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Patents and Market Efficiency

- An Analysis of Non-Qualitative Patents

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Abstract

Title: Patents and Market Efficiency – An Analysis of Non-qualitative Patents

The importance of intellectual property and intellectual property rights in today's economy steadily increases. By conducting event studies this report investigates whether the market is efficient when it comes to the granting and the invalidation of non-qualitative patents, hypothesizing that the granting and invalidation should not have an impact on abnormal returns. By non-qualitative patents it is meant patents that first have been granted and then later invalidated due to reasons that should not lead to the patent being granted from the beginning. An extensive cross-sectional regression analysis is conducted to further investigate what actually drives abnormal returns.

The hypotheses set out in the report are confirmed by the event study. The granting of the non-qualitative patent do not have a positive effect on abnormal returns and the invalidation of the non-qualitative patent do not have any effect on abnormal returns.

The cross-sectional regression analysis concludes that what drives abnormal returns is not the granting of the non-qualitative patent; instead it is efficiency in terms of asset turnover and knowledge capital in terms of intangible assets to total assets.

Keywords: patent valuation, event study, intellectual property, efficient market hypothesis, non-qualitative patents' impact on abnormal returns

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1. Introduction

Jonathan I. Schwartz, former CEO of Sun Microsystems said in 2004:

"I believe in intellectual property. In my view, it's the foundation of world economies, and certainly the foundation upon which Sun Microsystems was built. Copyright, trademark, patent - I believe in them all. I also believe in innovation and competition - and that these beliefs are not mutually exclusive (Wikiquote)."

Schwartz stresses the importance of intellectual property (IP) and intellectual property rights (IPR) for the economy. In recent time we have also seen the value of IP steadily increase and a beginning to what some newspapers refer to as a "patent war". During 2011 Apple and Microsoft acquired Novell and Nortel, the latter for \$4.5 billion, to lay hands on a portfolio consisting of over 6000 patents. Google, who earlier had bid on Nortel, later acquired Motorola for \$12.5 billion. The reason for the acquisition is thought to be Motorola's patent portfolio consisting of approximately 17000 patents (Costoulas, 10/04/2012). Not only have the billion dollar acquisitions showed the growing importance and value of IP. Numerous newspapers have written about Facebook's IPO which is believed to value the company around \$75-\$100 billion¹. This is for a company with \$3.7 billion revenue in 2011 (Raice, 02/02/2012).

There is no large market place or exchange for trading IP today, which probably spawns market inefficiencies and arbitrage opportunities. Even though a lot has been published about the value of IP and patents, so far no consensus around the valuation methods of patents has been reached. Numerous models have been analysed and discussed in the literature, but still there are no conclusive results. An important question to answer is therefore whether the market is efficient when it comes to valuing patents. This thesis will focus on whether the market is efficient and what underlying factors that do indeed affect a potential value of a non-qualitative patent. This study is conducted on what further is referred to as non-qualitative patents. By non-qualitative patents it is meant patents that first have been granted and then later invalidated due to reasons that should not lead to the patent being granted from the beginning. Previous research on patents has instead focused on "normal" or qualitative patents, i.e. patents that have been granted and stayed valid or assumed to stay valid. Unless it is clearly stated that the patents discussed are non-qualitative the patents referred to are qualitative patents, the only thing meant by "qualitative" is that the patent is not non-qualitative.

An event study will first be conducted to examine if the market is efficient when it comes to valuing patents that first have been granted and later invalidated. This will be continued by a regression analysis to determine the factors underlying the outcome from the event study. Previous research presented in the study shows a positive relationship between patents and firm value, however this study focuses on patents that should not be assigned any value at all. This is to test if the market truly is efficient when it comes to patents.

¹ The IPO valued Facebook at \$104 billion, however the stock value decreased during the following days, valuing the company closer to \$75 billion.

1.1 Problem Discussion

The shift towards a more knowledge based society puts more emphasis on IP and the need for accurate valuation methods. A trend identified in this shift is the constantly increasing relative importance of intangible assets to physical and financial assets (Hagelin 2003). Patents are unambiguously an important part in the knowledge society and Amable et al. (2008) show in their study that the assignment of patents as collateral is a determinant for savings in firms and growth of innovations. Ernst et al. (2010) concludes that despite the strong need for detailed patent valuation methods this area still constitutes a major challenge for many firms. A first step to exploring the potential of patent as collateral and a trading asset is to see if the market is able to efficiently value it. An efficient market where the prices reflect the assets intrinsic values is essential to be able to extend the field of application for patents as financial assets.

1.2 Research Questions and Hypotheses

- Do the granting of non-qualitative patents, which are not fulfilling the basic requirements for patentability have an impact on abnormal returns?

In this study the area of investigation is non-qualitative patents i.e. patents that have first been granted and then later invalidated due to not fulfilling the requirements for being patentable. Therefore, we argue that the patents should not have a positive impact on the abnormal returns, since they should not have been granted from the beginning. The following hypotheses are being tested:

H1: The granting of non-qualitative patents will not have a positive effect on abnormal returns

H2: The invalidation of non-qualitative patents will not have any effect on abnormal returns

1.3 Purpose of Study

The aim of this study is to provide an insight to the complex world of patents in terms of market efficiency. Using the event study methodology we will test the market's efficiency. A brief overview of previous research on patents' effect on firm value will be presented to give a background. The new area that the thesis will focus on is whether the market is able to predict the non-qualitative aspects of a patent and thus not assign it a value. By investigating whether the market is efficient in the sense of valuing patents the authors hope to stimulate further research on the subject of patent valuation.

1.4 Framework of Study

To give the reader a basic understanding of the subject and to be able to understand the study conducted, there will be a brief presentation about the nature of patents, the difficulties of patent valuation, the efficient market hypothesis and how patent valuation affects firm value in section 2, 3 and 4. Then in section 5 the reader will be presented with how an event study and regression analysis is conducted. The data used in the study will be described and discussed. Empirical results from the study conducted will be presented in section 6 and analyzed according to the former presented theory in section 7. In section 8 the authors present their conclusions and suggested further research.

2. Background

2.1 Intellectual Property

Chaplinsky (2002) explains that intellectual property (IP) shares many characteristics with real and personal property. They are both assets that can be sold, licensed, exchanged and given away. As with real property the owner of the asset has the right to deny other actors from using it. The most evident difference between the two types of property is that IP is an intangible asset, meaning that it cannot be identified by its own physical parameters.

IP's role in the society is according to Hagelin (2003-1) constantly increasing in importance with the on-going shift towards a more knowledge-based economy. Since the 1980s the relative importance of intangible assets to physical and financial assets has constantly increased. A clear indicator of this phenomenon is the changing trend noticed in the Market-to-book (M/B) ratios among S&P 500 companies. In the beginning of 1970s the M/B was almost one to one among the S&P companies while it in 2000 averaged almost six to one. Hagelin (2003-1) concludes that almost 83.3% of the total firm value is derived from something else than physical and financial assets.

2.2 Patents

A patent is a legal right allowing the patent holder to exclude other parties from using the technology or invention described in the patent (van Triest and Vis 2006). According to Chaplinsky (2002) a patent can be looked upon as a contract entered by the society overall and the inventor. A granted patent gives the holder the exclusive right to making, using and selling the invention for a limited period of time in exchange for the invention to be publically disclosed.

Van Triest and Vis (2006) explicate a patent as a possibility for the inventor to receive a temporary monopoly in the area covered by the patent. However, in most cases a patent only covers a fraction of the whole product or a production process. Due to this a patent holder does not necessary receive a monopoly position but instead allows the inventor to exclude other parties from using an important but limited part of a product.

2.3 Basic Requirements for Patentability

According to the Swedish patent law (SPL) an invention has to meet certain requirements to qualify for being patentable. In broad terms the innovation have to be novel, inventive and industrially applicable (PRV & SPL). The process of obtaining a patent constitutes of the inventor, alone or with the help of patent attorney, translates the invention into a patent application and sends it into the PRV. The application is then confidential for 18 months as long as the inventor does not request otherwise. If the patent is later granted it has a lifetime of 20 years from the date of application. This short presentation of the patent granting process intends to provide an overview of the process and therefore leaves out variations, additions and exceptions (PRV & SPL).

2.3.1 Novelty

According to §2 SPL for an invention to be patentable it has to be novel in the sense that it must not be known before the patent application is filed. In addition to the novelty requirement it also has to fulfill the requirement of an inventive step, which means that it has to substantially differ from any, previous work done. An invention is assumed to be known if it by any sense has been publically announced before the date of the patent application. It is of no importance according to §2 SPL whether this is done by writing, a seminar or if the product itself has been used. According to PRV it is neither of importance by whom or where in the world the invention has been publically made. Additionally, previous filed patent applications in Sweden counts as being known, according to §22 in SPL. Briefly §22 SPL says that a patent application will become public 18 months after the application date or if the applicant requires priority. According to the third section in §2 SPL this might in some cases also be true for patents applied for at the European Patent Office (EPO).

In the fifth section of §2 SPL two main exemptions are made concerning the novelty requirement when information have been published six months prior to the patent application date. Firstly, a patent can still be granted if the information published is a direct result of misuse when being in contact with the applicant or any of the actors that the applicant derive its right from. Secondly, the applicant is still eligible for having a patent granted if the innovation has been shown at an officially recognized show according to what is stated in the closing convention in Paris at the 22nd of November 1928 about international shows.

2.3.2 Inventive Step

As has been mentioned shortly when discussing the novelty requirement a second requirement for having a patent granted is that an inventive step takes place. According to §2 SPL an inventive step means that the innovation must significantly differ from what is already known and any previous work carried out. PRV clarifies that an inventive step could also be explained by stating that it should not be obvious to a person skilled in the technical area covered. This implies that new ways of combining already known methods or objects are not necessarily patentable.

