# Could market efficiency explain the disappearance of the “End of Month” effect?

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Abstract

This study investigates the disappearance of the end of month effect in the period from 2006 to 2023. Previously, from 1987 to 2005 the end of month effect was present in both CRSP value weighted and equal weighted indexes as proven by McConell and Xu (2008) which presents a challenge to Efficient Market Hypothesis introduced by Eugene Fama (1970), however in recent years the effect has vanished. An increase of market efficiency hypothesis is studied here using an event study methodology to evaluate abnormal returns and cumulative abnormal returns across the two periods. While some findings suggest that an increase in market efficiency may have influenced the disappearance of the effect, the evidence does not conclusively support a significant improvement in market efficiency between the two periods.

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**Keywords**: End of Month Effect, Market Efficiency, Abnormal Returns, Event Study, Calendar anomalies

Resumo

Este estudo investiga o desaparecimento do efeito de final de mês no período de 2006 a 2023. Anteriormente, de 1987 a 2005, o efeito de final de mês estava presente tanto no índice CRSP ponderado por valor de mercado como no índice índices igualmente ponderado, conforme comprovado por McConell e Xu (2008) o que representa um desafio à Hipótese de Mercado Eficiente introduzida por Eugene Fama (1970), mas nos últimos anos o efeito desapareceu. A hipótese de aumento de eficiência de mercado é estudada aqui usando uma metodologia de estudo de eventos para avaliar retornos anormais e retornos anormais acumulados ao longo dos dois períodos. Embora algumas conclusões sugiram que um aumento na eficiência do mercado possa ter influenciado o desaparecimento do efeito, os dados não apoiam de forma conclusiva uma melhoria significativa na eficiência do mercado entre os dois períodos.

**Titulo**: Poderá a eficiência do mercado explicar o desaparecimento do efeito “Fim de Mês”?

**Autor**: Henrique Gil

**Palavras-Chave**: Efeito Fim do Mês, Eficiência de Mercado, Retornos anormais, Estudo de eventos, Anomalias de Calendário

**Table of Contents**

# 1. Introduction:

The behavior of stock returns and the existence of calendar anomalies have been a topic of interest for decades in the world of finance. One anomaly included is the end of month effect, this phenomenon is defined as a higher return of stocks around the turn of the month compared to other days.

The first to study calendar anomalies in the stock market was Sidney B. Wachtel (1942) who documented several seasonalities in securities prices, however the author recognized that much more research was needed to fully comprehend the anomalies. That's exactly what Ariel (1987) did, several years later, using value weighted and equal weighted indexes to prove that the effect persisted from 1963-1981. His research suggests that cumulative returns from the last trading day of one month to the nineth trading day of the following month were consistently higher to cumulative returns outside of this window, indicating the presence of the end of month effect. One year later, Lakonishok and Smidt (1988) also explored calendar anomalies in the US stock market but this time using data from Dow Jones Industrial Average. The authors explored and found evidence that anomalies like the end of month effect, the January effect, the Halloween effect and much more were present in the 90 year period from 1897 until 1986. At this point in time, no one had presented an explanation for the end of month effect, research so far only focused on the existence of the effect and not the cause behind the effect. However in 1990 this changed with Ogden's research which provides an explanation to the end of month effect. Ogden's theory suggest that players in the economy such as banks, institutions and companies pay out funds like wages, interest payments and dividends at the end of the month. These funds increase the liquidity available to investors who then reinvest the money into the stock market, rising stock prices during this period and causing the end of month effect. More recently, McConell and Xu (2008) also studied the end of month effect using CRSP value weighted and equal weighted indexes in the period from 1986-2005. The authors find evidence that the effect persisted during this period with average returns around the turn of the month being significantly higher to those outside the end of month effect window. From 2008 on, research on the end of month effect has been focused on emerging markets which this leads to the following question: "Is the end of month effect still present in US stock markets?"

This thesis aims to answer this question and further explore the reasons behind the effect.

The presence of this anomaly, presents a challenge to the Efficient Market Hypothesis (EMH) introduced by Fama. According to this theory, all information is immediately and accurately reflected on prices, making it impossible to consistently achieve higher returns through patterns, timing strategies or other predictable means.

Understanding if anomalies like the end of month effect persist has practical implications for investors and policymakers. If these effects have diminished due to increased market efficiency, it suggests that markets are becoming more effective at incorporating information, reducing opportunities for abnormal profits based on predictable patterns. This has consequences for trading strategies, market regulation, and understanding of financial market behavior.

Firstly, this thesis aims to investigate if the of the end of month effect still persists in the period from 2006 to 2023 by using the same methodology used by McConell and Xu (2008). The findings from this analysis suggest a decrease in daily average returns and statistical significance for both CRSP value weighted and equal weighted indexes, revealing the disappearance of the end of month effect.

At first glance, there are many hypotheses that could explain the disappearance of the end of month effect. One of those hypotheses is the increase in Algorithmic trading and High-Frequency trading in the past decade. Hendershott, Jones, and Menkveld (2011) studied the impact of Algorithmic trading on liquidity. Their findings suggest that Algorithmic trading improves liquidity and enhances the informativeness of quotes which might have contributed to the correction of inefficiencies. Another theory is how institutional behavior affects stock returns. For instance, the growing dominance of institutional investors may have reduced the visibility of calendar anomalies. Griffin, Harris, and Topaloglu (2003) explore differences in behavior between institutional and retail traders and their implications for anomalies. Overall, the study finds minimal evidence that institutional trading predicts future price changes, implying that institutional trades are more reactive than proactive. Additionally, the widespread awareness of anomalies like the end of month effect, as highlighted by the adaptive market hypothesis (Lo, 2004), may have led to their exploitation and subsequent erosion. Moreover, increased global market integration and regulatory changes aimed at enhancing transparency and limiting manipulative trading practices have likely played a role in diminishing such anomalies (Chordia, Roll, and Subrahmanyam, 2008). This study explores the hypothesis of increased market efficiency. According to the Efficient Market Hypothesis (EMH), proposed by Fama (1970), securities prices fully reflect all available information. This raises the hypothesis that if markets have become more efficient over time, anomalies like the end-of-month effect should disappear or at least diminish. To study the evolution of market efficiency two approaches were followed. Starting with an autocorrelation analysis by examining the autocorrelation of stock returns at various lags (1,2,5 and 10) to assess the predictability of returns. A decline in significant autocorrelations over time may indicate increased market efficiency, as prices become less predictable based on past returns. The second approach focused on quarterly earnings announcements by deploying an event study methodology. The hypothesis here is that if market efficiency has increased then average abnormal returns and cumulative average abnormal returns should be lower both in terms of magnitude and statistical significance. This methodology followed the works of Brown and Warner (1985) and MacKinlay (1997). Three models are utilized to estimate expected returns: the market-adjusted model, the market model (based on the Capital Asset Pricing Model, CAPM), and the Fama-French three-factor model.

While the market-adjusted model suggests a decrease in abnormal returns over time, indicating increased market efficiency, the market model and Fama-French model do not provide conclusive evidence of such improvement. The market model, in particular, emerges as the most appropriate tool for this analysis. Supported by foundational literature, including Brown and Warner (1985) and MacKinlay (1997), the market model accounts for individual securities' systematic risks, offering accurate estimates of expected returns without the added complexity of multifactor models.

The differences between the models present challenges when attributing the disappearance of the end of month effect only to increased market efficiency. While some results indicate more efficient markets, particularly the autocorrelation analysis and the results from market adjusted model, the findings from the market model and Fama French model suggest that other factors may also play a role.

Overall, this thesis starts by studying if the end of month effect is still present in today's markets by replicating McConnel and Xu's (2008) methodology for the period 2006-2023. After finding evidence that the effect disappeared, a hypothesis of increased market efficiency is explored to understand if the vanishment of the effect could be explained by increased market efficiency. The findings suggest that no definitive conclusion about increased market efficiency can be drawn, as the results present varying outcomes.

Overall, by exploring the disappearance of the end of month effect and its relation to market efficiency, this study adds valuable insights to the field of finance, contributing to both theoretical understanding and practical applications in financial markets.

## 2. Literature review:

The End of Month Effect is part of a category named calendar anomalies, which includes anomalies like the January Effect and the Monday Effect. These anomalies have been studied several times in the past as they present challenges to the Efficient Market Hypothesis (EMH). The recurrent pattern of higher returns at the end and beginning of each month raises questions about market efficiency and the persistence of such anomalies over time.

The investigation of calendar effects in stock prices started with Sidney B. Wachtel (1942), who investigated seasonalities in stock prices. While Wachtel pioneered the research in stock market anomalies, he recognized that much more research was needed to fully understand these phenomena. Consequently, his research initiated a series of analyses on various other calendar anomalies, including the End of Month Effect.

One of those was conducted by Ariel (1987), who documented an empirical irregularity in stock returns and referred to it as the "monthly effect." Ariel used value-weighted and equally weighted daily stock index returns from 1963 to 1981. His findings indicated that almost all the cumulative returns on these indexes occurred during ten consecutive trading days, starting with the last trading day of the month and extending through the first nine trading days of the following month. Ariel considered various explanations for this phenomenon, including risk premiums and institutional behavior, but none were sufficient to fully explain the effect.

The End of Month Effect was also explored by Lakonishok and Smidt (1988), who examined several anomalies using data from the Dow Jones Industrial Average (DJIA) over a 90-year period (1897–1986). They found out that stock returns were persistently unusual not only around the turn of the month but also around the turn of the week, turn of the year, and holidays. The authors presented detailed statistics on rates of return for eight days surrounding the turn of the month, revealing a strong and persistent effect, with particularly high average returns from day -1 to day 3 relative to the start of the new month. Their work helped to solidify the End of Month Effect as a significant and recurring anomaly in financial markets.

A potential explanation for the End of Month Effect was offered by Ogden (1990), who explored the economic factors behind the anomaly. Ogden argued that the end of each calendar month is a "preferred habitat" for major economic entities, such as corporations, banks, and institutional investors, due to typical payoff dates for wages, dividends, interest, and other financial obligations. The increased demand for liquidity during this period leads investors to prefer securities maturing at the end of the month. This preference causes the prices of month-end securities to rise contributing to the higher returns observed during the turn of the month. Ogden's theory suggested that the End of Month Effect was driven by institutional behavior rather than market inefficiencies or speculative trading.

More recently, McConnell and Xu (2008) extended the analysis of the End of Month Effect using CRSP value-weighted and equal-weighted indexes from 1987 to 2005. They found that the effect was present in both small-cap and low-price stocks. They also documented that the effect wasn't confined to calendar year-ends or quarter-ends. Moreover, the study demonstrated that the end of month effect persisted in the U.S. across various market conditions, and it was not correlated with higher volatility or changes in interest rates at the turn of the month. McConnell and Xu also tested their hypothesis outside of the US, finding evidence that the effect was present in 30 of the 34 non-U.S. countries they studied.

These calendar anomalies present a challenge to the Efficient Market Hypothesis (EMH), introduced by Eugene Fama in 1970, this theory suggests that stock prices reflect all available information, making it difficult for investors to consistently achieve returns higher than average market performance. EMH is categorized into three forms depending on what type of information is incorporated in securities prices:

1. Weak Form: This suggests that current stock prices incorporate all past market data, such as historical prices and volumes.
2. Semi-Strong Form: Here, stock prices reflect all publicly available information, including financial statements, economic data, and news releases. According to this form, neither fundamental nor technical analysis can produce abnormal returns consistently, as prices adjust rapidly to new public information.
3. Strong Form: Finally the strong form suggests that stock prices reflect all information, both public and private (insider information), meaning that no group of investors can achieve abnormal returns even with exclusive access to privileged data.

One way to test market efficiency, particularly the semi-strong form, is through studies on abnormal returns around specific events such as quarterly earnings announcements or stock splits. Abnormal returns are no more than the difference between expected and actual returns around an event, giving insights into how accurately markets incorporate new information.

Eugene F. Fama, along with Lawrence Fisher, Michael C. Jensen, and Richard Roll (1969), were one of the first ones to investigate market efficiency by focusing on how stock prices adjust to new information, specifically stock splits. The authors observe that stock returns in the months before the stock splits are usually high, even before any announcement of a stock split. This increase is attributed to market anticipation of higher earnings which can result in higher dividends. However, after the split, stock prices tend to stabilize and the market adjusts quickly and accurately to the split. This fast adjustment supports the semi-strong form of market efficiency, as prices reflect all public information almost immediately.

Ball and Brown (1968) focused their research on markets' reaction to accounting reports. The authors find evidence that accounting reports due bring new information to investors, however much of the relevant information is anticipated by investors with about 85%-90% already reflected at the time of the report's release. This supports market efficiency as prices respond to the news contained in financial reports, but it also points to the market's ability to foresee much of this information in advance.

