent lawsuits.

In addition to the differences in the abnormal returns on stock prices of IC design houses in patent lawsuits tested by the event study method, the factors affecting abnormal returns are investigated in this study by cross-sectional multiple regression analysis. This paper first tests the significance of the samples in different time periods and then carries out multiple regression analysis, with cumulative abnormal return as the dependent variable and debt ratio, firm size, and trading volume as the independent variables.

In this study, the announcement effects of patent lawsuits on Taiwan’s upstream IC design houses are analyzed by the event study method, after which cross-sectional multiple regression analysis is conducted based on debt ratio, firm size, and trading volume, with the purpose of exploring whether the abnormal returns on stock prices on the event day are affected by the above variables. According to the analysis results of the time periods shown

in Table 3, CAR(−1,0) and CAR(0,1) are taken as the dependent variables of cross-sectional multiple regression in this paper for empirical analysis.

Table 3. Analysis of window periods of CAR of IC design houses in patent lawsuits. Unit: Percentage (%).

Period	(−1,0)	(0,1)	(−5,5)	(−3,0)	(−2,1)	(−2,2)
CAR	−177.860 ***	58.120 ***	11.522	−9.045	−0.488	12.382
T-value	−16.806	5.492	0.464	−0.604	−0.033	0.740

Note: *** indicates a significance level of 1%.

Table 4 shows the cross-sectional multiple regression analysis of IC design houses in patent lawsuits. White’s test for heteroscedasticity with a *p*-value does not show a heteroscedasticity problem. CAR(0,1) shows a significantly negative trading volume, indicating that firm size and trading volume become adverse factors for IC design houses in patent lawsuits. Therefore, they can easily become lawsuit subjects due to large market values. Firms with large trading volumes may experience significant negative effects, as lawsuits may lead to distrust among investors. That is why firms may attract the attention of patent owners due to their large market values. Moreover, due to the industrial characteristics, many different patents are involved in the IC design industry and larger firms are easy targets after patent lawsuits.

Table 4. Cross-sectional multiple regression analysis of IC design houses in patent lawsuits. Unit: Percentage (%).

CAR (−1,0)			CAR (0,1)		
Variable	Coefficient	t-Statistics	Variable	Variable	Coefficient
Intercept term	1.038	0.8418	Intercept term	1.869	1.328
Debt ratio	0.0263	−0.6741	Debt ratio	−0.0136	−0.3810
Firm size	1.132×10^{-6}	−1.622	Firm size	-3.240×10^{-7}	0.2467
Trading volume	9.564×10^{-5}	0.1192	Trading volume	−0.000 ***	−2.705
R-squared	0.0586		R-squared		0.0706
Sum squared resid	234.204		Sum squared resid		320.086
F(3,52)	1.060		F(3,52)		3.0214
White’s test with <i>p</i> -value	23.369		White’s test with <i>p</i> -value		5.284
	0.00542				0.809

Notes: *** indicates a significance level of 1%.

5. Conclusions

With the vigorous development of the economy and the continuous renewal of and competition in the technology industry, from the previous traditional OEM industry to the current private brands and patents, the use and authorization of patents has been a topic worth discussing under industrial expansion and technological innovation. Patent owners are in the leading position in the market and can file patent infringement lawsuits if manufacturers infringe. Patent infringement lawsuits are often time consuming, and the acquisition of key patents in commercial competition can restrict competitors’ access to technologies and thus reduce the possibility of competitors acquiring patents. From the perspective of investors, the patents held by firms are the key to their investment values and all investments have certain risks. Patent infringements are highly risky for IC design firms. Hence, this study explores the abnormal returns of IC design firms in patent lawsuits.

In the empirical study, according to the changes in the abnormal returns, there are significantly positive abnormal returns on Days 7 and 2 prior to the announcement day, indicating that investors are confident and supportive of IC design firms in the face of patent lawsuits. According to cross-sectional analysis of IC design firms in the face of patent lawsuits, firm size and trading volume are significantly negative, indicating that they

are considered as key variables by investors due to their financial variables and industrial characteristics. Therefore, the announcement effects of such variables on stock price returns are different.

From the results of this study, we believe that although Taiwan's highly developed technology industry should pay more attention to strengthening the acquisition of patent rights, investors find that companies facing patent litigation can have corresponding investment strategies and the investors do not need to take extreme steps upon receiving the news of litigation. Panic may force investors to immediately sell stocks, but stocks may also be transformed into long-term holdings. Since the samples in this study are set as the abnormal remunerations of Taiwan IC design companies in patent litigation, the total sample will be relatively limited. According to the research results, future research directions may include the larger scale analysis of patent litigation across the global technology industry.

Author Contributions: Investigation, S.-C.Y. and K.-H.S.; Methodology, S.-C.Y. and K.-H.S.; Formal Analysis, S.-C.Y. and K.-H.S.; Conceptualization, S.-C.Y. and K.-H.S.; validation, S.-C.Y. and K.-H.S.; writing-original draft preparation, S.-C.Y.; writing-review and editing, S.-C.Y.; visualization, S.-C.Y. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data sharing not applicable.

Acknowledgments: The authors thank the reviewers for their useful discussions.

Conflicts of Interest: The authors declare no conflict of interest.

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