2.3.3 Industrial Applicability

According to Article 57 in the European Patent Convention (EPC) and §1 SPL a further requirement is that an invention has to be industrial applicable to be patentable. PRV's criteria of industrial applicability requires that an invention is of technical nature, have a technical effect and is reproducible. A further explanation of the criteria is shown below with a citation from the Swedish Patent Office (PRV).

1. *“Technical nature means that the invention must comply with the accepted laws of physics. It must be tangible, such as a product or a process, and not just a theory.*
2. *Technical effect means that the invention must work and solve a problem in a technical way. The effect, however, does not need to be new or better than in previous solutions.*
3. *Reproducibility means that the result must be the same every time the invention is used².”*

The industrial applicability requirement implies that patents cannot be granted based on certain ideas. In the second section in §1 SPL an invention is defined negatively by showing what is not an invention.

1. *“A discovery, scientific theory or mathematical method*
2. *An artistic creation*
3. *A plan, a rule or a method for intellectual activity, a game or a commercial operation or a computer program, or*
4. *A presentation of information³.”*

According to PRV the requirement that the invention must be industrially applicable means that certain types of ideas cannot be the basis for patents. In addition to what is stated above there are also some exceptions made in the patent law to what can be patented, regardless of whether the three conditions discussed above are fulfilled. In rare cases, it is even possible that authorities other than PRV prevent the invention from being used, despite that the patent has been granted.

2.4 Difficulties of Patent Valuation

“Valuation is the estimation of an asset’s value based on variables perceived to be related to future investment returns, on comparisons with similar assets, or, when relevant, on estimates of immediate liquidation proceeds. (Pinto et al., 2010, p.1)”

Further the authors claim that the intrinsic value is an essential starting point when trying to determine the value of an asset.

“The intrinsic value of any asset is the value of the asset given a hypothetically complete understanding of the asset’s investment characteristics. (Pinto et al., 2010, p.2)”

Pointed out by Pinto et al. (2010) is also that the intrinsic value reflects the investors’ subjective view on what the true value of the asset is. In the context of equity there are a

² Direct translation SPL, Available at: http://www.riksdagen.se/sv/Dokument-Lagar/Lagar/Svenskforfattningssamling/Patentlag-1967837_sfs-1967-837/ [Cited 23/05/2012]

³ Direct translation SPL, Available at: http://www.riksdagen.se/sv/Dokument-Lagar/Lagar/Svenskforfattningssamling/Patentlag-1967837_sfs-1967-837/ [Cited 23/05/2012]

going-concern value and a liquidation value. The going-concern value relies on the assumption that the company will continue its revenue generating activities during a foreseeable future. Liquidation value is the value of the company if it was dissolved and all assets were sold. Pinto et al. (2010) also make a distinction between fair market value and investment value. The fair market value is the price when an asset is traded between a buyer and a seller that are not under any compulsion to trade. Investment value is a value perceived by the buyer when taking potential synergies into consideration.

Pitkethly (1997) says that:

“...the direct financial value of a patent or patent application per se, must be the value of the potential extra profits obtainable from fully exploiting the invention defined by the patent’s claims in the patent’s presence compared with those obtainable without patent protection. (Pitkethly, 1997, p.2)”

Pitkethly (1997) and Ernst (2010) both request practically applicable methods for patent valuation. Ernst (2010) discusses the challenges occurring when evaluating a patent, but also the importance and demand for practical and accurate models. The professional knowledge around patent valuation seems to be limited. Patents grant protection for the owner to use a technology in the future, which leads to a level of uncertainty. According to Ernst (2010), Hagelin (2003-1) and Pitkethly (1997) the uncertainty surrounding a patent makes existing models either too simple or too complex to be practically applicable and the need for new more accurate models is crucial. Hagelin (2003-2) emphasizes that the uncertainty is greater in patent valuation than in valuation of real or personal property assets. Pitkethly (1997) however makes a parallel between patent valuation and stock market prices since both involve forecasting future incomes and that speculation to some extent is unavoidable. Pinto et al. (2010) point out the subjective influences on the valuation process, which Pitkethly (1997) also does:

“The first questions to be asked of any valuation are: who is doing the valuation?, for whom? And for what purpose? (Pitkethly, 1997, p.3)”

Ernst (2010), Hagelin (2003-1) and Pitkethly (1997) all mention three different categories of valuation models: cost-based, income-based and market-based models. Option-based methods come in under income-based models, which tries to deal with the uncertainty problem. Hagelin (2003-1) also gives some examples of models more specifically developed for patents and intellectual property. Furthermore, Kamiyama et al. (2006) and others talk about qualitative measurements.

Cromley (2004) names 20 steps for pricing a patent, one important step is to clear whether the patent is actually valid i.e. that the patent fulfill the statutory requirements stated by law. Other important steps are the scope of the patent and potential synergies amongst patents before doing the valuation.

Factors that indicate quality of a patent could be the breadth and strength of patents and their legal certainty. Kamiyama et al. (2006) and Reinhardt (2008) describe different patent

functions that affect the value such as: monopoly, defensive, license and joint-venture. The monopoly function is the internal use of a patent with high value, the defensive function is using patents to block third party products generating a low value for the firm, the license function is generating high value by licensing out the right to a third party and last joint-venture are similar to the licensing, but with a low value. Reinhardt (2008) identifies five different indicators of patent quality: (i) Bibliographic, which consider remaining lifetime, citations and key inventors; (ii) Procedural, where the size of the patent family, legal status in different countries and if the patent has survived any law suits; (iii) Content related indicators such as patent claims and number of words describing the object of invention and its advantages; (iv) Technological which includes the technology, its status and patents in the same International Patent Classification (IPC) class; and last (v) Enterprise related indicators such as market value, ownership, number of R&D co-operations etc. Reinhardt (2008) then combines these quality indicators with the patent function and valuation methods to estimate the patent value.

According to Hagelin (2003-1) citation-based valuation estimates have been shown to be predictive when it comes to future returns on stocks of public companies. A citation is a reference to another patent. When an applicant refers to other patents it is called a backward citation and when others refer to the granted patent it is a forward citation.

3. Theoretical Framework

3.1 Efficient Market Hypothesis (EMH)

When conducting an event study you actually test the market efficiency. An efficient financial market is defined by Fama (1970) as a market in which security prices fully incorporate all available information. According to Bodie et al. (2011) investors faced with a profitable investment opportunity will immediately bid up or down the price to a fair level with respect to the individual stock's risk profile. This implies that stock prices will only react to new information and that new information by definition will have to be unpredictable.

Shleifer (2000) names three basic arguments that act as the theoretical proof for EMH:

- *“First, investors are assumed to be rational and hence value securities rationally.*
- *Second, to the extent that some investors are not rational, their trades are random and therefore cancel each other out without affecting prices.*
- *Third, to the extent that investors are irrational in similar ways, they are met in the market by rational arbitrageurs who eliminate their influence on prices (Shleifer, 2000, p.2).“*

According to Bodie et al. (2011) most commonly the EMH is divided into three versions; weak, semi-strong and strong forms of the hypothesis. The difference between the different versions is what is defined as “all available information”. The weak form hypothesis asserts that all historic trading information such as stock prices, trading volume and short interest are reflected in the stock price. The semi-strong form hypothesis asserts that all public available information is reflected in the stock price and thus this implies that the weak form hypothesis is also true. In addition to previous historical trading data all public information will also contain data such as fundamental information on the firm's product line, quality of management, balance sheet composition, earnings forecast and patents held. Finally, the strong form hypothesis asserts that all available information is incorporated into the stock price, meaning that even insider information is reflected.

Shleifer (2000) discusses whether the investors are truly rational. Conclusively the EMH is not necessarily invalidated by the fact that investors are not rational. Those irrational investors are also referred to as noise traders or unsophisticated traders. He claims that EMH still holds as long as many traders are active in the market, and that their irrational actions are not correlated, and hence the irrational trades tend to close out each other. Shleifer (2000) also refers to psychological evidence brought up by Kahneman and Tversky that unsophisticated traders not necessarily trade randomly irrational as is required by the EMH. Instead their evidence show that unsophisticated traders are often irrational in the same direction, thus they are not uncorrelated, and this is referred to as noise trader risk. This then violates the first assumption of EMH but it also implies that the arbitrage argument can be questioned. Firstly it is difficult to find perfect substitutes, but even if perfect substitutes are available the so called noise trader risk, meaning that you cannot know how long time it will take before prices converge to its fair value, stands. Also empirical challenges to the EMH has been presented, but will not be further discussed in this paper.

4. Empirical Evidence

4.1 Patents Effect on Firm Value

The patents investigated in the research presented under this topic are qualitative patents. Hall et al. (2005) explain that R&D conducted in private firms is an investment activity that is resulting in an output which is an intangible asset that can be said to be a part of the firm's "knowledge stock". Bloom and Van Reenen (2002) discuss the consensus that technological advance drives economic performance. There are numerous ways to conduct studies in this area, traditionally Solow measured technological advance as a residual from a production function. Other measurements have been R&D expenditures, patent counts etc. Among the research we have studied we have noticed a difference between the earlier works focusing on only R&D expenditures and the more recent work which is more refined and adds patents, patents citations etc. to measure how technological development affect firm value.

Griliches (1981) showed in his early work on large US firms that a firm's knowledge stock had a significant relationship with the firm's market value. Griliches used past R&D expenditures and patent counts as proxy for the knowledge capital. Later research have developed and refined the methodology measuring the knowledge capital. Johnson & Pazderka (1993) also made a study investigating R&D expenditures effect on the market value of the firm. They concluded a positive effect on market value when using Canadian stock market data.

Blundell et. al (1999) investigated the empirical relationship between technological innovation, market share and stock market value. The evidence brought forward in their research shows that innovation has a positive effect on firm value and that the effect is greater when it comes to firms with a greater market share.