More recent studies, like Foster, Olsen, and Shevlin (1984), and Bernard and Thomas (1989), have examined post-earnings announcement drift (PEAD), where stock prices continue to move in the direction of earnings news even after the initial announcement. Foster et al. (1984) identified persistent abnormal returns following unexpected earnings announcements, noting that factors such as forecast error magnitude and firm size significantly affect the drift. Smaller firms and larger forecast errors correspond to a more pronounced drift, accounting for 85% of the variation in PEAD during the 1974-1981 period.

Bernard and Thomas (1989) also explored PEAD, studying whether it represents a delayed market response or an unaccounted-for risk premium. They found that a significant portion of the drift results from delayed responses, as stocks in the highest and lowest unexpected earnings deciles display notable abnormal returns beyond the earnings announcement period. This persistence of drift extends up to 60 days post-announcement. Additionally, the drift magnitude is inversely related to firm size, with larger firms exhibiting a smaller PEAD effect.

Together these studies suggest that the market is at least partly efficient meaning that while markets are largely efficient in processing public information, certain inefficiencies still exist.

# 3. Data

## 3.1 End of Month Effect

To study the End Of Month effect, CRSP (Center for Research in Security Prices) value weighted (VW) and equal weighted indexes (EW) were used. The dataset covers a period of 37 years divided into 2 subperiods, 1987-2005 and 2006-2023. The indexes used represent a value or equal weighted portfolio built each calendar period and include all securities listed on NYSE, AMEX, NASDAQ, and NYSE Arca exchanges that have available shares outstanding and valid prices. The weighting is based on market capitalization as of the end of the preceding period, meaning that larger companies have a proportionally higher influence on the index.

## 3.2 Market Efficiency

To study the market efficiency, the data was divided into two sample periods which allows the comparison over time. The first sample period incorporates data from 1987 to 2005, while the second sample period includes data from 2006 to 2023. In each of these periods, a sample of 2,400 randomly selected firms was obtained in order to create a suitable and varied sample in both periods. This procedure resulted in 281,089 observations, where each corresponds to one quarterly earnings announcement for one of the selected companies.

These observations provide data to evaluate changes in market response over time, as quarterly earnings announcements are key events through which new information is available to the market. This dataset was gathered from the CRSP/Compustat Merged accessible through WRDS (Wharton Research Data Services).

# 4. Methodology

## 4.1 End of Month Effect

The End of Month Effect window is established in the literature as the last trading day of month t and the first three trading days of month t+1. In this study, the effect is defined in a similar way, starting from the last trading day of month t and the first three trading days of month t+1, with the last 10 trading days of month t and the first 10 days of the subsequent month also considered for comparison.

To examine the end-of-month effect, initially an investigation for the period  from 1987 to 2005, as previously analyzed by McConnell and Xu (2008) is performed. This methodology involves analyzing daily returns for CRSP value weighted and equal weighted indexes depending on the day of the month. At the same time, statistical tests were used to compare average daily returns at the turn of the month with those of other periods. The same methodology is then applied to data from 2006 to 2023 to determine if the effect persists in this more recent period. In this setup, Day -1 refers to the last trading day of the month, Day 1 to the first trading day of the next month, and so forth.

The primary hypothesis under examination is that returns from Day -1 until Day 3 are equal to zero. Additionally, average returns within the End of Month effect window were compared to the average returns of days outside this window.

## 4.2 Market Efficiency

To study market efficiency two approaches were followed.

Firstly, an analysis of autocorrelation of orders 1,2,5, and 10 is deployed with coefficients as well as their respective significance being analyzed. Autocorrelation is defined as:

$$R_{i,t} = \alpha + \beta R_{i,t-x}$$

Where $R_{i,t}$ is CRSP value weighted or equal weighted return on time t, β is the autocorrelation coefficient, and x represents the lag order (1, 2, 5, or 10).

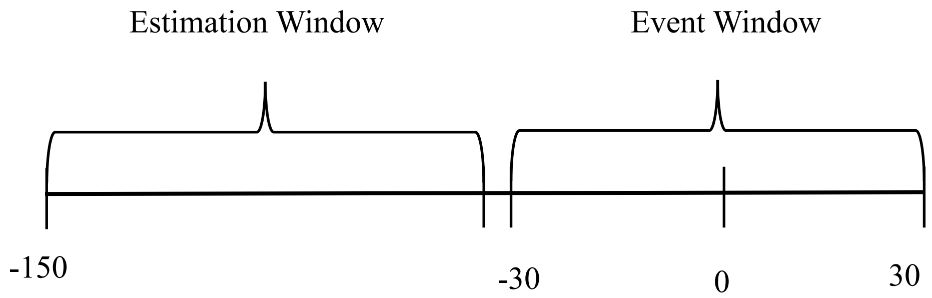
The idea behind this analysis is that if autocorrelation coefficients decrease in terms of magnitude and statistical significance it means that in the second period, returns have become less predictable and therefore suggest an increase in market efficiency.

Additionally, to study market efficiency an event study methodology was used, focusing on abnormal returns around quarterly earnings announcement dates. An event study methodology has been a useful tool and its methods have been discussed in several papers like Brown and Warner (1985) and MacKinlay (1997). It has been used for various events such as earnings announcements, stock splits, dividend announcements, or merger and acquisition studies.

Numerous studies have used this methodology to examine the relationship between new information and stock price behavior. Early influential papers such as Fama, Fisher, Jensen, and Roll (1969) and Ball and Brown (1968), as well as later studies by Foster, Olsen, and Shevlin (1984) and Bernard and Thomas (1989), have utilized event studies to demonstrate how markets react to information, making this approach a solid tool to assess market efficiency.

In this event study, abnormal returns across two different periods are compared. If there is a significant decrease in terms of magnitude and statistical significance in abnormal returns in the second period when compared to the first one, this might suggest that markets have become more efficient over time and that this increase in efficiency might be the cause behind the vanishment of the end of month effect.

The event window in this case is 61 days consisting of 30 days prior to the quarterly earnings announcement and 30 days following the event. The estimation window, used to calculate expected returns, covers 120 days, consisting of the 120 trading days immediately preceding the start of the event window.




Three distinct models were used, each providing a different approach to estimate expected returns.

1. Market-Adjusted Model: Abnormal returns (AR) are calculated as the difference between a company's actual return $R_i$ and the market return $R_{mkt}$, represented by the CRSP value-weighted (VW) index. The abnormal return on day t for company i is given by:

$$AR_{i,t}=R_{it}-R_{mkt}$$

where $R_{mkt}$ is the CRSP VW index return on day t.

2. Market Model: Abnormal returns are defined according to the Capital Asset Pricing Model (CAPM), which accounts for the risk-free rate and the stock's market sensitivity. In this model, the expected return E(R) on day t for company i is calculated as:

$$E(R_{i,t})=R_f+\alpha+\beta\cdot(R_{mkt}-R_f)$$

where $R_f$ is the risk-free rate, $\alpha$ is the intercept, and $\beta$ represents the stock's beta or sensitivity to the market. The abnormal return under this model is therefore:

$$AR_{i,t}=R_{i,t}-E(R_{i,t})=R_{i,t}-(R_f+\alpha+\beta\cdot(R_{mkt}-R_f))$$

3. Fama-French Three-Factor Model: This model extends the CAPM by including two additional factors—Small Minus Big (SMB), which captures the size premium, and

High Minus Low (HML), which captures the value premium. The expected return for this model is expressed as:

$$E(R_{i,t})=R_f+\alpha+\beta_1\cdot(R_{mkt}-R_f)+\beta_2\cdot SMB+\beta_3\cdot HML$$

where $\beta_1$, $\beta_2$, and $\beta_3$ are the sensitivities to the market, SMB, and HML factors, respectively. Abnormal returns for this model are calculated as:

$$AR_{i,t}=R_{i,t}-E(R_{i,t})=R_{i,t}-(R_f+\alpha+\beta_1\cdot(R_{mkt}-R_f)+\beta_2\cdot SMB+\beta_3\cdot HML)$$

In this study, the primary hypotheses are that the Average Abnormal Returns (AAR) and the Cumulative Average Abnormal Returns (CAAR) over the event window are equal to zero. To evaluate these hypotheses, both AAR and CAAR are computed for each day in the event window.

The Average Abnormal Return (AAR) on any given day t across all  companies is calculated as:

$$AAR_{i,t} = \frac{1}{N}\sum_{i=1}^{N} AR_{i,t}$$

The Cumulative Abnormal Return from the start to the end of a specified period within the event window is computed by averaging by summing the average abnormal returns over that period:

$$CAR_{i,t} = \sum_{t_1+1}^{t_2} AR_{i,t}$$

Cumulative Average Abnormal Return (CAAR) on day t is calculated as:

$$CAAR_{i,t} = \frac{1}{N}\sum_{i=1}^{N} CAR_{i,t}$$

In addition to t-tests, Patell Z tests were also performed. Patell Z tests standardize event window abnormal returns by the standard deviation of estimation window abnormal returns. As recognized by MacKinlay (1997), Patell Z tests are a valid alternative to usual t-tests as they account for heteroscedasticity and therefore allow for a more accurate statistical measure.

Finally, a Wilcoxon Rank Sum (or Mann–Whitney U test) test was computed. This is a non-parametric test used to compare two independent groups, it assumes that data is not normally distributed. The null hypothesis tested is the following “abnormal returns in the second period are greater than or equal to those in the first period". This measure allows for a more precise comparison of the two groups and their distributions.

## 5. Results

### 5.1 End of Month Effect

Figure 1 shows daily returns from 1987 to 2005 for day of the month. The X-axis displays the day of the month where -1 corresponds to the last trading day of one month, 1 corresponds to the first day of the subsequent month, and so on while the Y-axis shows average returns. In this case, the last and first 10 days of the month are taken into account for comparison purposes. From Figure 1, it's observable that returns are not distributed evenly across the days with a clear pattern observed around the end of the month. During this period CRSP value weighted and equal weighted indexes show returns consistently higher compared to other days however this effect diminishes over time with returns after day 3 starting to slow down for both indexes.

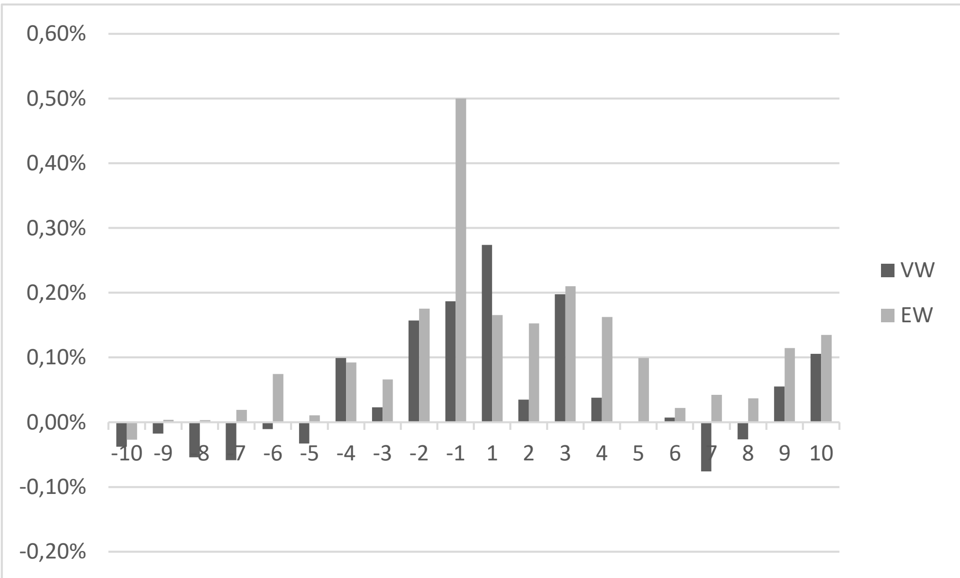



Figure 1- Average market returns per day of the month 1987-2005

Numerical values for days defined in the end of month window as well as average returns for this 4-day period and average daily return for days outside of the end of month effect window are displayed in Table 1. In addition, a t-test was performed to assess the statistical significance of these returns.

| *Period* | *Day -1* | *Day 1* | *Day 2* | *Day 3* | *Day (-1,3)* | *Other Days* |
|---|---|---|---|---|---|---|
| ***CRSP VW*** | | | | | | |
| *01/2006 – 12/2023* | | | | | | |
| *Mean daily return* | -0,04% | 0,13% | 0,13% | 0,02% | 0,05% | 0,04% |
| *T-stat* | -0,54 | 1,31 | 1,49 | 0,27 | 1,165 | 1,87* |
| *01/1987 – 12/2005* | | | | | | |
| *Mean daily return* | 0,19% | 0,27% | 0,03% | 0,20% | 0,16% | 0,02% |
| *T-stat* | 2,88*** | 4,63*** | 0,47 | 2,85*** | 3,87*** | 1,28 |
| *01/1987 – 12/2023* | | | | | | |
| *Mean daily return* | 0,08% | 0,20% | 0,08% | 0,11% | 0,11% | 0,03% |
| *T-stat* | 1,59 | 3,49*** | 1,41 | 2,13** | 3,63*** | 2,26** |
| ***CRSP EW*** | | | | | | |
| *01/2006 – 12/2023* | | | | | | |
| *Mean daily return* | 0,08% | 0,08% | 0,17% | 0,04% | 0,06% | 0,03% |
| *T-stat* | 1,25 | 0,87 | 2,11** | 0,56 | 1,47 | 1,72* |
| *01/1987 – 12/2005* | | | | | | |
| *Mean daily return* | 0,50% | 0,17% | 0,15% | 0,21% | 0,21% | 0,07% |
| *T-stat* | 9,15*** | 3,47*** | 2,69*** | 3,91*** | 5,71*** | 5,71*** |
| *01/1987 – 12/2023* | | | | | | |
| *Mean daily return* | 0,29% | 0,13% | 0,16% | 0,13% | 0,14% | 0,05% |
| *T-stat* | 6,91*** | 2,37** | 3,31*** | 2,87*** | 4,91*** | 4,55*** |

*,**;*** indicates statistical significance at 10%, 5% and 1% level, respectively.