Bloom and Van Reenen (2002) use a methodology starting with a Cobb-Douglas production function including where real sales is a function of the knowledge stock, number of employees, the capital stock and an efficiency parameter. Since there is uncertainty surrounding the development of new technology and patents the authors also account for this by adding a real options approach to the knowledge stock variable. Instead of using only simple patent counts they use a citation weighted patent measurement. Bloom and Van Reenen conducted their study on data since 1968 from over 200 major British firms. Conclusively their study showed that patents have an economically and statistically significant effect on the firms' productivity and market value. The study also shows that even though patents seem to immediately be reflected in the market value, the effect on productivity is slower. Bloom and Van Reenen also find that a higher uncertainty reduces the patents' impact on firm productivity.

Similar to Bloom and Van Reenen (2002), Hall et al. (2005) takes a starting point in a production function and estimate Tobin's q equations on different ratios: i) R&D to assets, ii) patents to R&D and iii) citations to patents. Their study concludes that citation has a significant explanatory value when it comes to firm value. Hall et al. concludes that the marginal effect of an additional citation is increasing the firm value by 3%. In the report they

stress the fact that an additional citation is hard to get, considering the mean number of citations per patent is only just above three and about 25% of the patents never get cited. Hall et al. divided their data in to six major sectors to test for industry effects and showed there were some differences, where for example the Drug industry is heavily impacted by the changes in the knowledge stock. Another interesting finding made by Hall et al. is that “unexpected” citations has a larger positive impact on firm value, “unexpected” in the sense that they cannot be predicted based on past citations.

Wang et al. (2010) use an event study approach to explore how patent infringement litigation impacts the underlying stock’s value. The study is conducted on Taiwanese listed companies during the time period from 1998-2008. Wang et al. conclude that patent litigation negatively affect the underlying stocks’ price, where statistically significant negative abnormal returns occur on day 1 and 2 after the announcement day.

Chondrakis and Sako (2011) examine the private value of patents. They discuss how difficult it could be to measure the actual patent value since it is hard to separate total patent value and the patent premia, where the latter represent the actual value of the patent protection. Chondrakis and Sako refer to upcoming work by Jensen et al. who surveyed patent applicants and suggest that patented inventions are 38-47% more valuable than inventions without the patent protection. Chondrakis and Sako also explain that the firm size affects the patent value, since litigation costs are usually higher for small firms. Also the composition of the patent portfolio held by the assignee affect the value of the patent likewise does the access to complementary assets. The study concludes that the patent value is highly dependent on the assignee characteristics and their analysis evidently shows a positive relationship between patent value and three characteristics: i) firm size, ii) R&D intensity and the composition of the assigning firm’s patent portfolio. Chondrakis and Sako also suggest that a patent is usually more valuable to the assignee than to other firms and therefore the demand side in patent trades is reduced.

4.2 Our Contribution

In our knowledge no previous research has ever focused on non-qualitative patents. Previous research have focused on qualitative patents effect on firm value, this study do however focus on how the non-qualitative patents’ grant and invalidation affect the abnormal returns. Previous findings and relationships between qualitative patents’ effect on firm value are analogously tested, analyzed and interpreted in the context of non-qualitative patents’ effect on abnormal returns.

5. Methodology

5.1 Introduction Methodology

Event studies focusing on non-qualitative patents granting and later invalidation, are conducted to investigate if the patents have a significant effect on abnormal returns. Two event studies will be carried out, first to investigate what happens to the abnormal return when a patent is granted and then later on how the abnormal return react on a patent invalidation.

5.2 Event Studies

According to MacKinlay (1997) an event study is used to estimate the impact of an event on the company value using financial data. Essential for the event study is the abnormal return compared to the normal return. According to Kothari and Warner (2004) short-horizon event studies focus on the announcement effects of a certain event. Campbell et al. (1997) say that event studies are useful because, given rational markets, the effect of an event would be reflected in stock prices immediately.

Campbell et al. (1997) discuss some potential biases in event studies. One potential bias is the non-trading or nonsynchronous effect which arises when prices of a security is to be recorded at a certain time interval, but in reality are recorded at time intervals of irregular lengths. Usually closing prices are used in event studies and these prices do not occur at the same time every day. The non-trading effect influences the variances and covariances and therefore the market model beta. Empirical evidence however shows that this usually only causes problems for less traded stocks. For more regularly traded stocks the influence becomes less important. A second type of bias discussed by Campbell et al. (1997) is that a jointly normal independent distribution is assumed. The normality assumption is important and a lapse from that assumption can lead to biases. The results would all be asymptotic if normality was not assumed. Campbell et al. (1997) however conclude that this type of bias is not so probable since the test statistics converge to their asymptotic distribution relatively fast.

Both MacKinlay (1997) and Kothari and Warner (2004) raise the question of the power of the test. MacKinlay (1997) argues that the power will be low if the abnormal return is low and the sample size is small. Kothari and Warner (2004) point out the importance of the time-horizon and state that short-horizon methods are more powerful than long-horizon.

Chondrakis and Sako (2011) shed light on an occurring problem using the event study methodology when measuring patent value, namely that a firm can release information about pending patents before they have been granted. The problem is that events in an event study are assumed to be unexpected by the market. Earlier studies carried out on US-listed companies do however suggest that only 0.0025% of the total population of patents is concerned with leakage of information prior to the granting of a patent. Furthermore Chondrakis and Sako points out that the actual timing of the granting of a patent is unexpected. Chondrakis and Sako also explain that the announcement of a patent grant actually is two different announcements: i) that the company has come up with a new invention and ii) that it has patented this invention. Therefore the event study accounts for the total patent value not only the patent premium.

MacKinlay (1997) summarizes the analysis conducted in an event study in his paper. To begin with the event of interest and the event window should be defined. The latter is simply during which time period the abnormal return of the investigated firms will be examined. MacKinlay (1997) claims that the event window usually consists of multiple days in cases where daily data is used. The day or days before the event day should also be included in the event window since information about the event can have been acquired before the event day. Another important aspect is to define the selection criteria for the firms that should be included in the study. Seiler (2004) says that 30-60 observations are usually viewed as a minimum requirement to get significant results when running regressions.

MacKinlay(1997) stresses the importance of defining the measurement of abnormal returns to measure an event's impact on the firm's value. He defines the abnormal return for firm i at time t as:

$$AR_{it} = R_{it} - E(R_{it}|X_t)$$

Where AR_{it} is the abnormal return, R_{it} is the actual return and $E(R_{it}|X_t)$ normal return at time t . X_t is the conditioning information for the normal return model. To measure the normal returns an estimation window is used, excluding the event window since the event could have a significant impact on the normal return. Seiler (2004) entitles it contamination if the event window and estimation window overlap. According to Seiler (2004) the estimation window is most common set to a period prior to the event window. To increase the robustness of the test MacKinlay (1997) says that sometimes a post event estimation window is used when measuring the normal return.

Seiler (2004) recommends a 20-60 trading days event window. The period should start before the event day to take leakage of information in consideration. Estimation windows are rarely set to longer periods than 1 year when it comes to daily data, which is roughly 250 trading days.

MacKinlay (1997) proposes some different models when conducting event studies, statistical and economic, however the economic models are still relying on statistical assumptions. An easy and widely used model is the market model, which is a one factor model. The market model relies on statistical properties where a joint normal distribution of asset returns is assumed. MacKinlay (1997) defines the market model's expression for the return for any security as:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \varepsilon_{it}$$

$$E(\varepsilon_{it}) = 0 \quad \text{var}(\varepsilon_{it}) = \sigma_{\varepsilon_i}^2$$

Where R_{it} is the return on security at time period t and R_{mt} the market return. ε_{it} is the zero mean error term and α_i, β_i and $\sigma_{\varepsilon_i}^2$ are the model's parameters. As a proxy for the market return a broad stock market index is often used.

According to MacKinlay (1997) ordinary least squares (OLS) is an efficient way to estimate the market model. From the OLS we get the market models estimates. To measure the abnormal return during the event window the following model is used:

$$AR_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i R_{mt})$$

Where AR_{it} is the abnormal return during the event window, R_{it} is the actual return during the event window, $\hat{\alpha}_i$ and $\hat{\beta}_i$ are the parameters from the estimation window and R_{mt} the market return during the event window (Seiler, 2004).

Some important formulas for continuing the study is given by Zhang (1997). First to calculate the average abnormal return \overline{AR}_t for a sample of N , for the event t the following formula is used:

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

To calculate the average standardized abnormal return $ASAR_t$ for the event t , compute:

$$ASAR_t = \frac{1}{N} \sum_{i=1}^N \frac{AR_{it}}{S_{it}}$$

S_{it} is the square root of the variance of the abnormal return for firm i in time period t :

$$S_{it} = \left[\sigma_\varepsilon^2 \left[1 + \frac{1}{T} + \frac{(R_{mt} - \hat{\mu}_m)^2}{T \hat{\sigma}_m^2} \right] \right]^{\frac{1}{2}}$$

In the formula σ_ε^2 is the residual variance for the i th security, given from the market model. The number of observations during the estimation period is T . Seiler (2004) defines R_{mt} as the market return at day t during the event window. The mean return and variance of the market during the estimation window is given by $\hat{\mu}_m$ and $\hat{\sigma}_m^2$ (Zhang, 1997).

Zhang (1997) shows how to calculate the t-score for the $ASAR_t$ to be able to conduct a hypothesis test:

$$t_t = \sqrt{N} ASAR_t$$

To go further with the study it is interesting to calculate the average cumulative abnormal return $CAR_{\tau, \tau+k}$, which stretches over k dates in the event window:

$$CAR_{\tau, \tau+k} = \sum_{t=\tau}^{\tau+k} \overline{AR}_t$$

The standardized average cumulative abnormal return $ASCAR_{\tau, \tau+k}$ is computed as:

$$ASCAR_{\tau,\tau+k} = \frac{\sum_{t=\tau}^{\tau+k} ASAR_t}{\sqrt{k}}$$

To compute the t-value, the following formula is used:

$$t_{\tau,\tau+k} = \sqrt{N} ASCAR_{\tau,\tau+k}$$

Zhang (1997) also points out that it could be of interest to look at the number of days with positive return during the event window as well as the mean difference. The latter is computed as:

$$AR_{(diff)t} = ASAR_{1t} - |ASAR_{2t}|$$

Where 1 subscripts the group of stocks with positive abnormal return and 2 subscripts the group of stocks with negative abnormal returns. To test if the mean difference is statistically significant compute the test statistic:

$$t_t = \frac{AR_{(diff)t}}{\sqrt{\frac{1}{N_1} + \frac{1}{N_2}}}$$

5.3 Factors That Affect Abnormal Returns

Additional theoretical insights can be reached, according to MacKinlay (1997), due to analyzing the relationship between the abnormal returns and characteristics specific to the event observation. This is done by running a cross-sectional regression with the ASCAR as the dependent variable and the characteristics of interest as regressors.

The regression function used is constructed as follows:

$$ASCAR_{(t_1,t_2)} = \beta_0 + \beta_1 X_1 + \dots + \beta_k X_k + e_t$$

Where $ASCAR_{(t_1,t_2)}$ represent average standardized cumulative abnormal return from time t_1 to t_2 , β_k is the coefficient for the variable X_k and e_t the error term.

5.4 Data Selection

The selection criteria for the observations in this study have been patents held by companies (or a subsidiary to a company) listed during the time period when a non-qualitative patent has been granted and later invalidated.

The Swedish patent office (PRV) was contacted for guidance in searching their online database. A search for invalidated patents gave us in total 85 hits, starting from events occurring in the 1980's. Of those 85 hits, only 20 were interesting for this report in accordance with the selection criteria. In some cases the company that was granted the patent was not listed itself on an exchange, but a fully owned subsidiary by a listed company during the event period, and then included. Even though patents registered at PRV are the only examined, there are foreign companies granted patents and Swedish subsidiaries with foreign

mother companies. Due to the few events found, some events studied occurred in the same company, but regarding different patents.

20 different non-qualitative patents will be investigated divided amongst 14 different companies and 4 different sectors. The following pie charts respectively show in percentage the companies and patents by sector. The sector classifications are from the respective exchange where each company is listed.

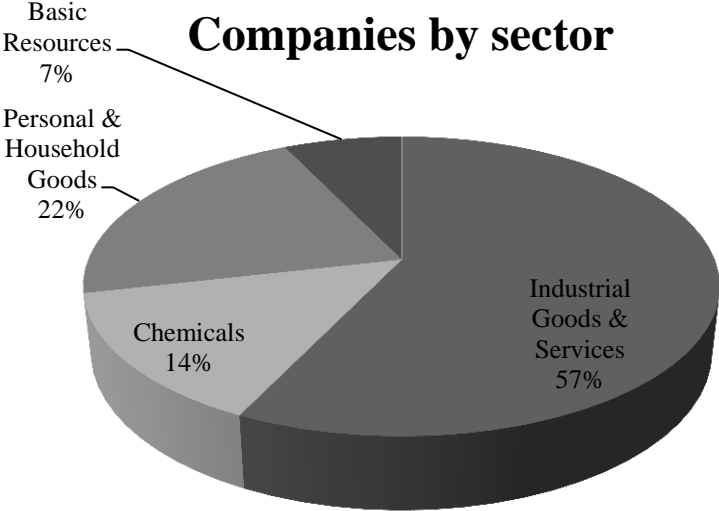


Figure 1 - Companies by Sector

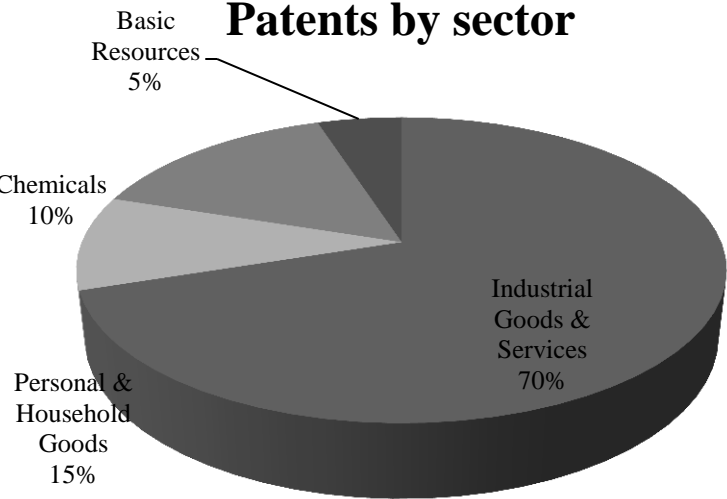


Figure 2 - Patents by Sector

Another question that arises when analyzing the data is when the decision about a granted or invalidated patent becomes public information. Since our data is ranging from 1994 up until

today the data given in PRV's database is somewhat inconsistent. It is not questionable when the patent has been granted, since it is reported in the same way in all cases. According to a conversation with PRV the decisions are later published in PRV's magazine, which is published on Tuesdays every week of the year. If Tuesday occurs on a national holiday, the magazine will be published the day after the holiday. When it comes to the date for invalidation of a patent it becomes a little bit more problematic to specify the event day. First a decision is made by PRV to invalidate a patent. According to a lawyer at *Patentbesvärsrätten*⁴ (PBR), the patentee then has a two month period to appeal PRV's decision, if they do not appeal, the decision then gains legal force. If the patentee appeals it can lead to a process that stretches over months or years. The reporting in PRV's database is also inconsistent when it comes to the invalidation of patents. According to PRV, in later years there is a date when the decision has gained legal force, but in most of the cases used in this study, there is no such information. In all the observations there is however a date when the decision from PRV to invalidate the patent was made. This view is also shared by PRV, where a lawyer explains that a patent is invalidated from the day when the decision was made. The publication is done after the decision has gained legal force, which explains why the publishing in a few cases occurs years after the decision (see *Appendix I*). The focus in this report will be on the day when the decision was made and the main reason is to be consistent in the tests. Other reasoning behind this is that one can believe that the decision about invalidation of a patent is an indicator that the company actually will lose the patent, which then would have an impact on the stock price. Conclusively the decision day for granting and invalidating of a patent will be used as the event day.

Historical pricing data, financial reports and key ratios have been collected from Thomson Reuters' Datastream. All pricing data and financial information has been collected in the local currency. When data from the financial reports have been used in the regression analysis it has been converted to Swedish SEK using oanda.com to convert with the correct historic exchange rate. In case of A and B stocks, the B stock is chosen for investigation since it is usually more traded. This is done to avoid biases such as the non-trading effect. To measure the normal return we have used the local exchange, where the stock is traded as proxy for the market return. For a Swedish stock for example the OMXS is used as a proxy for the market return. To see what index serves as proxy for the market return for each studied stock see *Appendix I*. In the table in *Appendix I* you can also find the event window and estimation window for each event.

Conducting an event study demands an estimation window and an event window defined in accordance with the figure below:

⁴Patentbesvärsrätten is in Sweden the court that process appeals on the patent office's decisions about invalidation of patents

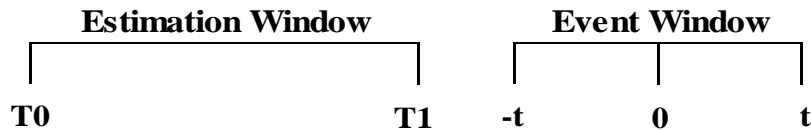


Figure 3 - Estimation and Event Window

The estimation window's length was set to 250 trading days prior to the event window, the time period from $T0$ to $T1$. The event window is set to 20 trading days starting 5 days prior to the event day, in terms of returns the time line then will range from -4 ($-t$) to 14 (t) with the event day as day 0. In some cases where there are more than one event in the same company the same estimation window is used, to make sure it does not include any of the events. In the case of the company Andritz they were not listed 250 trading days before two of the investigated events, therefore the event window starts from the first day available, and the event window then is approximately 180 trading days. In the case with Scania there are 5 events where 4 estimation windows easily could be contaminated by the different event windows in a short period of time, why the same estimation windows for the normal return is chosen in many of them. In the Scania events there are also 2 event periods overlapping each other when it comes to the granting of 2 patents (patent publication no. 530695 and 530677) as you can see in *Appendix I*.

5.5 Methodology Critique

One can question the use of the market model, which usually has a lower explanatory value than multi-factor models. The choice of the market model is motivated by that it is simple to apply. Other critique of the market model has come up regarding beta-estimates where for example Montier (2009) concludes that theory does not seem to be consistent with empirics.

6. Empirical Results

In this section first the results from the two event studies performed will be presented. When further discussing average abnormal return (AR) and average cumulative return (CAR) the standardized variables are referred to if nothing else is stated, for example ASCAR is represented by the abbreviation CAR. The event study will be continued with a regression analysis intending to identify possible factors having an explanatory value. First the main reason for the invalidation of the patents is showed.