Table 1 – Average daily VW and EW market returns at the end of the month

For the value-weighted index, the average returns per day for days -1, 1, 2, and 3 are 0,19%, 0,27%, 0,03%, and 0,20%, respectively. Additionally, the t-statistics show significance at a 1% level for every day in the end of month effect window excluding day 2 which is not significant at all. Furthermore, the average return of 0,16% of these 4 days is also significant at a 1% level.

For the equal weighted index, the average return per day -1,1,2 and 3 are 0,5%, 0,17%, 0,15% and 0,21%, respectively. In this case, the t-statics show significance at a 1% level every day including day 2. The average return for the 4-day period in the analysis is 0,21%, significant at a 1% level while the average daily return for other days excluding the end of month effect window is 0,07% also significant at a 1% level.

Similar results were achieved by McConell and Xu (2008), proving that the end of month effect persisted from 1987 to 2005. At the same time, these results confirm the results previously achieved by Lakonishok and Smidt (1988).

To understand if this results were being influenced by outliers, an analysis removing the top and bottom 1% observations was conducted. As shown in Figure 1 in the Appendix, the results were practically unaffected by eliminating extreme observations, reinforcing the robustness of the end of month effect.

A similar analysis was conducted for the period from 2006 to 2023. Figure 2 shows the average stock market returns by day of the month for this more recent period. Here the period defined as the end of month effect, spanning from the last day of the month until the third day of the next month, no longer exhibits the higher returns seen in the earlier period. While some days within the window, such as day 1 and day 2, still show positive returns on average, days -1 and 3 show returns more consistent with other days.

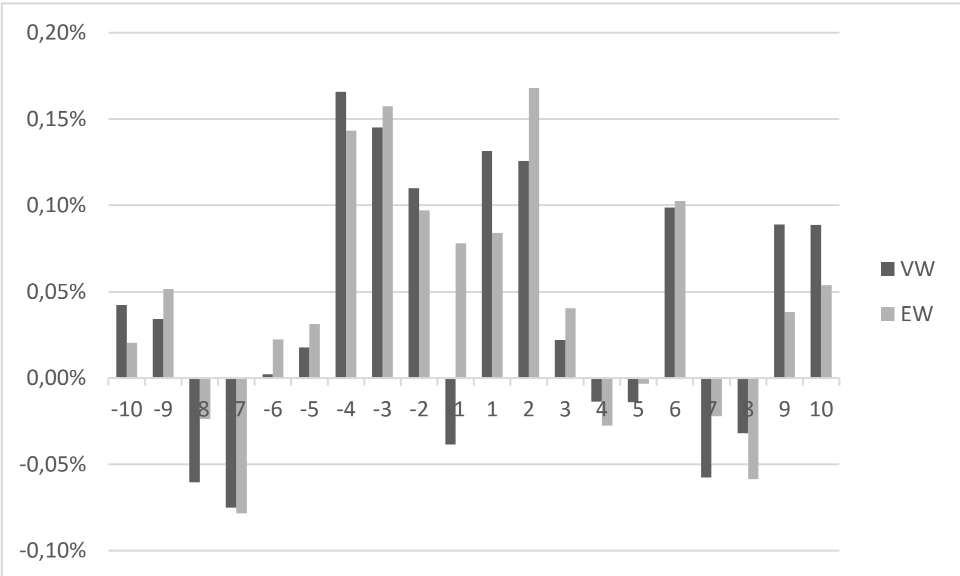



Figure 2 – Average market returns per day of the month 2006-2023

Specifically, the CRSP value weighted index registered returns of -0,04%, 0,13%, 0,13% and 0,02% for days -1,1,2 and 3 respectively. Average returns in these days fell when compared to the first period (1987-2005). Average return of this 4 day period also fell to 0,05% from 0,16%. In terms of significance, none of the days returns are statistically significant at 10%, 5% or 1% levels. This clearly shows the disappearance of the end of month effect in this more recent period, in contrast to the pronounced effect observed from 1987 to 2005.

When analyzing CRSP equal weighted index, similar conclusions can be taken. Returns on the end of month effect window days were 0,08%, 0,08%, 0,17%, and 0,04% for days -1,1,2 and 3 respectively. Here returns fell in every day of the window except for day 2 which increased to 0,17% from 0,15%, it is also the only day that maintains significance at a 5% level. Returns across the 4-day period in analysis also decreased to 0,06%.

Based on this analysis, there is a clear decline in average returns for days included in the end of month effect window for both CRSP value and equal weighted indexes when comparing the 2 periods. During the first period, days included in the end of month effect window were higher both in terms of magnitude and statistical significance. These results are confirmed by McConnell and Xu (2008). However, in the more recent period from 2006 to 2023, average returns decreased significantly for days included in the end of month effect window. For instance, the CRSP value weighted saw a decrease in average return for the end of month effect window from 0,16% to 0,05% while the equal weighted index also experienced a decrease from 0,07% to 0,03%, with only one day in the window maintaining statistical significance.

Overall, the decrease in average returns in the days included in the end of month effect window for both indexes in terms of magnitude and statistical significance suggest the disappearance of the end of month effect in the more recent period.

## 5.2 Market Efficiency

The disappearance of the end-of-month effect could be attributed to several factors. In this study, the increase in market efficiency is examined as a potential reason for this change. As markets become more efficient, calendar anomalies, such as the end-of-month effect, may diminish, as market participants are able to quickly incorporate all relevant information into stock prices, reducing predictable patterns in returns.

### 5.2.1 Autocorrelation analysis

To study market efficiency, the analysis begins with the examination of autocorrelation of order 1,2,5 and 10 for the value weighted (VW) and (EW) indexes across the two distinct periods, 1987-2005 and 2006-2023.

For the VW index during 1987-2005 the autocorrelation coefficients were 0,05 significant at a 1% level for order 1, at lag 2 the coefficient is -0,03 significant at a 5% level, finally the coefficients of order 5 and 10 were -0,005 and -0,008, respectively with both coefficients not being statistically significant.

For the same period, the EW index showed differences results with autocorrelation coefficients being , 0,24 for order 1, statistically significant at 1% level, 0,08 for both orders 2 and 5 also significant a 1% level and 0,02 which is not statistically significant for order 10.

For the period 1987-2005 these results suggest that the VW index exhibits weak autocorrelation coefficients and significance with only the first two orders (1,2) showing statistical significance when compared to the EW index. This latter one shows stronger autocorrelation, particularly the first three orders where coefficients are statistically significant at a 1 % level. Overall this suggests that that from 1987 to 2005 the returns of the VW and EW indexes exhibit some level of persistence, which may indicate predictable returns and patterns in returns that could be a sign of potential inefficiency in the market during this time.

Moving to the 2006-2023 period, the VW index shows the following autocorrelation coefficients: order 1, the coefficient is -0,1 significant at 1% level, for orders 2,5 and 10 the coefficients are 0,007, -0,02 and 0,004 respectively, all not statistically significant.

In the same period the EW index autocorrelation coefficients are 0,007, 0,07, -0,008, 0,02 for orders 1,2,5 and 10 respectively. In this case, significance is only observed in order 2 at a 1% significance level.

These results show a significant change in autocorrelation behavior from the 1987-2005 period to the 2006-2023 period. For the VW index, the autocorrelation of order 1 is now negative but still maintains its significance, while subsequent orders show no significant autocorrelation. Similarly, for the EW index, only the autocorrelation of order 2 is significant.

The results from this analysis reveal that the autocorrelation coefficients have reduced in absolute terms and also in statistical significance across the two data segments. In the earlier period which is 1987-2005, the presence of significant autocorrelation in several orders in both indexes suggest that the market returns were more predictable and therefore less efficient. However, in the later period (2006-2023), the decrease in autocorrelation significance for both indexes, suggests that the market has become more efficient. The decrease in autocorrelation coefficients in the more recent period imply that stock returns are becoming less predictable and more aligned with the efficient market hypothesis.

Numerical values as well as their significance are presented in Table 2.

| *Order* | ***87-05*** | | ***06-23*** | |
|---|---|---|---|---|
| | VW | EW | VW | EW |
| *1* | 0,05*** | 0,24*** | -0,1*** | 0,007 |
| *2* | -0,03** | 0,08*** | 0,007 | 0,07*** |
| *5* | -0,005 | 0,08*** | -0,02 | -0,009 |
| *10* | -0,008 | 0,02 | 0,004 | 0,02 |

*,**;*** indicates statistical significance at 10%, 5% and 1% level, respectively.

Table 2 – Autocorrelation coefficients for VW and EW indexes

## 5.2.2 Market adjusted model

This section discusses the results obtained from the event study conducted to evaluate efficiency across two different periods, specifically, here, a market adjusted model was used. This model defines abnormal returns as follows:

$$AR_{i,t} = R_i – R_{mkt}$$

Where $R_{mkt}$ represents the market return which is this case is CRSP value weighted index.

The null hypothesis for the statistical tests performed is that AAR = 0 and CAAR = 0, CAAR stands for cumulative average abnormal returns over the event window.

**Average Abnormal Returns and Statistical Significance**

This analysis shows that average abnormal returns were consistently higher in the first period (1987–2005) when compared to the second period (2006–2023). Figure 3 shows average abnormal returns throughout days in the event window. The darker line corresponds to average abnormal returns per day of event window in the period from 1987 to 2005 while the lighter line indicates the same metric but for the period from 2006 to 2023. From Figure 3, it is evident that abnormal returns exhibit similar patterns across the two periods, with a spike around day 0 and comparable oscillations on other days. However, during the first period, the magnitude of these movements is significantly larger, indicating greater variability in abnormal returns.

From the 61 days in the event window, statistical significance of at least 5% level was achieved for all but one day in the first period. In contrast, the second period exhibited weaker statistical significance, with 39 days in the event window failing to reach significance at the 5% level.

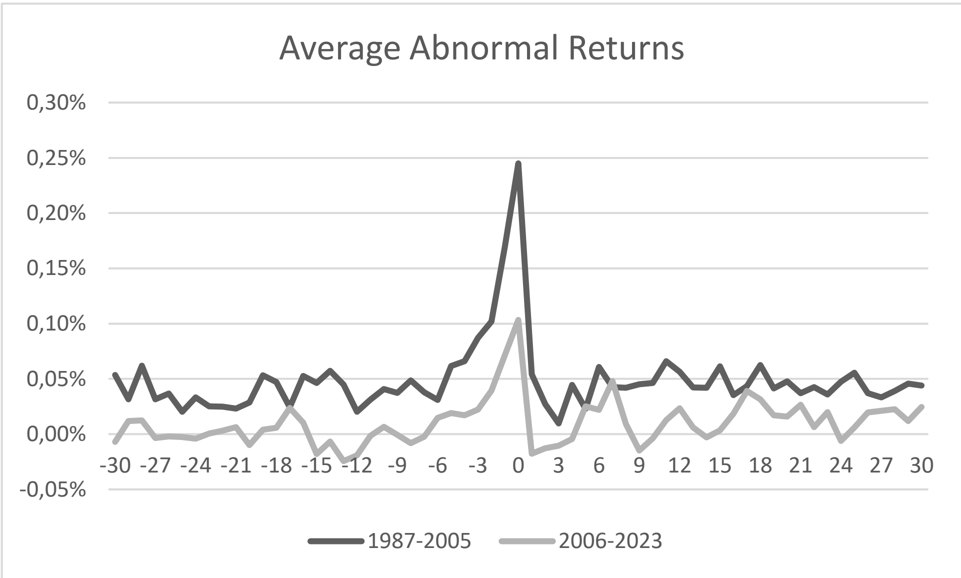



Figure 3 – Average Abnormal Returns per day of event window using the market adjusted model

**Cumulative Average Abnormal Returns (CAAR)**

When looking at the results for cumulative average abnormal returns, these highlight the differences between the two periods. Figure 4 displays cumulative average abnormal returns per day of event window. The darker line represents the cumulative average abnormal returns for each day in the event window during the period from 1987 to 2005, while the lighter line illustrates the same metric for the period from 2006 to 2023. By the end of the event window, cumulative average abnormal returns in the first period reached 2,99%, while in the second period, cumulative average abnormal returns were 0,65%, a significantly lower value (Figure

4). In the first period, CAARs were statistically significant at the 1% level across all 61 days in the event window. However, in the second period, statistical significance for CAARs only began on day -2, continuing until the end of the event window. This pattern reinforces the conclusion that the first period exhibited stronger and more consistent deviations from market efficiency compared to the second period.