6.1 Reasons for Invalidation

To investigate the reasons for invalidation of the non-qualitative patents PRV's database was referenced. The results are presented in the pie chart below:

Reasons for Invalidation

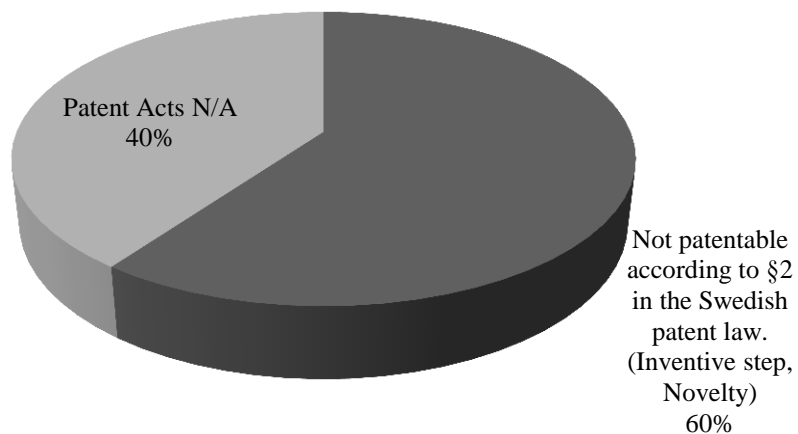


Figure 4 - Reasons for Invalidation

The main reason for invalidation of a patent is that the observed patent applications are not patentable from the start. In practice this means that one or more of the requirements for an innovation to be patentable are violated. In the study conducted 20 observations were included and among those 20 observations 8 observations lacked the accompanying patent acts and the remaining 12 patent applications violated §2 SPL by not fulfilling the requirements of novelty and inventive step. According to PRV they started to digitally file all applications in 2004. The only cases prior to 2004 that have available information in their database are patents that have been part of a larger dispute that has ended after 2004.

6.2 Event: Granted Patent

In *Table 1* below the results from the event study when the non- qualitative patent was granted is displayed, where day 0 represents the day of the granting.

Table 1 - Patent Granted

Day	AR(%)	t-value	Positive (%)	AR diff (%)	t(diff)-value
-4	-0,108	-0,483	50%	-0,216	-0,483
-3	-0,188	-0,839	45%	-0,057	-0,125
-2	0,034	0,152	60%	-0,362	-0,772
-1	0,163	0,727	60%	0,124	0,272
0	0,230	1,029	60%	0,241	0,527
1	0,255	1,139	60%	0,201	0,440
2	0,445**	1,992	65%	0,417	0,889
3	0,400**	1,787	75%	0,191	0,369
4	0,369	1,650	60%	0,475	1,040
5	-0,135	-0,606	35%	0,097	0,207
6	-0,051	-0,229	45%	0,030	0,066
7	-0,127	-0,569	50%	-0,254	-0,569
8	0,193	0,864	60%	0,149	0,327
9	-0,025	-0,112	45%	-0,050	-0,112
10	-0,593***	-2,651	15%	-0,476	-0,760
11	-0,226	-1,012	35%	-0,156	-0,333
12	0,336	1,502	60%	0,452	0,990
13	0,042	0,188	40%	0,425	0,930
14	-0,025	-0,112	50%	-0,050	-0,112
<hr/>					
CAR[-4,4] (t)	0,533***	2,385			
CAR[-2,4] (t)	0,716***	3,204			
CAR [0,1] (t)	0,343*	1,533			
CAR [0,2] (t)	0,537**	2,402			
CAR [0,4] (t)	0,760***	3,397			
CAR [2,4] (t)	0,701***	3,134			

Significance-level:

*0.10

**0.05

***0.01 or better

As shown in the second column the firm will have no positive abnormal return at either the event day or the day after. A positive abnormal return on average is obtained during day 2 and day 3, which is significant at a 5% level. At 10% significance the firm will also earn an abnormal return on day 4 after a patent has been granted. At day 2, 65% of the firms experience a positive AR of 0.445% and on the third day after the patent was granted 75% of the firms have an AR of 0.4%. The number of firms with positive ARs is more than 50% from

day -2 until day 4. This could be interpreted as a weak hint that the granting of a patent has a positive effect on the abnormal returns from 2 days before the event until 4 days after the event day. The graph below can be helpful to visualize the event.

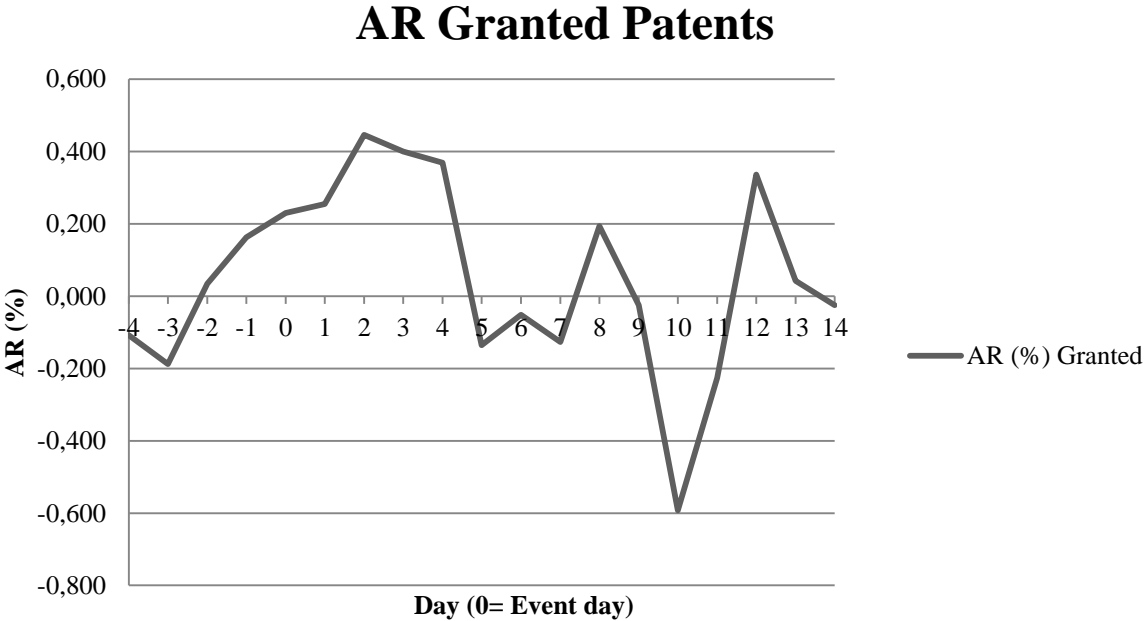


Figure 5 - AR Granted Patents

This graph shows the average abnormal return for the investigated companies when a patent has been granted. The patent was granted on day 0, the event day. Studying the graph it seems like, as earlier stated, the firm will have a positive abnormal return from 2 days before the patent is granted until 4 days after the granting. This implies that the companies experience abnormal returns for 6 days in total. However, as earlier stated, the AR is only significant at day 2,3,4 and 10.

In column 5 in *Table 1* the mean difference in average abnormal return between the groups of stocks with positive AR compared to the group of stocks with negative AR is shown. The 6th column shows the t-statistic for the mean difference and as stated in the table, the null hypothesis that there is no difference in the means cannot be rejected. Studying the percentage of firms with positive AR together with the mean difference could however lead to some interesting notations. At day -2, 60% of the firms enjoy a positive AR but the mean difference is negative, which implies that there is a bigger movement in the prices for the stocks showing a negative AR.

Looking at the average cumulative abnormal return (CAR) in *Table 1* the results support that the granting of a patent actually has a positive effect on the abnormal returns. A 3-day period starting on the event day shows a CAR at 0.537% and on a 5-day period the CAR has increased to 0.76%. Below we have graphed the CAR during the whole event period.

CAR Granted Patents

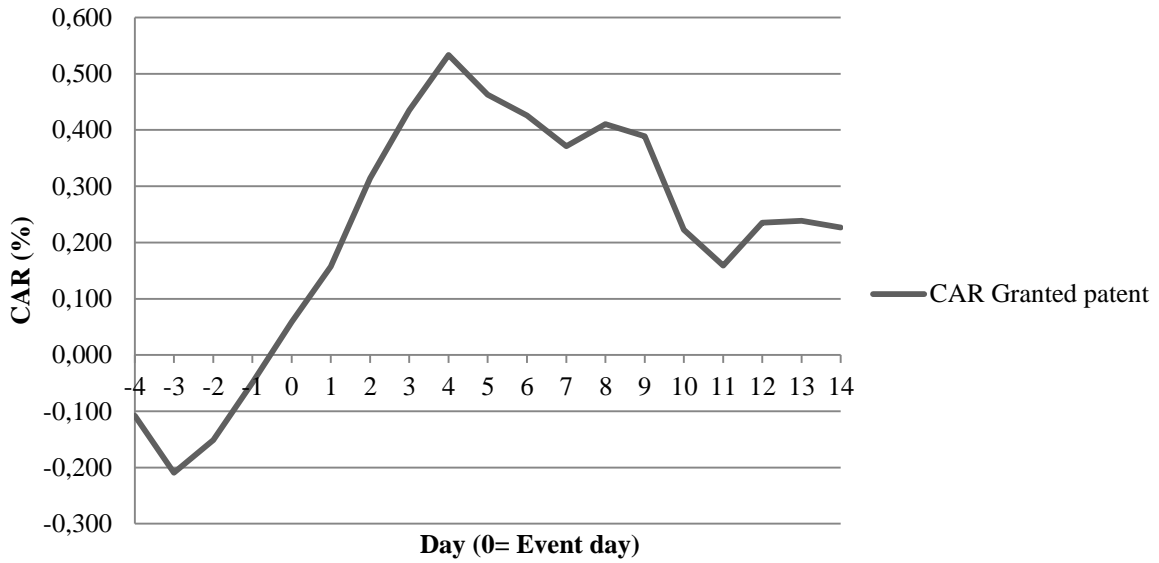


Figure 6 - CAR Granted Patents

The graph clearly shows how the CAR grows from the event day until day 4, when it starts to slowly dip and then a significant dip on day 10. The CAR values in the table above and the graph imply that a granted patent will have a positive impact on the abnormal returns. As presented in the table above all the CARs are also statistically significant at different levels.

6.3 Event: Invalidated Patent

To test the second hypothesis an event study was performed on the invalidation of non-qualitative patents. In *Table 2*, below, the results from the event study are displayed. In column 2 the AR for each day is given.

Table 2 - Patent Invalidated

Day	AR(%)	t-value	Positive (%)	AR diff (%)	t(diff)-value
-4	0,363*	1,623	65%	0,426	0,909
-3	-0,344*	-1,537	20%	0,207	0,371
-2	0,244	1,089	55%	0,365	0,812
-1	0,068	0,304	65%	-0,032	-0,068
0	0,166	0,743	40%	0,656	1,438
1	0,270	1,210	65%	0,188	0,401
2	-0,125	-0,557	40%	0,027	0,058
3	-0,133	-0,593	40%	0,012	0,026
4	0,153	0,683	40%	0,489	1,072
5	-0,073	-0,328	45%	-0,026	-0,058
6	0,084	0,375	45%	0,260	0,578
7	0,145	0,648	55%	0,136	0,302
8	0,013	0,056	50%	0,025	0,056
9	-0,019	-0,085	45%	0,033	0,073
10	-0,107	-0,477	30%	0,191	0,392
11	0,016	0,073	60%	-0,198	-0,433
12	0,036	0,163	55%	-0,054	-0,121
13	-0,315*	-1,410	55%	-0,764	-1,700
14	-0,089	-0,397	50%	-0,178	-0,397
<hr/>					
CAR [0,2] (t)	0,180	0,806			
CAR [0,4] (t)	0,149	0,664			
CAR[0,14] (t)	0,006	0,026			
CAR [2,4] (t)	-0,060	-0,270			
CAR [2,14] (t)	-0,115	-0,514			

Significance-level:

*0.10

**0.05

***0.01 or better

The tests show that no results are significant at a 5% level. At a 10% significance level the tests show that at day -4 an AR of 0,363% is gained by 65% of the firms. Also at day -3 and day 13 the results are significant at a 10% level and 80% and 45% of the firms respectively experience a negative AR on average at approximately 0.3%. Taking a look at column 4 shows that from the event day until 4 days after, 60% of the firms experience a negative AR, with exception from the day after the event day, where only 35% of the firms show a negative AR.

Graphing the average abnormal return on the event that a patent has been invalidated gives the following diagram:

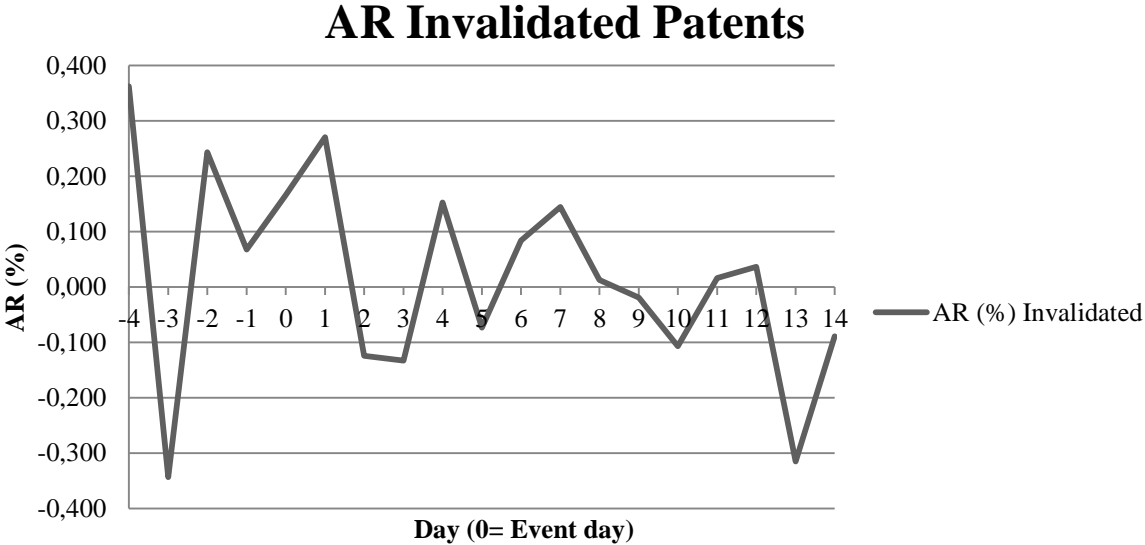


Figure 7 - AR Invalidated Patents

Juxtaposed to the event when a patent is granted, this graph implies a higher inconsistency in the average abnormal returns. A more substantial negative AR is experienced at day -3 and 13, however there are also positive ARs gained at a similar level on day -2 and day 1. The results are not statistically significant though.

The CAR has also been computed and the result is displayed in the graph below. Examining the computation of the CAR for some different time periods in *Table 2* above, shows that no CAR is statistically significant.

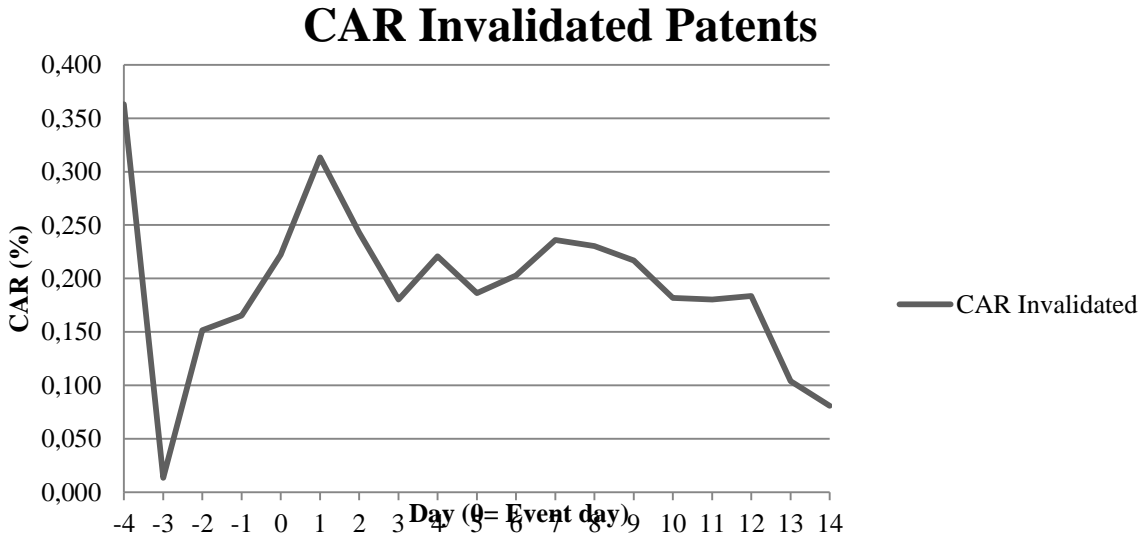


Figure 8 - CAR Invalidated Patents

The lack of significant results support's the hypothesis that an invalidated patent would not have any impact on the AR. This is further strengthened by the computations of the CARs for different time periods in the table above. The results are not significant, but worth noticing is that the CARs if starting at day 2 are negative.

6.4 Cross-sectional Regression of the Factors Affecting the Abnormal Returns

The insignificant results when a non-qualitative patent was invalidated supports the hypothesis that the non-qualitative patent has no effect on abnormal returns. Due to the insignificant results associated with the invalidation this cross-sectional analysis will only cover the granting of a patent where significant CARs were received. To determine the underlying factors causing the positive CAR present at days 0-1, 0-4 and 2-4 cross-sectional regression analyses are performed for each individual CAR. The null hypothesis states that the granting of a non-qualitative patent should not affect abnormal returns and thus other significant variables are expected to be identified. Three separate cross-sectional regression analyses are performed, first with the CAR 0-1 and then for the CAR 0-4 and CAR 2-4.

To assess a factor to proxy the firm size the natural logarithm of total assets and sales are tested. The ratios R&D expenditures to total assets and intangible assets to total assets were tested to see if the “knowledge capital” has any effect. Leverage was also considered by testing the debt to equity ratio. Additionally asset turnover was used to test whether firm efficiency affects the CAR. Finally the possible effect from the sector belonging and if the company was listed on a Swedish exchange or not were tested by adding dummy variables. The ex ante expectations for the latter one was that it may have an effect since the patents investigated were patents filed and approved by the Swedish patent office, PRV.

Testing for leverage, Swedish listing and R&D expenditures resulted in no significant results and were not discussed.

The models tested are constructed as follows:

$$CAR[t_1, t_2,] = \beta_0 + \beta_1 \frac{Rev}{TA} + \beta_2 \ln(S) + \beta_3 \frac{IA}{TA} + \beta_4 Ind_1 + \beta_5 Ind_2 + \beta_6 Ind_3 + e_t$$

Where:

$CAR[t_1, t_2,]$ is the average standardized cumulative abnormal return generated during the time period from day t_1 to day t_2 .

$\frac{Rev}{TA}$ is the asset turnover, which is used to measure the firm's efficiency.

$\ln(S)$ is the natural logarithm of the firm's sales used as a proxy for the firm size.

$\frac{IA}{TA}$ is the ratio of intangible assets to total assets to test if the “knowledge capital” of the firm has an impact.

Ind_1, Ind_2 and Ind_3 are sector dummies where subscript 1) is the Basic resources sector, 2) stands for Industrial sector and 3) represents Chemical sector.

A brief description of the data used is displayed below in the summary statistics and correlation tables.

Table 3 - Summary Statistics

Summary Statistics	Sales / Total Assets	Intangible Assets / Total Assets			
Variable	Obs	Mean	Std. Dev.	Min	Max
Sales / Total Assets	20	1.015	0.238	0.684	1.462
Intangible Assets / Total Assets	20	0.095	0.076	0.016	0.274

As can be seen in the summary statistics above Sales / Total Assets or *Asset Turnover* experience a higher mean and more wide spread values than *Intangibles to Total Assets*.