Numerical values for AAR's and CAAR's as well as their statistical significance is presented in Table 3 and Table 4.

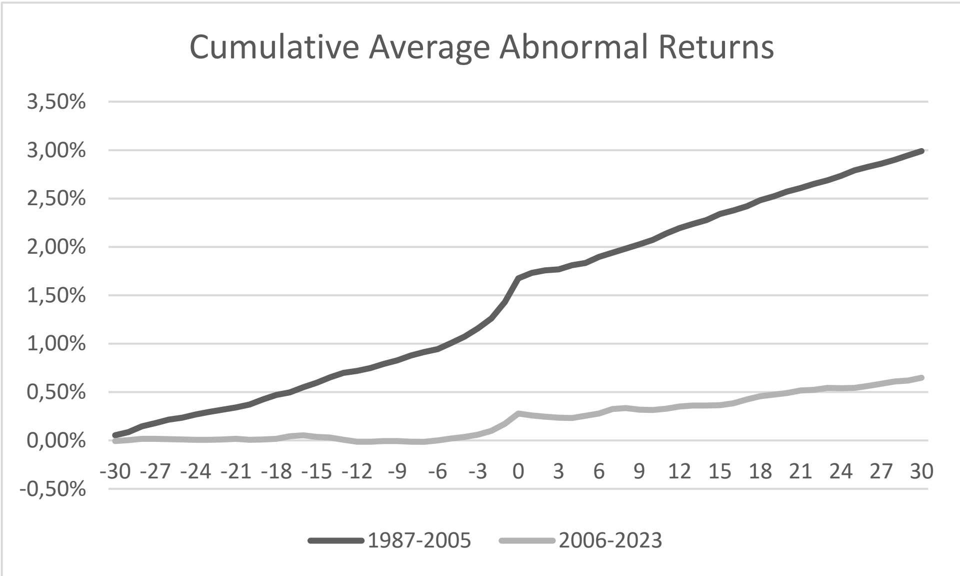



Figure 4 – Cumulative Average Abnormal Returns per day of event window using the market adjusted model

**Wilcoxon Rank-Sum Test**

Finally, to evaluate the differences between the two periods, a Wilcoxon rank-sum test was performed. This is a non-parametric test that compares the distributions of two independent samples and does not assume normality. The null hypothesis for the test is that abnormal returns in the second period are greater than or equal to those in the first period. The Wilcoxon rank-sum test resulted in a p-value of 1, which means that the null hypothesis could not be rejected.

**Implications for Market Efficiency**

The combined evidence from the t-tests and Wilcoxon rank-sum test strongly suggests that market efficiency increased between the two periods. In the first period, the presence of statistically significant average abnormal returns across almost the entire event window, combined with significant CAARs, indicates greater deviations from market efficiency. In contrast, the second period shows a substantial reduction in both the magnitude and statistical significance of AARs and CAARs, consistent with the hypothesis of increased market efficiency.

**Consideration of the Market-Adjusted Model**

While the market-adjusted model was employed in this study to calculate abnormal returns, its results should be interpreted carefully. The market-adjusted model assumes that all securities have a beta of 1, implying that they move in perfect correlation with the market. This simplifying assumption does not account for differences in individual stocks' systematic risk and may introduce biases in the estimation of abnormal returns. Therefore, while the market-adjusted model provides a useful baseline for comparison, its limitations must be acknowledged, especially when interpreting results that rely heavily on this method.

**Conclusions**

Overall, the findings from this event study provide evidence of increased market efficiency over time. The first period exhibited more pronounced and consistently significant AARs and CAARs. The second period, however, demonstrated a reduction in both the magnitude and significance of abnormal returns, suggesting a more efficient market where prices better reflect available information.

***87-05***

| *Day Relative to Event* | *Average Abnormal Return* | *Cumulative Average Abnormal Return* |
|---|---|---|
| ***-30*** | 0,00% | 0,00% |
| ***-29*** | -0,02%*** | -0,02%** |
| ***-28*** | 0,01% | -0,02% |
| ***-27*** | -0,03%*** | -0,05%*** |
| ***-26*** | -0,03%*** | -0,08%*** |
| ***-25*** | -0,04%*** | -0,11%*** |
| ***-24*** | -0,02%* | -0,13%*** |
| ***-23*** | -0,03%*** | -0,16%*** |
| ***-22*** | -0,03%*** | -0,19%*** |
| ***-21*** | -0,03%*** | -0,22%*** |
| ***-20*** | -0,02%*** | -0,24%*** |
| ***-19*** | 0,00% | -0,24%*** |
| ***-18*** | 0,00% | -0,24%*** |

| | | |
|---|---|---|
| ***-17*** | -0,03%*** | -0,27%*** |
| ***-16*** | -0,01% | -0,28%*** |
| ***-15*** | -0,02%** | -0,30%*** |
| ***-14*** | 0,00% | -0,30%*** |
| ***-13*** | -0,01% | -0,31%*** |
| ***-12*** | -0,02%*** | -0,33%*** |
| ***-11*** | -0,02%** | -0,35%*** |
| ***-10*** | 0,00% | -0,35%*** |
| ***-9*** | 0,00% | -0,35%*** |
| ***-8*** | 0,00% | -0,36%*** |
| ***-7*** | -0,02%** | -0,38%*** |
| ***-6*** | -0,02%** | -0,39%*** |
| ***-5*** | 0,01% | -0,39%*** |
| ***-4*** | 0,02%* | -0,37%*** |
| ***-3*** | 0,03%*** | -0,35%*** |
| ***-2*** | 0,05%*** | -0,30%*** |
| ***-1*** | 0,11%*** | -0,19%*** |
| ***0*** | 0,19%*** | 0,00% |
| ***1*** | 0,00% | 0,01% |
| ***2*** | -0,03%*** | -0,02% |
| ***3*** | -0,04%*** | -0,06%* |
| ***4*** | -0,01% | -0,07%* |
| ***5*** | -0,02%*** | -0,09%** |
| ***6*** | 0,01% | -0,09%** |
| ***7*** | -0,01% | -0,09%** |
| ***8*** | 0,00% | -0,09%** |
| ***9*** | -0,01% | -0,10%** |
| ***10*** | 0,00%* | -0,10%** |
| ***11*** | 0,02% | -0,08%* |
| ***12*** | 0,01% | -0,07%* |
| ***13*** | -0,01% | -0,08%* |
| ***14*** | -0,01% | -0,09%* |
| ***15*** | 0,01% | -0,07% |
| ***16*** | -0,02%** | -0,09%** |
| ***17*** | -0,01% | -0,11%** |
| ***18*** | 0,00% | -0,11%** |
| ***19*** | -0,02%** | -0,12%** |
| ***20*** | -0,02%** | -0,14%*** |
| ***21*** | -0,02%** | -0,16%*** |
| ***22*** | -0,01% | -0,17%*** |

| | | |
|---|---|---|
| ***23*** | -0,03%*** | -0,20%*** |
| ***24*** | -0,01% | -0,22%*** |
| ***25*** | -0,01% | -0,22%*** |
| ***26*** | -0,02%** | -0,24%*** |
| ***27*** | -0,02%** | -0,26%*** |
| ***28*** | -0,02%** | -0,28%*** |
| ***29*** | -0,02%** | -0,30%*** |
| ***30*** | -0,01% | -0,31%*** |

*,**;*** indicates statistical significance at 10%, 5% and 1% level, respectively.

Table 3 – Average Abnormal Returns using the market adjusted model per day of event window and respective significance, period 1987-2005

***06-23***

| *Day Relative to Event* | *Average Abnormal Return* | *Cumulative Average Abnormal Return* |
|---|---|---|
| *-30* | -0,03%** | -0,03%** |
| *-29* | 0,00% | -0,03%** |
| *-28* | 0,00% | -0,03%* |
| *-27* | -0,02%* | -0,05%*** |
| *-26* | -0,03%*** | -0,07%*** |
| *-25* | -0,02%* | -0,09%*** |
| *-24* | -0,02%** | -0,11%*** |
| *-23* | -0,01% | -0,12%*** |
| *-22* | -0,01% | -0,13%*** |
| *-21* | -0,01% | -0,14%*** |
| *-20* | -0,02%*** | -0,17%*** |
| *-19* | -0,01% | -0,18%*** |
| *-18* | -0,01% | -0,19%*** |
| *-17* | 0,01% | -0,19%*** |
| *-16* | -0,01% | -0,19%*** |
| *-15* | -0,04%*** | -0,23%*** |
| *-14* | -0,03%*** | -0,26%*** |
| *-13* | -0,04%*** | -0,29%*** |
| *-12* | -0,03%*** | -0,33%*** |
| *-11* | -0,02%** | -0,35%*** |
| *-10* | -0,02%* | -0,36%*** |
| *-9* | -0,02%*** | -0,39%*** |
| *-8* | -0,03%*** | -0,41%*** |
| *-7* | -0,02%** | -0,43%*** |
| *-6* | -0,01% | -0,44%*** |
| *-5* | 0,00% | -0,43%*** |

| | | |
|---|---|---|
| *-4* | 0,00% | -0,43%*** |
| *-3* | 0,00% | -0,43%*** |
| *-2* | 0,02%*** | -0,40%*** |
| *-1* | 0,06%*** | -0,34%*** |
| *0* | 0,08%*** | -0,26%*** |
| *1* | -0,03% | -0,29%*** |
| *2* | -0,03%*** | -0,32%*** |
| *3* | -0,03%*** | -0,34%*** |
| *4* | -0,01% | -0,36%*** |
| *5* | 0,01% | -0,35%*** |
| *6* | 0,01% | -0,33%*** |
| *7* | 0,03%*** | -0,30%*** |
| *8* | 0,00% | -0,31%*** |
| *9* | -0,03%*** | -0,33%*** |
| *10* | -0,01% | -0,34%*** |
| *11* | 0,00% | -0,34%*** |
| *12* | 0,01% | -0,33%*** |
| *13* | 0,00% | -0,33%*** |
| *14* | -0,02%** | -0,34%*** |
| *15* | -0,01% | -0,35%*** |
| *16* | 0,01% | -0,34%*** |
| *17* | 0,03%** | -0,31%*** |
| *18* | 0,01% | -0,30%*** |
| *19* | 0,00% | -0,30%*** |
| *20* | 0,00% | -0,30%*** |
| *21* | 0,01% | -0,28%*** |
| *22* | 0,00% | -0,29%*** |
| *23* | 0,01% | -0,28%*** |
| *24* | -0,02%** | -0,30%*** |
| *25* | -0,01% | -0,30%*** |
| *26* | 0,00% | -0,31%*** |
| *27* | 0,01% | -0,30%*** |
| *28* | 0,01% | -0,29%*** |
| *29* | 0,00% | -0,29%*** |
| *30* | 0,01% | -0,28%*** |

*,**;*** indicates statistical significance at 10%, 5% and 1% level, respectively.

Table 4 – Average Abnormal Returns using the market adjusted model per day of event window and respective significance, period 2006-2023

### 5.2.3 Market model

In this section a market model is used to predict expected returns. In this case abnormal returns are defined as follows:

$$AR_{i,t} = R-(Rf+\alpha+\beta*(R_{mkt}-Rf))$$

Where Rf is the risk free rate taken from the Fama-French library, $R_{mkt}$ is the market return also taken from the Fama-French library, and α and β are parameters estimated from the OLS regression.

Statistical significance was assessed using t-tests and the Patell Z test for both average abnormal returns (AAR) and cumulative average abnormal returns (CAAR). The null hypothesis for both tests is that AAR=0 and CAAR=0.

**Average Abnormal Returns and Statistical Significance**

The analysis showed that the average daily abnormal returns were similar across the two periods. During the 1987–2005 period, average daily abnormal returns were -0,01% and during the 2006-2023 period the same value was registered. While both periods had similar average abnormal returns, the magnitude of average abnormal returns tended to be larger around the earnings announcement days in the first period. These results can be visually seen in Figure 5 which displays average abnormal returns per day of event window across the 2 periods. With the darker line corresponding to the first period (1987-2005) and the lighter one to the second period (2006-2023).