Table 4 - Correlation Matrix Independent Variables

	Sales / Total	Log(Sales)	Intangible Asset	Basic Resources	Industrial Goods	Chemicals
Sales / Total Assets	1					
Log(Sales)	-0.516	1				
Intangible Assets / Total Assets	-0.057	-0.262	1			
Basic Resources	-0.173	0.201	-0.085	1		
Industrial Goods	0.050	-0.052	-0.118	-0.350	1	
Chemicals	0.212	0.048	-0.184	-0.077	-0.509	1

The highest correlation among the independent variables is -0.516. This implies that there is no risk for perfect collinearity, which would otherwise limit the study.

Three models were tested, referred to as CAR[0,1], CAR[0,4], and CAR[2,4], where CAR[0,1] measures the average standardized cumulative abnormal returns during the event day and the day after and so on. In the table below the results from the cross-sectional regressions are presented:

Table 5 - Cross-sectional Regression Analyses

Independent Variable	Dependent Variable		
	CAR [0,1]	CAR [0,4]	CAR [2,4]
Constant	-7,819 <i>(-1,66)</i>	-8,896** <i>(-2,4)</i>	-5,101 <i>(-1,56)</i>
Asset Turnover	3,231*** <i>(2,87)</i>	3,361*** <i>(3,8)</i>	1,701** <i>(2,18)</i>
ln (Sales)	0,645 <i>(1,26)</i>	0,695 <i>(1,73)</i>	0,37 <i>(1,04)</i>
Intangibles to Total Assets	2,986 <i>(0,94)</i>	5,590** <i>(2,25)</i>	4,778** <i>(2,18)</i>
Basic Resources	0,101 <i>(0,09)</i>	1,304 <i>(1,48)</i>	1,601* <i>(2,06)</i>
Industrial	-0,584 <i>(-0,92)</i>	0,416 <i>(0,84)</i>	1,014** <i>(2,31)</i>
Chemical	0,549 <i>(0,58)</i>	0,296 <i>(0,4)</i>	-0,066 <i>(-0,1)</i>
F-Value	0,098	0,035	0,056
R-squared	0,515	0,601	0,565

The t-values are in italic and inside parentheses. Significance-level: *0.10, **0.05 and ***0.01 or better

The only individual significant results obtained from the event study appear at the days 2, 3 and 4. The CAR for days 0-4 and CAR 2-4 is significant at a 1 % level. Also remember that the CAR at the days 0-1 is significant at the 10% level and thus raises some suspicion that a patent would result in an abnormal return. When looking at the magnitudes of the CAR for 0-4 and the CAR for 2-4 it can be seen that the majority of the CAR originates from days 2-4. Since the patent is non-qualitative and the event study show that a granting do not have an effect on the abnormal return, but significant CARs, significant results are expected for at least some variables to be able to validate the null hypothesis.

CAR 0-1 results in only *Asset Turnover* being statistically significant at the 1% level with a value of 3.231. Although *ln (Sales)* and *Intangibles to Total Assets* are both statistically insignificant they both have positive signs, which at least is in line with previous results. A F-value of 2.3 is obtained and it is significant at the 10% level.

Using CAR 0-4 as the dependent variable generates similar results as in CAR 2-4. *Asset Turnover* and *Intangibles to Total Assets* are both economically and statistically significant. *Asset Turnover* has a slightly more positive value of 3.361 and is significant at the 1% level while *Intangibles to Total Assets* also has a slightly more positive value of 5.590 at the 5% significance level. When using CAR 0-4 *ln (Sales)* also appear as a significant coefficient with a value of 0.695 at the 10% significance level. A relatively high F-value of 3.27 is obtained. Notice that the sign for all variables are positive, i.e. has a positive effect on CAR 0-

4. This strengthens the argument that efficiency and the level of intangible assets have a positive impact on CAR. In addition it shows that firm size also has a positive impact on the CAR 0-4. Even here no significant interaction effects were found.

The column for CAR 2-4 shows significant results on the coefficient for *Asset Turnover*, *Intangibles to Total Assets* and for the industry dummies relating to *Industrial* goods and *Basic Resources*. *Asset Turnover* has a positive value of 1.701 which is statistically significant. *Intangibles to Total Assets* has a value of 4.778 and is also both statistically and economically significant. *Basic Resources* and *Industrial* also show significant results of 1.601 respectively 1.014. All coefficients are significant at or close to the 5 % significance level. The relatively high F-value implicates that the joint null hypothesis stating that all coefficients are equal to zero can be rejected at the 5% level. Note that the sign of all variables are positive, i.e. it has a positive effect on CAR 2-4. In other words efficiency, the level of intangible assets and industry belonging have a positive impact on CAR 2-4. Tests were also conducted to see if there were any significant interaction effects between different variables, but no statistically significant results were found.

7. Analysis

7.1 Event Study

The empirical results originating from the event study confirm H1, that there is no significant effect on abnormal returns when a patent is granted. No individual significant results are obtained either at day 0 or 1. Worthwhile noticing though is that the CAR 0-1 is positive and significant at the 10% level and both the CAR 2-4 and the CAR 0-4 are positive and significant at the 1% level. A majority of the CAR 0-4 is although originating from the CAR2-4 and makes these days interesting for further analysis.

When conducting an event study a semi-strong efficient market should incorporate all new information at the event day. Since no significant effect in the AR can be identified on the event day it is evidence supporting that the market is semi-strong efficient, and thus it does not give the patent any value. This in line with H1: The granting of the patent will not have a positive effect on abnormal returns. However, there are significant positive effects at a 5% level on day 2 and 3, and also on day 4 at a 10% level. As mentioned above the CAR is significant from day 0 until day 4. This raises some suspicion about a possible time lag in the market, where it takes 2 days until the information is reflected in the price. If this is the case that implies that the granting of the patent actually would have a positive impact on abnormal returns, and thus does not support the arguments for being a semi-strong efficient market. This scenario is supported by Wang et al. (2010) who showed that a one day time lag existed when performing an event study focusing on patents being litigated.

When a patent is granted, individually significant effects at the 5% level can be distinguished at day 2 and 3 and at the 10% level at day 4. Wang et al. (2010) did also find that the significant effects occurred prior to and slightly after the event day in their study on Taiwanese companies' patent litigations. The CAR is highly significant at the 1% level or better in the time period ranging from day 0 to day 4. Assuming that a time lag exists, these results could imply that there is actually a positive effect on abnormal returns when a patent is granted even though the information is not fully incorporated on the event day. This is in accordance with Bloom and Van Reenen (2002) who showed that patents have a positive impact on firm value. Note that the positive effect of the AR is not significant on the event day and also the CAR start counting at day -4 is significant. This would then indicate a possible leakage before the event day and if so that the total impact on abnormal returns does not necessary occur during the event day. This would then imply that the market values the patent even though it should not have been patented from the beginning.

According to Bodie et al (2011) the effects resulting from the event should only occur on the event day for a market to be truly efficient. In this report it is however hypothesized that the event should not have any impact on the abnormal returns, i.e. there should be no effect on the event day. The empirical results from the event study do not show any significant results on the abnormal returns at the event day. This does not allow a rejection of the null hypothesis that the parameter is zero and therefore implies a support for our hypotheses that the granting or invalidation of a non-qualitative patent does not have any affect abnormal returns. However there are significant results after the event day, when it comes to the granting of a

non-qualitative patent. Two possible explanations may be, firstly that the market is efficient and other factors are causing the abnormal return and secondly that the market is inefficient and simply do not fulfill the requirements for being a semi-strong efficient market. In a semi-strong market the stock price instantaneously reflects all public information and it is therefore not possible to earn abnormal returns from using this information. Bodie et al (2011) also argue that leakage often is the case and it is therefore necessary to discuss the degree of efficiency instead of only looking at the mere fact whether it is semi-strong or not.

Another explanation for the impact could be found in behavioural finance. Shleifer (2000) refers to research by Kahneman and Tversky which has shown that noise trading could lead to irrational market behavior. The connection between this theory and the empirical results would then be that unsophisticated traders irrationally buys the stock and rational traders short it because they know that the patent should not have been granted, but the effect from the unsophisticated traders overtakes the rational investors.

As stated in H2 no significant negative results appear upon the invalidation of a patent. This is reasonable when assuming market efficiency and that the patent is not given any value at the granting. The market seem to efficiently have accounted for and expected the patent to be invalidated since it did not fulfill the requirements for being patentable.

7.2 Cross-sectional Regression of the Factors Affecting the Abnormal Returns

Previous research shows that factors such as firm size, R&D expenditures, citations etc. affect the firm value. Analogously interpreted in this report, these findings are used to see how these factors affect the abnormal returns. In this study the citations will be irrelevant since the patent should not have been patentable from the beginning and do not fulfill the basic requirement for patentability. The patent portfolio is supposed to play a role as complement to the patent and/or strengthen it. The variables tested are instead measurements or ratios related to firm size and R&D expenditures.

From regressing CAR 2-4 it is clear that other factors than the patent is causing the abnormal return to appear. This is further strengthened with the regression when CAR 0-4 is used as the dependent variable.

Bloom and Van Reenen (2002) took a starting point in a production function when they investigated patents' effect on firm value. In the function they used an efficiency parameter, which the model used in this report also accounts for by including the factor *Asset Turnover*. Asset turnover is an easy way to measure and compare how efficient different firms use their capital. The asset turnover is statistically significant for the CAR 2-4. This result clearly also have economic relevance since an efficient use of one's assets is something positive and increases the return in accordance with traditional DuPont analysis. It is rather incontestable that sales are a main driver for firm value in general. This is in line with the study by Bloom and Van Reenen (2002) which considered the firm's efficiency when looking on patents' effect on firm value. This result supports H1 since the positive CAR to some extent can be explained by asset turnover and hence makes it less likely that the granting of the patents have had a positive impact on abnormal returns. By looking at the regression with CAR 0-4 as the

dependent variable similar results are obtained for the *Asset Turnover*, where it equals to 3.361 and is significant at the 5% level.