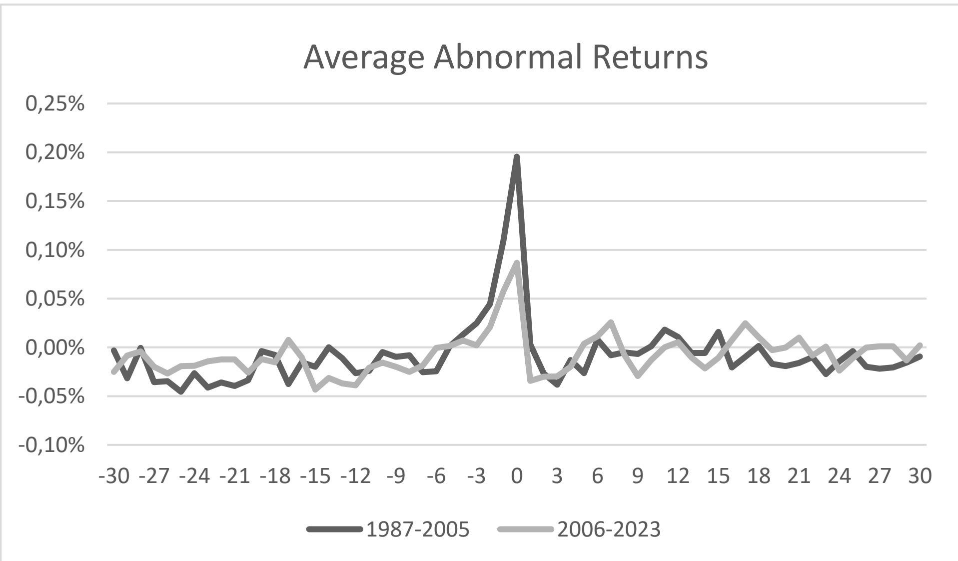



Figure 5 – Average Abnormal Returns per day of event window using the market model

In terms of statistical significance, similarities are observable in the two periods. During the first period, of the 61 days included in the event window, 22 days were significant at the 1% level, 8 days at the 5% level, and 4 days at the 10% level, while the remaining days were not statistically significant. For the second period, significance was observed on 14 days at the 1% level, 11 days at the 5% level, and 1 day at the 10% level, with the majority of days not reaching statistical significance. These findings suggest that while abnormal returns were present in both periods, they were more pronounced and statistically significant during the first period.

**Cumulative Average Abnormal Returns (CAAR)**

Figure 6 displays cumulative average abnormal returns per day of event window for both periods independently. When looking at this figure it's observable that by the end of the event window, CAARs in the first period reached -0,46%, compared to -0,43% in the second period. Additionally, CAARs were statistically significant at the 1% level for the majority of days within the event window for both periods. This suggests that cumulative deviations from expected returns were persistent across both periods, with only slight differences in magnitude.

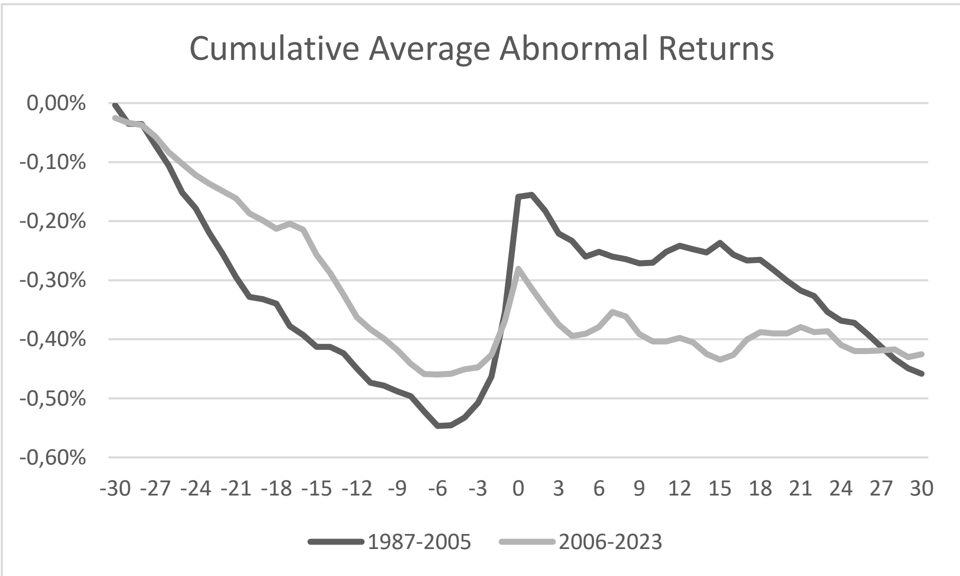



Figure 6 - Cumulative Average Abnormal Returns per day of event window using the market model

**Patell Z Test Results**

In addition to t-tests, Patell tests were conducted to provide an alternative assessment of statistical significance. The Patell's Z test firstly introduced by Patell standardizes the abnormal returns during the event window by the standard deviation of the abnormal returns from the estimation period. This test assumes that abnormal returns are cross-sectionally independent and that there is no event-induced change in the variance of abnormal returns during the event period (Patell 1976). The Patell Z test produced results consistent with the t-tests. During the first period, significance at the 1% level was observed for 25 days, at the 5% level for 8 days, and at the 10% level for 4 days. In this first period significance was concentrated in the days before the event. In the second period, 26 days were significant at the 1% level, 6 days at the 5% level, and 3 days at the 10% level. At the end of the event window, the Patell Z test indicated significant CAARs at 1% level for both periods, suggesting that cumulative deviations from expected returns persisted throughout the event window. (Patell Z tests significance are shown in Appendix)

**Wilcoxon Rank-Sum Test Results**

A Wilcoxon rank-sum test was performed to compare the distributions of abnormal returns between the two periods. This non-parametric test does not assume normality and tests the null hypothesis that abnormal returns in the second period are greater than or equal to those in the first period. The test resulted in  a p-value of 1, indicating that the null hypothesis could not be rejected. The result from the Wilcoxon Rank-Sum Test supports the conclusion that abnormal returns were similar across both periods, with no evidence of greater abnormal returns in the second period.

**Conclusions**

The findings from this event study suggest that abnormal returns were present in both periods, however the results were very similar both in terms magnitude and statistical significance. While the first period (1987–2005) exhibited slightly more days with statistically significant abnormal returns and slightly greater movements around earnings announcements, these differences are not substantial enough to take definitive conclusions about changes in market efficiency between the two periods.

Cumulative average abnormal returns (CAARs) also showed similar behavior across the two periods, with both exhibiting statistically significant CAARs for most of the event window. The Patell Z test results reinforce this similarity, showing persistent significance for CAARs in both periods.

Finally, the Wilcoxon rank-sum test, which tests whether abnormal returns in the second period are greater than or equal to those in the first period, produced a p-value of 1. This suggests that there is no significant difference between the two periods.

Given these results, it is not possible to conclusively determine whether market efficiency improved over time. The similarities in abnormal returns, statistical significance, and cumulative measures across the two periods suggest that the level of market efficiency may have remained relatively stable. While some differences exist, they are insufficient to support an argument for changes in market efficiency.

***87-05***

| *Day Relative to Event* | *Average Abnormal Return* | *Cumulative Average Abnormal Return* |
|---|---|---|
| ***-30*** | 0,00% | 0,00% |
| ***-29*** | -0,03%*** | -0,04%*** |
| ***-28*** | 0,00% | -0,04%** |
| ***-27*** | -0,04%*** | -0,07%*** |
| ***-26*** | -0,03%*** | -0,11%*** |
| ***-25*** | -0,05%*** | -0,15%*** |
| ***-24*** | -0,03%*** | -0,18%*** |
| ***-23*** | -0,04%*** | -0,22%*** |
| ***-22*** | -0,04%*** | -0,26%*** |
| ***-21*** | -0,04%*** | -0,29%*** |
| ***-20*** | -0,03%*** | -0,33%*** |
| ***-19*** | 0,00% | -0,33%*** |
| ***-18*** | -0,01% | -0,34%*** |
| ***-17*** | -0,04%*** | -0,38%*** |
| ***-16*** | -0,02%* | -0,39%*** |
| ***-15*** | -0,02%** | -0,41%*** |
| ***-14*** | 0,00% | -0,41%*** |
| ***-13*** | -0,01% | -0,42%*** |
| ***-12*** | -0,03%*** | -0,45%*** |
| ***-11*** | -0,02%*** | -0,47%*** |
| ***-10*** | 0,00% | -0,48%*** |
| ***-9*** | -0,01% | -0,49%*** |
| ***-8*** | -0,01% | -0,50%*** |
| ***-7*** | -0,03%*** | -0,52%*** |
| ***-6*** | -0,02%*** | -0,55%*** |
| ***-5*** | 0,00% | -0,55%*** |
| ***-4*** | 0,01% | -0,53%*** |
| ***-3*** | 0,02%*** | -0,51%*** |

| | | |
|---|---|---|
| ***-2*** | 0,04%*** | -0,46%*** |
| ***-1*** | 0,11%*** | -0,35%*** |
| ***0*** | 0,20%*** | -0,16%*** |
| ***1*** | 0,00% | -0,16%*** |
| ***2*** | -0,03%*** | -0,18%*** |
| ***3*** | -0,04%*** | -0,22%*** |
| ***4*** | -0,01% | -0,23%*** |
| ***5*** | -0,03%*** | -0,26%*** |
| ***6*** | 0,01% | -0,25%*** |
| ***7*** | -0,01% | -0,26%*** |
| ***8*** | -0,01% | -0,26%*** |
| ***9*** | -0,01% | -0,27%*** |
| ***10*** | 0,00% | -0,27%*** |
| ***11*** | 0,02%** | -0,25%*** |
| ***12*** | 0,01% | -0,24%*** |
| ***13*** | -0,01% | -0,25%*** |
| ***14*** | -0,01% | -0,25%*** |
| ***15*** | 0,02%* | -0,24%*** |
| ***16*** | -0,02%** | -0,26%*** |
| ***17*** | -0,01% | -0,27%*** |
| ***18*** | 0,00% | -0,27%*** |
| ***19*** | -0,02%** | -0,28%*** |
| ***20*** | -0,02%** | -0,30%*** |
| ***21*** | -0,02%* | -0,32%*** |
| ***22*** | -0,01% | -0,33%*** |
| ***23*** | -0,03%*** | -0,35%*** |
| ***24*** | -0,01% | -0,37%*** |
| ***25*** | 0,00% | -0,37%*** |
| ***26*** | -0,02%** | -0,39%*** |
| ***27*** | -0,02%** | -0,41%*** |
| ***28*** | -0,02%** | -0,43%*** |
| ***29*** | -0,02%* | -0,45%*** |
| ***30*** | -0,01% | -0,46%*** |

*,**;*** indicates statistical significance at 10%, 5% and 1% level, respectively.

Table 5 – Average Abnormal Returns using the market model per day of event window and respective significance, period 1987-2005

***06-23***

| *Day Relative to Event* | *Average Abnormal Return* | *Cumulative Average Abnormal Return* |
|---|---|---|
| ***-30*** | -0,03%** | -0,03%** |
| ***-29*** | -0,01% | -0,03%** |
| ***-28*** | 0,00% | -0,04%** |
| ***-27*** | -0,02%** | -0,06%*** |
| ***-26*** | -0,03%*** | -0,08%*** |
| ***-25*** | -0,02%** | -0,10%*** |
| ***-24*** | -0,02%** | -0,12%*** |
| ***-23*** | -0,01% | -0,14%*** |
| ***-22*** | -0,01% | -0,15%*** |
| ***-21*** | -0,01% | -0,16%*** |
| ***-20*** | -0,03%*** | -0,19%*** |
| ***-19*** | -0,01% | -0,20%*** |
| ***-18*** | -0,02% | -0,21%*** |
| ***-17*** | 0,01% | -0,20%*** |
| ***-16*** | -0,01% | -0,21%*** |
| ***-15*** | -0,04%*** | -0,26%*** |
| ***-14*** | -0,03%*** | -0,29%*** |
| ***-13*** | -0,04%*** | -0,32%*** |
| ***-12*** | -0,04%*** | -0,36%*** |
| ***-11*** | -0,02%** | -0,38%*** |
| ***-10*** | -0,02% | -0,40%*** |
| ***-9*** | -0,02%** | -0,42%*** |
| ***-8*** | -0,03%*** | -0,44%*** |
| ***-7*** | -0,02%** | -0,46%*** |
| ***-6*** | 0,00% | -0,46%*** |
| ***-5*** | 0,00% | -0,46%*** |
| ***-4*** | 0,01% | -0,45%*** |
| ***-3*** | 0,00% | -0,45%*** |
| ***-2*** | 0,02%** | -0,43%*** |
| ***-1*** | 0,06%*** | -0,37%*** |
| ***0*** | 0,09%*** | -0,28%*** |
| ***1*** | -0,03%* | -0,31%*** |
| ***2*** | -0,03%*** | -0,35%*** |
| ***3*** | -0,03%*** | -0,37%*** |
| ***4*** | -0,02%** | -0,39%*** |
| ***5*** | 0,00% | -0,39%*** |
| ***6*** | 0,01% | -0,38%*** |
| ***7*** | 0,03%*** | -0,35%*** |

| | | |
|---|---|---|
| ***8*** | -0,01% | -0,36%*** |
| ***9*** | -0,03%*** | -0,39%*** |
| ***10*** | -0,01% | -0,40%*** |
| ***11*** | 0,00% | -0,40%*** |
| ***12*** | 0,01% | -0,40%*** |
| ***13*** | -0,01% | -0,41%*** |
| ***14*** | -0,02%** | -0,42%*** |
| ***15*** | -0,01% | -0,43%*** |
| ***16*** | 0,01% | -0,43%*** |
| ***17*** | 0,02%** | -0,40%*** |
| ***18*** | 0,01% | -0,39%*** |
| ***19*** | 0,00% | -0,39%*** |
| ***20*** | 0,00% | -0,39%*** |
| ***21*** | 0,01% | -0,38%*** |
| ***22*** | -0,01% | -0,39%*** |
| ***23*** | 0,00% | -0,39%*** |
| ***24*** | -0,02%*** | -0,41%*** |
| ***25*** | -0,01% | -0,42%*** |
| ***26*** | 0,00% | -0,42%*** |
| ***27*** | 0,00% | -0,42%*** |
| ***28*** | 0,00% | -0,42%*** |
| ***29*** | -0,01% | -0,43%*** |
| ***30*** | 0,00% | -0,43%*** |

*,**;*** indicates statistical significance at 10%, 5% and 1% level, respectively.

Table 6 – Average Abnormal Returns using the market model per day of event window and respective significance, period 2006-2023

### 5.2.4 Fama and French Model

Finally, a Fama-French model was used to predict abnormal returns. In this model abnormal returns are defined as follows:

$$AR_{i,t} = R-(Rf+\alpha+\beta_1*(R_{mkt}-Rf)+ \beta_2*SMB+ \beta_3*HML)$$

where Rf is the risk-free rate, $R_{mkt}$ is the market return, SMB represents the size premium (Small Minus Big), and HML represents the value premium (High Minus Low), all taken from Fama-French data library.

To evaluate statistical significance, both t-tests and Patell Z-tests are performed for average abnormal returns (AAR) and cumulative abnormal returns (CAAR). The null hypothesis in these tests is that AAR and CAAR are equal to zero.

**Average Abnormal Returns and Statistical Significance**

The average daily abnormal returns was  the same for both periods and stood at -0,01%. Both periods show similar patterns in abnormal returns, with higher absolute values occurring around the announcement of earnings, particularly in the first period.

In terms of statistical significance, the first period demonstrates a slightly higher number of significant days within the 61-day event window. Specifically, 3 days exhibit significance at the 10% level, 10 days at the 5% level, and 22 days at the 1% level. In contrast, the second period shows 6 days with significance at the 10% level, 6 days at the 5% level, and 15 days at the 1% level. The remaining days in both periods fail to achieve statistical significance. This distribution suggests a marginally stronger reaction to earnings announcements in the first period but not to a point where definitive conclusions indicate a significant difference in market efficiency.

Figure 7 shows average abnormal returns for each day in event window. The darker line represents the average abnormal returns observed during the first period (1987–2005) while the lighter one indicates average abnormal returns during the second period (2006-2023).

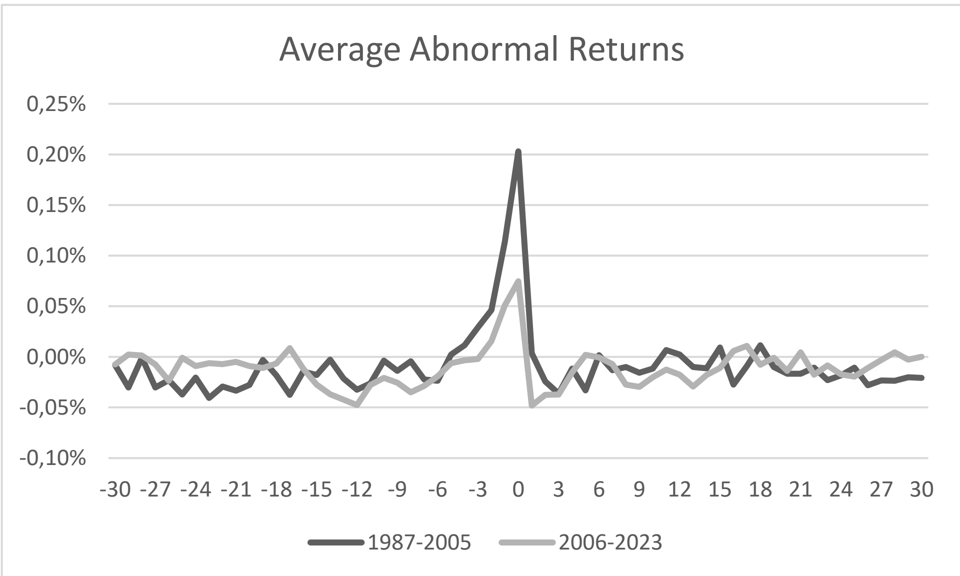



Figure 7 – Average Abnormal Returns per day of event window using the Fama-French model

**Cumulative Average Abnormal Returns (CAAR)**

Cumulative abnormal returns (CAARs) exhibit similar results. At the end of the event window, the CAARs are -0,51% for the first period and -0,62% for the second period. While these cumulative returns are slightly more negative in the second period, the differences remain small. Moreover, most days within both periods show statistically significant CAARs at the 1% level, highlighting consistent reactions to earnings announcements across both periods. Figure 8 highlights the differences between the two periods by showing cumulative average abnormal returns for each day in event window across the two periods.

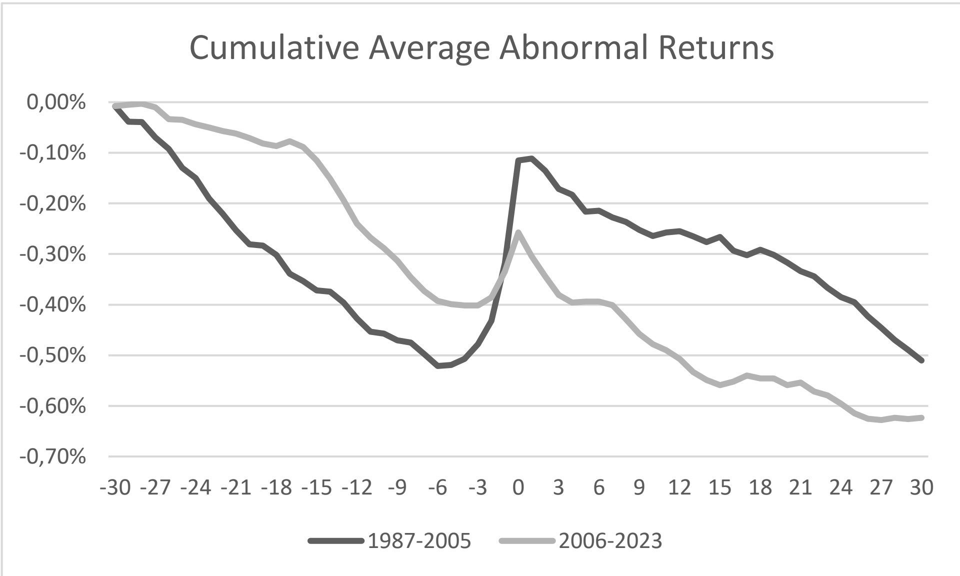



Figure 8 - Cumulative Average Abnormal Returns per day of event window using the Fama-French model

**Patell Z Test Results**

The Patell Z-test results, which standardize returns by incorporating the standard deviation of the estimation window, further reinforce the findings. In the first period, 2 days are significant at the 10% level, 10 at the 5% level, and 26 at the 1% level, with significant days concentrated primarily before the earnings announcements. For the second period, 6 days show significance at the 10% level, 7 at the 5% level, and 21 at the 1% level. The end-of-event window CAARs remain statistically significant for both periods under the Patell Z-test.

**Wilcoxon Rank-Sum Test Results**

Finally, the Wilcoxon rank-sum test was conducted to compare the distributions of ARs between the two periods. With a p-value of 1, the test fails to reject the null hypothesis that the second period has equal or greater abnormal returns than the first period. This result evidences that the differences in abnormal returns across the two periods are minor.

**Comparisons with the Market Model**

The results of the Fama-French model are in line with those obtained using the market model. Both models indicate similar average daily ARs and CARs across the two periods, with slightly more significant days observed in the first period under both approaches. While the Fama-French model accounts for additional factors such as SMB and HML, these factors do not seem to introduce significant deviations in the overall conclusions compared to the simpler market model.

**Conclusions**

The findings from the Fama-French model do not provide strong evidence to conclude whether market efficiency has increased over time. The similarities in abnormal returns, statistical significance, and cumulative measures between the two periods suggest a consistent level of market behavior across both periods. Like the market model, definitive conclusions about changes in market efficiency can’t be taken, particularly when the observed differences are so small.

Overall, while the Fama-French model adds robustness by incorporating additional risk factors, the results remain consistent with those of the market model, highlighting stable market reactions to earnings announcements over the analyzed periods.

***87-05***

| *Day Relative to Event* | *Average Abnormal Return* | *Cumulative Average Abnormal Return* |
|---|---|---|
| ***-30*** | -0,01% | -0,01% |
| ***-29*** | -0,03%*** | -0,04%*** |
| ***-28*** | 0,00% | -0,04%*** |
| ***-27*** | -0,03%*** | -0,07%*** |
| ***-26*** | -0,02%** | -0,09%*** |
| ***-25*** | -0,04%*** | -0,13%*** |
| ***-24*** | -0,02%** | -0,15%*** |
| ***-23*** | -0,04%*** | -0,19%*** |
| ***-22*** | -0,03%*** | -0,22%*** |
| ***-21*** | -0,03%*** | -0,25%*** |
| ***-20*** | -0,03%*** | -0,28%v |
| ***-19*** | 0,00% | -0,28%*** |
| ***-18*** | -0,02%** | -0,30%*** |

| | | |
|---|---|---|
| ***-17*** | -0,04%*** | -0,34%*** |
| ***-16*** | -0,01% | -0,35%*** |
| ***-15*** | -0,02%** | -0,37%*** |
| ***-14*** | 0,00% | -0,37%*** |
| ***-13*** | -0,02%** | -0,40%*** |
| ***-12*** | -0,03% | -0,43%*** |
| ***-11*** | -0,03%** | -0,45%*** |
| ***-10*** | 0,00%*** | -0,46%*** |
| ***-9*** | -0,01%*** | -0,47%*** |
| ***-8*** | 0,00% | -0,48%*** |
| ***-7*** | -0,02%** | -0,50%*** |
| ***-6*** | -0,02%*** | -0,52%*** |
| ***-5*** | 0,00% | -0,52%*** |
| ***-4*** | 0,01% | -0,51%*** |
| ***-3*** | 0,03%*** | -0,48%*** |
| ***-2*** | 0,05%*** | -0,43%*** |
| ***-1*** | 0,11%*** | -0,32%*** |
| ***0*** | 0,20%*** | -0,11%** |
| ***1*** | 0,00% | -0,11%** |
| ***2*** | -0,02%** | -0,14%*** |
| ***3*** | -0,04%*** | -0,17%*** |
| ***4*** | -0,01% | -0,18%*** |
| ***5*** | -0,03%*** | -0,22%*** |
| ***6*** | 0,00% | -0,21%*** |
| ***7*** | -0,01% | -0,23%*** |
| ***8*** | -0,01% | -0,24%*** |
| ***9*** | -0,02%* | -0,25%*** |
| ***10*** | -0,01% | -0,26%*** |
| ***11*** | 0,01% | -0,26%*** |
| ***12*** | 0,00% | -0,25%*** |
| ***13*** | -0,01% | -0,26%*** |
| ***14*** | -0,01% | -0,28%*** |
| ***15*** | 0,01% | -0,27%*** |
| ***16*** | -0,03%*** | -0,29%*** |
| ***17*** | -0,01% | -0,30%*** |
| ***18*** | 0,01% | -0,29%*** |
| ***19*** | -0,01% | -0,30%*** |
| ***20*** | -0,02%* | -0,32%*** |
| ***21*** | -0,02%* | -0,33%*** |
| ***22*** | -0,01% | -0,34%*** |

| | | |
|---|---|---|
| ***23*** | -0,02%*** | -0,37%*** |
| ***24*** | -0,02%** | -0,38%*** |
| ***25*** | -0,01% | -0,40%*** |
| ***26*** | -0,03%*** | -0,42%*** |
| ***27*** | -0,02%*** | -0,45%*** |
| ***28*** | -0,02%*** | -0,47%*** |
| ***29*** | -0,02%** | -0,49%*** |
| ***30*** | -0,02%** | -0,51%*** |

*,**;*** indicates statistical significance at 10%, 5% and 1% level, respectively.