Chondrakis and Sako (2004) include a firm size variable in their model when investigating the private value of patents and find a positive relationship. The proxy used for firm size in this report is the natural logarithm of sales. This was chosen after testing both total assets and *ln (Sales)* but only the latter one gave significant results. Chondrakis and Sako (2004) find evidence for the firm size having a positive effect on patent value. For example they argue that larger firms have an advantage when it comes to enforcing the legal right a patent gives the owner. Although when CAR 2-4 is used as the dependent variable no significant results are obtained for *ln (Sales)*. A positive sign is however present and could potentially indicate the direction. When CAR 0-4 is used as regressand, *ln (Sales)* equal to 0.695 and is significant at the 10% level. Based on Chondrakis and Sako (2004) one could then argue that it is due to the positive relation between firm size and patent value. On the other hand the test only shows the variable's impact on CAR and hypothesizing that the patents should not have any value one could instead see that the variable itself has an explanatory value for the CAR. There is a clear economic rationale behind the positive relationship between revenue and firm value, since larger revenues in general lead to larger profits and therefore the relationship could also exist for abnormal returns.

Griliches (1981), Johnson and Pazderka (1993), Blundell et al. (1999), Hall et al. (2005) and Chondrakis and Sako (2011) amongst others have all discussed and included variables measuring the firms knowledge capital, innovative skills or R&D investments. All have found a positive relationship between a large knowledge capital and firm value. To account for this we have tested different variables, but the one giving best explanatory value was *Intangibles to Total Assets*. Hagelin (2003-1) concludes that almost 83.3% of the total firm value is derived from something else than physical and financial assets, which shows the increasing importance of the intangible assets.

When CAR 2-4 is used as the dependent variable the coefficient is statistically significant at a 5% level and *Intangibles to Total Assets* is equal to 4.778. Using CAR 0-4 as the dependent variable generates similar results and helps to validate the result. In the latter regression *Intangibles to Total Assets* is significant at the 5 % level and has a value of 5.590. The results are clearly in line with previous research. Chondrakis and Sako (2004) also discussed that the patent portfolio held by the assignee affect the value of a patent and thus the firm value. Chondrakis and Sako (2004) argue that the intensity and the composition of the assigning firm's patent portfolio is important for the firm value. This implies that it has economic significance. Although *Intangibles to Total Assets* has a larger magnitude than *Asset Turnover* the summary statistics show that the *Asset Turnover* takes on larger values and thus have a larger effect on the CAR.

Companies from four different sectors have been included in the study. To separate possible differences among the sectors three dummy variables were added. The base value is personal goods and the included dummy variables represent *Industrial Goods*, *Basic Resources* and

Chemicals. When using CAR 2-4 significant results were obtained for *Basic Resources* and *Industrial Goods*. *Basic Resources* have a value of 1.601 and is significant at the 10% level while *Industrial Goods* have a value of 1.014 and is significant at the 5% level. This implies that companies in the *Basic Resources* and *Industrial Goods* sectors on average experience higher CARs. In the regression when CAR 0-4 is used as the dependent variable no significant results are obtained

In summary the results clearly show that the granting of the investigated patents do not affect abnormal returns, which we hypothesized in H1. Instead what affects the abnormal returns and the returns in the firms investigated are knowledge capital and the asset turnover.

8. Conclusion

The patents investigated in this study do not have any significant impact on abnormal returns. Markets in which patents are involved are semi-strong by EMH's strict definition that the event should only have an impact on the event day. The hypotheses set out in the report are confirmed by the event study. The granting of the non-qualitative patent do not have a positive effect on abnormal returns and the invalidation of the non-qualitative patent do not have any effect on abnormal returns

The regression analysis gives further evidence and concludes that what drives the CAR is not the granting of the non-qualitative patent; instead it is efficiency in terms of asset turnover and knowledge capital in terms of intangible assets to total assets. In summary this study concludes that the market is efficient when it comes to valuing non-qualitative patents, i.e. the market does not value them at all.

8.1 Suggested Further Research

This study concludes that further research is needed within the subject. At first the same study containing more observations should be conducted. Secondly it would also be of interest to test for the effects when a patent is lost to another actor due to better right. It would also be of interest to perform a similar study on qualitative patents to be able to distinguish the effect on granting under normal circumstances.

Patents as collateral is also a topic that would be very interesting, however reliable valuation models is essential for the idea of patents as collateral to come true. To investigate whether an exchange for trading assets could be possible in the future is also regarded as highly interesting.

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Appendix I

Company name	Patent publication no.	Index	Event: Granted				Event window		Estimation window		Event: Invalidated				Event window		Estimation window	
			Event day	Published	Start	End	Start	End	Event day	Published	Start	End	Start	End				
ABB	SE 500539	SWISS	1994-07-11	no 25, 1994	1994-07-04	1994-07-29	1993-07-19	1994-07-01	1997-11-24	no 47, 1997	1997-11-17	1997-12-12	1996-12-02	1997-11-14				
Andritz	SE 518080	ATX	2002-08-20	no 34, 2002	2002-08-13	2002-09-09	2001-06-22	2002-02-25	2007-10-31	no 5, 2008	2007-10-24	2007-11-20	2006-11-08	2007-10-23				
Andritz	SE 516814	ATX	2002-03-05	no 10, 2002	2002-02-26	2002-03-25	2001-06-22	2002-02-25	2004-03-31	no 28, 2004	2004-03-24	2004-04-20	2003-04-09	2004-03-23				
Andritz	SE 527390	ATX	2006-02-21	no 8, 2006	2006-02-14	2006-03-13	2005-03-01	2006-02-13	2011-05-20	no 33, 2011	2011-05-13	2011-06-09	2010-05-28	2011-05-12				
Atlas Copco	SE 527424	OMXS	2006-02-28	no 9, 2006	2006-02-21	2006-03-20	2005-03-08	2006-02-20	2009-10-22	no 6, 2010	2009-10-15	2009-11-11	2008-10-30	2009-10-14				
Akzo Nobel	SE 512617	AEX	2000-04-10	no 14, 2000	2000-04-03	2000-04-28	1999-04-19	2000-03-31	2002-06-19	no 39, 2002	2002-06-12	2002-07-09	2001-06-27	2002-06-11				
Electrolux	SE 500640	OMXS	1994-08-01	no 28, 1994	1994-07-25	1994-08-19	1993-08-09	1994-07-22	1995-10-27	no 23, 1997	1995-10-20	1995-11-16	1994-11-04	1995-10-19				
Saint-Gobain	SE 507079	CAC40	1998-03-23	no 11, 1998	1998-03-16	1998-04-10	1997-03-31	1998-03-13	2000-12-20	no 11, 2001	2000-12-13	2000-01-09	1999-12-29	2000-12-12				
Kemira	SE 521857	OMXH	2003-12-16	no 51, 2003	2003-12-09	2004-01-05	2002-12-24	2003-12-08	2005-12-02	no 13, 2006	2005-11-25	2005-12-22	2004-12-10	2005-11-24				
Metso	SE 525983	OMXH	2005-06-07	no 23, 2005	2005-05-31	2005-06-27	2004-06-15	2005-05-30	2007-09-12	no 51, 2007	2007-09-05	2007-10-02	2006-09-20	2007-09-04				
Nolato	SE 510262	OMXS	1999-05-03	no 16, 1999	1999-04-26	1999-05-21	1998-05-11	1999-04-23	2000-09-01	no 47, 2000	2000-08-25	2000-09-21	1999-09-10	2000-08-24				
SCA	SE 500353	OMXS	1994-06-06	no 20, 1994	1994-05-30	1994-06-24	1993-06-14	1994-05-27	1997-10-24	no 2, 1998	1997-10-17	1997-11-13	1996-11-01	1997-10-16				
Scania	SE 532359	OMXS	2009-12-22	no 52, 2009	2009-12-15	2010-01-11	2008-12-30	2009-12-14	2011-08-30	no 48, 2011	2011-08-23	2011-09-19	2008-12-30	2009-12-14				
Scania	SE 530875	OMXS	2008-09-30	no 40, 2008	2008-09-23	2008-10-20	2007-08-21	2008-08-04	2010-12-21	no 13, 2011	2010-12-14	2011-01-10	2008-12-30	2009-12-14				
Scania	SE 530695	OMXS	2008-08-19	no 34, 2008	2008-08-12	2008-09-08	2007-08-21	2008-08-04	2010-10-18	no 5, 2011	2010-10-11	2010-11-05	2008-12-30	2009-12-14				
Scania	SE 530677	OMXS	2008-08-12	no 33, 2008	2008-08-05	2008-09-01	2007-08-21	2008-08-04	2011-04-07	no 27, 2011	2011-03-31	2011-04-27	2008-12-30	2009-12-14				
Scania	SE 519180	OMXS	2003-01-28	no 5, 2003	2003-01-21	2003-02-17	2002-02-05	2003-01-20	2004-05-19	no 35, 2004	2004-05-12	2004-06-08	2003-05-28	2004-05-11				
Stora Enso	SE 528626	OMXS	2007-01-09	no 2, 2007	2007-01-02	2007-01-29	2006-01-17	2006-12-29	2008-10-27	no 6, 2009	2008-10-20	2008-11-14	2007-11-05	2008-10-17				
Swedish Match	SE 529462	OMXS	2007-08-14	no 33, 2007	2007-08-07	2007-09-03	2006-08-22	2007-08-06	2009-06-10	no 38, 2009	2009-06-03	2009-06-30	2008-06-18	2009-06-02				
Volvo	SE 524209	OMXS	2004-07-13	no 29, 2004	2004-07-06	2004-08-02	2003-07-22	2004-07-05	2007-03-07	no 24, 2007	2007-02-28	2007-03-27	2006-03-15	2007-02-27				