Table 7 – Average Abnormal Returns using the Fama-French model per day of event window and respective significance, period 1987-2005

| | ***06-23*** | |
|---|---|---|
| *Day Relative to Event* | *Average Abnormal Return* | *Cumulative Average Abnormal Return* |
| ***-30*** | -0,01% | -0,01% |
| ***-29*** | 0,00% | -0,01% |
| ***-28*** | 0,00% | 0,00% |
| ***-27*** | -0,01% | -0,01% |
| ***-26*** | -0,02%** | -0,03% |
| ***-25*** | 0,00% | -0,03% |
| ***-24*** | -0,01% | -0,04%* |
| ***-23*** | -0,01% | -0,05%* |
| ***-22*** | -0,01% | -0,06%** |
| ***-21*** | 0,00% | -0,06%** |
| ***-20*** | -0,01% | -0,07%** |
| ***-19*** | -0,01% | -0,08%*** |
| ***-18*** | -0,01% | -0,09%*** |
| ***-17*** | 0,01% | -0,08%** |
| ***-16*** | -0,01% | -0,09%** |
| ***-15*** | -0,03%*** | -0,12%*** |
| ***-14*** | -0,04%*** | -0,15%*** |
| ***-13*** | -0,04%*** | -0,19%*** |
| ***-12*** | -0,05%*** | -0,24%*** |
| ***-11*** | -0,03%*** | -0,27%*** |
| ***-10*** | -0,02%** | -0,29%*** |
| ***-9*** | -0,03%*** | -0,31%*** |
| ***-8*** | -0,04%*** | -0,35%*** |
| ***-7*** | -0,03%*** | -0,37%*** |
| ***-6*** | -0,02%** | -0,39%*** |

| | | |
|---|---|---|
| ***-5*** | -0,01% | -0,40%*** |
| ***-4*** | 0,00% | -0,40%*** |
| ***-3*** | 0,00% | -0,40%*** |
| ***-2*** | 0,02%* | -0,39%*** |
| ***-1*** | 0,05%*** | -0,33%*** |
| ***0*** | 0,07%*** | -0,26%*** |
| ***1*** | -0,05%** | -0,31%*** |
| ***2*** | -0,04%*** | -0,34%*** |
| ***3*** | -0,04%*** | -0,38%*** |
| ***4*** | -0,02%* | -0,40%*** |
| ***5*** | 0,00% | -0,39%*** |
| ***6*** | 0,00% | -0,39%*** |
| ***7*** | -0,01% | -0,40%*** |
| ***8*** | -0,03%*** | -0,43%*** |
| ***9*** | -0,03%*** | -0,46%*** |
| ***10*** | -0,02%** | -0,48%*** |
| ***11*** | -0,01% | -0,49%*** |
| ***12*** | -0,02%* | -0,51%*** |
| ***13*** | -0,03%*** | -0,53%*** |
| ***14*** | -0,02%* | -0,55%*** |
| ***15*** | -0,01% | -0,56%*** |
| ***16*** | 0,01% | -0,55%*** |
| ***17*** | 0,01% | -0,54%*** |
| ***18*** | -0,01% | -0,55%*** |
| ***19*** | 0,00% | -0,55%*** |
| ***20*** | -0,01% | -0,56%*** |
| ***21*** | 0,00% | -0,55%*** |
| ***22*** | -0,02%* | -0,57%*** |
| ***23*** | -0,01% | -0,58%*** |
| ***24*** | -0,02%* | -0,60%*** |
| ***25*** | -0,02%** | -0,61%*** |
| ***26*** | -0,01% | -0,63%*** |
| ***27*** | 0,00% | -0,63%*** |
| ***28*** | 0,00% | -0,62%*** |
| ***29*** | 0,00% | -0,63%*** |
| ***30*** | 0,00% | -0,62%*** |

*,**;*** indicates statistical significance at 10%, 5% and 1% level, respectively.

Table 8 – Average Abnormal Returns using the Fama-French model per day of event window and respective significance, period 2006-2023

## 6. Conclusion

This study investigates the end-of-month effect and its disappearance in the period from 2006 to 2023. The analysis begins by replicating the methodology used by McConnell and Xu (2008) to study whether this calendar anomaly persisted over time. The results confirm that the end of month effect was present in earlier decades (1987-2005) but has vanished in the period from 2006 to 2023. A comparison of daily average returns and statistical significance between the two periods demonstrates a reduction in both measures during the later period for both value-weighted (VW) and equal-weighted (EW) indexes.

To explore potential explanations for the disappearance of the effect, market efficiency was examined using two complementary approaches: autocorrelation analysis and an event study methodology focused on quarterly earnings announcements.

The autocorrelation analysis focuses on orders 1, 2, 5, and 10 for VW and EW indexes. The results show a loss of significance in the later period. For the VW index, only the first order autocorrelation remains significant in the 2006–2023 period, compared to significant autocorrelations of orders 1 and 2 in the earlier period. Similarly, for the EW index, significance reduces to orders 1 and 2 in the second period from orders 1, 2, and 5 in the first. These results suggest a reduction in dependencies in returns over time, which could be indicative of increased market efficiency.

In addition to the autocorrelation analysis, an event study methodology on quarterly earnings announcements was used to evaluate market efficiency. The null hypotheses for these analysis were that average abnormal returns (AAR) and cumulative average abnormal returns (CAAR) are equal zero. Three models were deployed to estimate abnormal returns: the market-adjusted model, the market model, and the Fama-French three-factor model.

The market-adjusted model, which defines abnormal returns as the difference between a firm's return and the CRSP VW index return on the same day, was the first one being implemented. The results were clear in this case with the first period exhibiting average abnormal returns of greater magnitude and significance when compared to the second period, suggesting an improvement in market efficiency over time.

In addition to the market adjusted model, a market model was used. This model incorporates the CAPM framework, providing a more robust assessment of expected returns by considering individual securities' systematic risks. Unlike the market-adjusted model, the market model accounts for varying betas, giving a more precise estimation of expected returns. The results from this model did not show conclusive evidence of increased market efficiency across the two periods. The similarities in average abnormal returns, statistical significance, and cumulative abnormal returns between the two periods suggest that market efficiency remained relatively stable. Minor differences in significance and CAARs between the two periods are insufficient to support definitive conclusions about changes in efficiency.

Finally, a Fama-French model was also used incorporating additional factors, including SMB (size premium) and HML (value premium), to estimate expected returns. While this model adds theoretical robustness by accounting for more risk factors, the results remained consistent with those of the market model. Both periods exhibited similar patterns in average abnormal returns and CAARs, with no substantial evidence indicating significant changes in market efficiency. The differences observed across the two periods are minimal and are not enough to take definitive conclusions about changes in market efficiency.

The results from the market adjusted model indicate an increase in market efficiency while the results from the market and Fama French models indicate that a definitive conclusion about increase in market efficiency can't be taken. These differences in outcomes can be attributed to the limitations of the market adjusted model. This model assumes that all securities have a beta of 1, meaning there is a perfect correlation with the market. This assumption oversimplifies the complexity of individual stock's systematic risks and introduces biases in abnormal return estimates. In contrast, the market and Fama French models include more robust factors to calculate expected returns and account for individual stock characteristics.

Consequently, while the market-adjusted model is a useful baseline for comparison, its limitations should be taken into account when analyzing the results, especially in cases involving market behavior.

Based on the present study findings along with literature insights, the market model remains the most valid approach to evaluate abnormal returns. By having into account variations in beta, the market model addresses the limitations of the market-adjusted model, as highlighted by MacKinlay (1997) and Brown and Warner (1985).

According to MacKinlay (1997), the Fama-French model complexity has the risk of overfitting, particularly in short-term analyses where adding factors may not be beneficial and deteriorate the explicative power of the model. Additionally, Brown and Warner (1985) also advise against excessive model complexity in event studies.

Market's model simplicity and reliance on the well-established CAPM framework allow for straightforward interpretation of results while maintaining a strong theoretical foundation. Brown and Warner (1985) emphasize that the market model is an optimal balance between complexity and interpretability, making it a preferred approach for event studies where the goal is to evaluate market efficiency and behavior over time.

In summary, while multifactor models may offer additional insights in specific contexts, these models may also add unnecessary information without improving abnormal returns estimates making the market model the most reliable and effective choice for analyzing abnormal returns in event studies.

Although the disappearance of the end of month effect can’t be attributed to increased market efficiency, it carries important implications. The disappearance of this effect challenges the assumption that calendar anomalies persist indefinitely, demonstrating how markets evolve over time. The findings suggest that anomalies may not constitute permanent violations of market efficiency but rather reflect inefficiencies that are corrected as markets adapt to new conditions.

The results show the necessity of reevaluating strategies that rely on calendar effects. The increased presence of algorithmic and high-frequency trading, alongside greater market transparency has likely contributed to the correction of inefficiencies. As such, the reliance on historical patterns for abnormal returns is becoming less viable, requiring investors to adapt their strategies to new market dynamics.

Overall, while the autocorrelation analysis and results from the market-adjusted model suggest an increase in market efficiency, the findings from the market model and Fama-French model provide a different perspective. The similarities in AARs, CAARs, and statistical significance across the two periods suggest that market efficiency may have remained relatively stable over time. Therefore, while increased efficiency could be a factor in the disappearance of the end of month effect, it cannot be argued with absolute certainty as the only cause.

# 7. Appendix

| *Period* | *Day -1* | *Day 1* | *Day 2* | *Day 3* | *Day (-1,3)* | *Other Days* |
|---|---|---|---|---|---|---|
| *CRSP VW* | | | | | | |
| *01/2006 – 12/2023* | | | | | | |
| *Mean daily return* | -0,08% | 0,21% | 0,09% | 0,05% | 0,06% | 0,04% |
| *T-stat* | -1,27 | 2,64*** | 1,23 | 0,66 | 1,56 | 2,64*** |
| *01/1987 – 12/2005* | | | | | | |
| *Mean daily return* | 0,21% | 0,26% | 0,08% | 0,17% | 0,21% | 0,002% |
| *T-stat* | 4,05*** | 4,57*** | 1,32 | 2,97*** | 5,86*** | 1,76* |
| *01/1987 – 12/2023* | | | | | | |
| *Mean daily return* | 0,23% | 0,25% | 0,11% | 0,18% | 0,23% | 0,01% |
| *T-stat* | 4,21*** | 4,27*** | 1,73* | 2,80*** | 6,15*** | 0,90 |
| *CRSP EW* | | | | | | |
| *01/2006 – 12/2023* | | | | | | |
| *Mean daily return* | 0,03% | 0,21% | 0,12% | 0,06% | 0,06% | 0,04% |
| *T-stat* | 0,49 | 2,72*** | 1,66* | 0,85 | 1,51 | 2,63*** |
| *01/1987 – 12/2005* | | | | | | |
| *Mean daily return* | 0,49% | 0,20% | 0,19% | 0,17% | 0,25% | 0,08% |
| *T-stat* | 13,43*** | 4,66*** | 4,37*** | 4,01*** | 8,69*** | 7,87*** |
| *01/1987 – 12/2023* | | | | | | |
| *Mean daily return* | 0,53% | 0,17% | 0,16% | 0,20% | 0,24% | 0,08% |
| *T-stat* | 12,85*** | 3,49*** | 3,10*** | 4,20*** | 6,98*** | 7,52*** |

Table 1 Appendix - Average daily VW and EW market returns at the end of the month without outliers

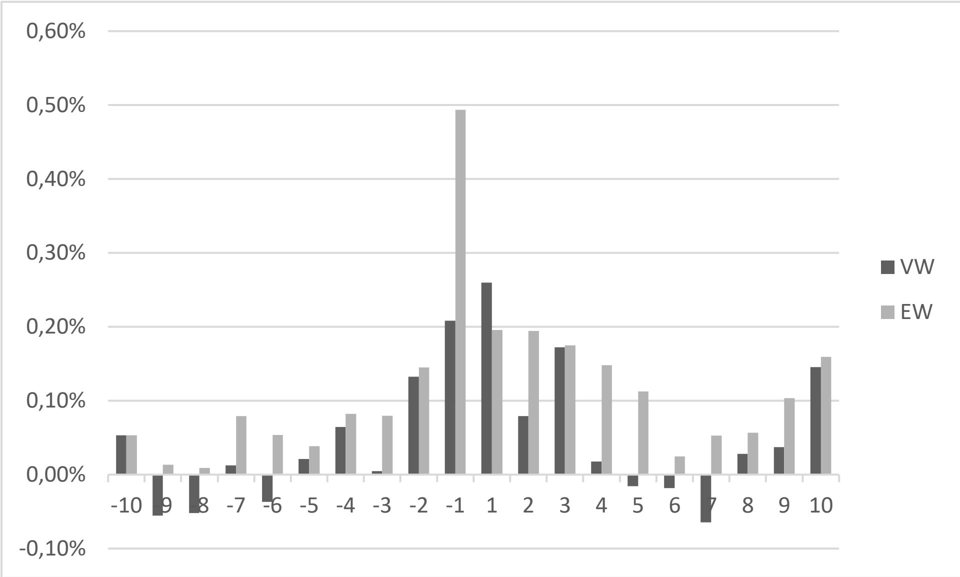



Figure 1 Appendix – Average market returns per day of the month 1987-2005 without outliers

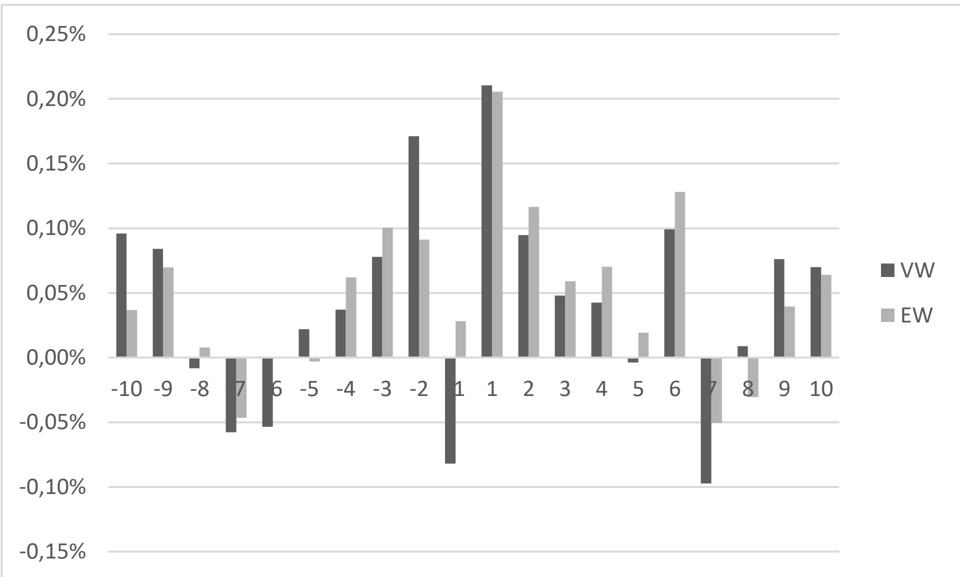



Figure 2 Appendix – Average market returns per day of the month 2006-2023 without outliers

***87-05***

| *Day Relative to Event* | *Average Abnormal Return* |
|---|---|
| ***-30*** | 0,00% |
| ***-29*** | -0,03%*** |
| ***-28*** | 0,00% |
| ***-27*** | -0,04%*** |
| ***-26*** | -0,03%*** |
| ***-25*** | -0,05%*** |
| ***-24*** | -0,03%*** |
| ***-23*** | -0,04%*** |
| ***-22*** | -0,04%*** |
| ***-21*** | -0,04%*** |
| ***-20*** | -0,03%*** |
| ***-19*** | 0,00% |
| ***-18*** | -0,01%* |
| ***-17*** | -0,04%*** |
| ***-16*** | -0,02%*** |
| ***-15*** | -0,02%*** |
| ***-14*** | 0,00% |
| ***-13*** | -0,01%** |
| ***-12*** | -0,03%*** |
| ***-11*** | -0,02%*** |
| ***-10*** | 0,00%*** |
| ***-9*** | -0,01%*** |
| ***-8*** | -0,01%*** |
| ***-7*** | -0,03%*** |
| ***-6*** | -0,02%*** |
| ***-5*** | 0,00%* |
| ***-4*** | 0,01% |
| ***-3*** | 0,02% |
| ***-2*** | 0,04%*** |
| ***-1*** | 0,11%*** |
| ***0*** | 0,20%*** |
| ***1*** | 0,00%*** |
| ***2*** | -0,03% |
| ***3*** | -0,04%*** |
| ***4*** | -0,01% |
| ***5*** | -0,03%** |
| ***6*** | 0,01% |
| ***7*** | -0,01% |

| | |
|---|---|
| ***8*** | -0,01% |
| ***9*** | -0,01% |
| ***10*** | 0,00%** |
| ***11*** | 0,02%** |
| ***12*** | 0,01% |
| ***13*** | -0,01% |
| ***14*** | -0,01% |
| ***15*** | 0,02% |
| ***16*** | -0,02% |
| ***17*** | -0,01% |
| ***18*** | 0,00% |
| ***19*** | -0,02%** |
| ***20*** | -0,02%* |
| ***21*** | -0,02% |
| ***22*** | -0,01% |
| ***23*** | -0,03%*** |
| ***24*** | -0,01% |
| ***25*** | 0,00% |
| ***26*** | -0,02%** |
| ***27*** | -0,02%* |
| ***28*** | -0,02%** |
| ***29*** | -0,02%** |
| ***30*** | -0,01% |

*,**;*** indicates statistical significance for Patell Z test at 10%, 5% and 1% level, respectively.

Table 2 Appendix – Average Abnormal Returns using the market model per day of event window and respective significance for Patell Z test, period 1987-2005

***06-23***

| *Day Relative to Event* | *Average Abnormal Return* |
|---|---|
| ***-30*** | -0,03%*** |
| ***-29*** | -0,01% |
| ***-28*** | 0,00%* |
| ***-27*** | -0,02% |
| ***-26*** | -0,03% |
| ***-25*** | -0,02%*** |
| ***-24*** | -0,02%** |
| ***-23*** | -0,01% |
| ***-22*** | -0,01% |

| | |
|---|---|
| ***-21*** | -0,01% |
| ***-20*** | -0,03%*** |
| ***-19*** | -0,01% |
| ***-18*** | -0,02% |
| ***-17*** | 0,01% |
| ***-16*** | -0,01%* |
| ***-15*** | -0,04%*** |
| ***-14*** | -0,03%*** |
| ***-13*** | -0,04%*** |
| ***-12*** | -0,04%*** |
| ***-11*** | -0,02%*** |
| ***-10*** | -0,02%*** |
| ***-9*** | -0,02%*** |
| ***-8*** | -0,03%*** |
| ***-7*** | -0,02%*** |
| ***-6*** | 0,00% |
| ***-5*** | 0,00% |
| ***-4*** | 0,01% |
| ***-3*** | 0,00% |
| ***-2*** | 0,02%** |
| ***-1*** | 0,06%*** |
| ***0*** | 0,09%*** |
| ***1*** | -0,03%*** |
| ***2*** | -0,03%*** |
| ***3*** | -0,03%*** |
| ***4*** | -0,02%*** |
| ***5*** | 0,00% |
| ***6*** | 0,01% |
| ***7*** | 0,03%*** |
| ***8*** | -0,01%* |
| ***9*** | -0,03%*** |
| ***10*** | -0,01%*** |
| ***11*** | 0,00% |
| ***12*** | 0,01% |
| ***13*** | -0,01% |
| ***14*** | -0,02%*** |
| ***15*** | -0,01%*** |
| ***16*** | 0,01% |
| ***17*** | 0,02%** |
| ***18*** | 0,01% |

| | |
|---|---|
| ***19*** | 0,00%** |
| ***20*** | 0,00% |
| ***21*** | 0,01% |
| ***22*** | -0,01%*** |
| ***23*** | 0,00% |
| ***24*** | -0,02%*** |
| ***25*** | -0,01% |
| ***26*** | 0,00%** |
| ***27*** | 0,00%** |
| ***28*** | 0,00% |
| ***29*** | -0,01%*** |
| ***30*** | 0,00% |

*,**;*** indicates statistical significance for Patell Z test at 10%, 5% and 1% level, respectively.

Table 3 Appendix – Average Abnormal Returns using the market model per day of event window and respective significance for Patell Z test, period 2006-2023

***87-05***

| *Day Relative to Event* | *Average Abnormal Return* |
|---|---|
| ***-30*** | -0,01% |
| ***-29*** | -0,03%*** |
| ***-28*** | 0,00% |
| ***-27*** | -0,03%*** |
| ***-26*** | -0,02%** |
| ***-25*** | -0,04%*** |
| ***-24*** | -0,02%** |
| ***-23*** | -0,04%*** |
| ***-22*** | -0,03%*** |
| ***-21*** | -0,03%*** |
| ***-20*** | -0,03%*** |
| ***-19*** | 0,00% |
| ***-18*** | -0,02%*** |
| ***-17*** | -0,04%*** |
| ***-16*** | -0,01%** |
| ***-15*** | -0,02%*** |
| ***-14*** | 0,00% |
| ***-13*** | -0,02%*** |
| ***-12*** | -0,03%*** |

| | |
|---|---|
| ***-11*** | -0,03%*** |
| ***-10*** | 0,00%*** |
| ***-9*** | -0,01%*** |
| ***-8*** | 0,00% |
| ***-7*** | -0,02%*** |
| ***-6*** | -0,02%*** |
| ***-5*** | 0,00% |
| ***-4*** | 0,01% |
| ***-3*** | 0,03%** |
| ***-2*** | 0,05%*** |
| ***-1*** | 0,11%*** |
| ***0*** | 0,20%*** |
| ***1*** | 0,00%*** |
| ***2*** | -0,02% |
| ***3*** | -0,04%*** |
| ***4*** | -0,01% |
| ***5*** | -0,03% |
| ***6*** | 0,00%** |
| ***7*** | -0,01% |
| ***8*** | -0,01% |
| ***9*** | -0,02% |
| ***10*** | -0,01% |
| ***11*** | 0,01% |
| ***12*** | 0,00% |
| ***13*** | -0,01% |
| ***14*** | -0,01% |
| ***15*** | 0,01% |
| ***16*** | -0,03% |
| ***17*** | -0,01% |
| ***18*** | 0,01% |
| ***19*** | -0,01% |
| ***20*** | -0,02%** |
| ***21*** | -0,02% |
| ***22*** | -0,01% |
| ***23*** | -0,02%** |
| ***24*** | -0,02%** |
| ***25*** | -0,01% |
| ***26*** | -0,03%*** |
| ***27*** | -0,02%* |
| ***28*** | -0,02%*** |

| | |
|---|---|
| ***29*** | -0,02%*** |
| ***30*** | -0,02%** |

*,**;*** indicates statistical significance for Patell Z at 10%, 5% and 1% level, respectively.

Table 4 – Average Abnormal Returns using the Fama-French model per day of event window and respective significance for Patell Z test, period 1987-2005

***06-23***

| *Day Relative to Event* | *Average Abnormal Return* |
|---|---|
| ***-30*** | -0,01%** |
| ***-29*** | 0,00% |
| ***-28*** | 0,00%** |
| ***-27*** | -0,01% |
| ***-26*** | -0,02% |
| ***-25*** | 0,00% |
| ***-24*** | -0,01% |
| ***-23*** | -0,01% |
| ***-22*** | -0,01% |
| ***-21*** | 0,00% |
| ***-20*** | -0,01% |
| ***-19*** | -0,01% |
| ***-18*** | -0,01% |
| ***-17*** | 0,01% |
| ***-16*** | -0,01% |
| ***-15*** | -0,03%*** |
| ***-14*** | -0,04%*** |
| ***-13*** | -0,04%*** |
| ***-12*** | -0,05%*** |
| ***-11*** | -0,03%*** |
| ***-10*** | -0,02%*** |
| ***-9*** | -0,03%*** |
| ***-8*** | -0,04%*** |
| ***-7*** | -0,03%*** |
| ***-6*** | -0,02% |
| ***-5*** | -0,01%** |
| ***-4*** | 0,00% |
| ***-3*** | 0,00% |
| ***-2*** | 0,02%* |
| ***-1*** | 0,05%*** |
| ***0*** | 0,07%*** |

| | |
|---|---|
| ***1*** | -0,05%** |
| ***2*** | -0,04%*** |
| ***3*** | -0,04%*** |
| ***4*** | -0,02%** |
| ***5*** | 0,00% |
| ***6*** | 0,00% |
| ***7*** | -0,01% |
| ***8*** | -0,03%*** |
| ***9*** | -0,03%*** |
| ***10*** | -0,02%*** |
| ***11*** | -0,01%** |
| ***12*** | -0,02%* |
| ***13*** | -0,03%*** |
| ***14*** | -0,02%*** |
| ***15*** | -0,01%*** |
| ***16*** | 0,01% |
| ***17*** | 0,01% |
| ***18*** | -0,01%* |
| ***19*** | 0,00%* |
| ***20*** | -0,01%* |
| ***21*** | 0,00% |
| ***22*** | -0,02%** |
| ***23*** | -0,01%* |
| ***24*** | -0,02%*** |
| ***25*** | -0,02% |
| ***26*** | -0,01%** |
| ***27*** | 0,00%* |
| ***28*** | 0,00% |
| ***29*** | 0,00% |
| ***30*** | 0,00% |

*,**;*** indicates statistical significance for Patell Z test at 10%, 5% and 1% level, respectively.

Table 5 – Average Abnormal Returns using the Fama-French model per day of event window and respective significance for Patell Z test, period 2006-2023

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