MASTERARBEIT

Titel der Masterarbeit

„The Efficient Market Hypothesis
and the
Video Game Industry“

verfasst von

Martin Račko, BSc

angestrebter akademischer Grad

Master of Science (MSc)

Wien, 2013

Studienkennzahl lt. Studienblatt:	A 066 915
Studienrichtung lt. Studienblatt:	Masterstudium Betriebswirtschaft
Betreut von:	a.o.Univ.-Prof. Mag. Dr. Christian Keber

Eidesstattliche Erklärung

Ich erkläre an Eides statt,

dass ich die vorliegende Arbeit selbstständig und ohne fremde Hilfe verfasst, andere als die angegebenen Quellen nicht benützt und die den benutzten Quellen wörtlich oder inhaltlich entnommenen Stellen als solche kenntlich gemacht habe,

dass ich dieses Diplomarbeitsthema bisher weder im In- noch im Ausland in irgendeiner Form als Prüfungsarbeit vorgelegt habe,

dass diese Arbeit mit der vom Begutachter beurteilten Arbeit übereinstimmt.

______________________	______________________
(Ort und Datum)	(Unterschrift)

Acknowledgments

I would like to thank everyone who helped me through the completion of this thesis. First of all, to my supervisor a.o.Univ.-Prof. Mag. Dr. Christian Keber for his valuable feedback and support. Then of course to my family and Linda for their enduring support during my entire studies.

Thank you!

Abstract English:

The first part of this master's thesis covers the theoretical principles of the efficient market hypothesis. Major academic empirical findings as well as a guideline on how to perform market efficiency tests are discussed. These include statistical tests for randomness of returns and event study mechanics.

The second part comprises of an empirical analysis of the video game industry's market efficiency. Tests for randomness of daily returns are performed as well as an event study. Events covered by the event study include video game announcements, release delays, release dates, and public exhibitions.

Abstract deutsch:

Der erste Teil dieser Masterarbeit behandelt die theoretischen Grundlagen der Effizienzmarkthypothese. Die wichtigsten empirischen Erkenntnisse werden erörtert sowie auch ein Leitfaden für die Durchführung von Effizienztests im Sinne der Effizienzmarkthypothese. Der Leitfaden umfasst Zufälligkeitstests für Aktienrenditen und Event-Studies.

Der zweite Teil befasst sich mit der empirischen Markteffizienzanalyse der Videospielindustrie. Zufälligkeitstests für Tagesrenditen werden durchgeführt sowie auch eine Event-Studie. Von der Event-Studie sind folgende Ereignisse umfasst: Bekanntmachungen von neuen Videospielen, Verspätungen von Erscheinungsterminen, Erscheinungstage und Videospielmessen.

Table of contents

List of abbreviations

ADF	Augmented Dickey-Fuller
AMEX	American Stock Exchange
APT	Arbitrage pricing theory
CAPM	Capital asset Pricing model
CRSP	Center for Research in Security Prices
DF-GLS	Dickey-Fuller generalized least square
EDGAR	Electronic Data Gathering, Analysis, and Retrieval system
KPSS	Kwiatowski-Phillips-Schmidt-Shin
NGP	Ng-Perron
NYSE	New York Stock Exchange
OLS	Ordinary least square
P/B	Price-to-book ratio
P/E	Price-to-earnings ratio
p.a.	Per annum
PEGI	Pan European
PP	Phillips-Peron
SEC	Securities and Exchange Commission

Index of figures

Index of tables

1 Introduction

Video games have grown over the past five decades into a multi-billion dollar industry – an industry capable of selling millions of copies of a single video game in just a couple of days. Nowadays, most leading video game publishers and developers are publicly traded on major stock exchanges around the world. This gives private individuals and professional investors the opportunity to invest money into this growing industry. But can investors expect predictive patterns in the stock prices of video game companies? How do the prices of these companies react to specific video game-related events? Is the video game industry market efficient? The aim of this master's thesis is to shed light on these questions. Fortunately, the theory behind these questions has been well studied, just as different research methodologies have already been developed to study such issues in a general perspective. This thesis is therefore divided into two main parts – a theoretical part, covering the basic principles surrounding the efficient market hypothesis, and a practical part, answering the aforementioned key questions about the market efficiency of the video game industry.

The goal of the first part is to give a compact overview about the efficient market hypothesis and to answer questions such as: *"What is the efficient market hypothesis?"*, *"Does the theory hold in practice?"*, and *"How is such efficiency assessed?"*. These main questions are answered in succession in order to best explain the core concepts of this controversial theory. Beginning with a brief history and a classification of the three types of market efficiency forms, the focus then shifts onto discussing existing academic findings relating to market efficiency. Extra attention is paid on presenting findings with opposing results for each individual market efficiency form. As a consequence, both findings that support and reject the hypothesis, are presented. The theoretical part is concluded with a guide on how to perform tests on market efficiency. Focus is put on the mechanics of weak-form market efficiency tests and event studies.

The second part builds upon the theory set forth in the first part. By utilizing the theoretical principles discussed in the first part, an efficiency analysis of the video game industry is made. Covering years from 2005 to 2012, a weak-form efficiency analysis for random returns is performed utilizing both parametric and non-parametric tests. An event study is performed to analyze the semi-strong form efficiency of the video game industry. This conveys a study of market's reactions to certain video game-related events such as video game announcements, delays, release dates, and major video game exhibitions. Daily stock price movements of individual video game companies as well as the industry are analyzed for abnormalities around these events. The goal of these tests is to bring new insight into the behavior of the video game industry's market prices and to expand our current knowledge of market efficiency.

PART I:

The theory behind the efficient market hypothesis

2 What is the Efficient Market Hypothesis?

The term “efficient market” was first defined by Fama (1965) as *“a market, where given the available information, actual prices at every point in time represent very good estimates of intrinsic values”* and that these intrinsic values depend *“on the earnings prospects of a company”*.[1]

Fama may be regarded as the father of the efficient market hypothesis, but it was the French mathematician Louis Bachelier who laid the groundwork for modern financial mathematics when he published his dissertation *Théorie de la Spéculation* in 1900. Apart from developing formulas for put and call options 73 years earlier than Black and Scholes (1973), he was also the first to describe a stochastic process which is essential to the random walk hypothesis. Developed by Cootner (1964) and then made famous by Malkiel (1973), the random walk hypothesis is a theory stating that changes in market prices are independent of each other and boast an equal distribution. As a result market prices move randomly, independent of their past movement and cannot be forecasted.

The efficient market as well as the random walk hypothesis are both highly interlinked and supplement each other. While the random walk hypothesis claims that market prices move randomly, the efficient market hypothesis extends the latter theory by stating that stock prices reflect all available information known to investors. Since the time when new information appears is unknown and because it shows up at random, so is the behavior of market prices – like a random walk. Additionally, according to the efficient market hypothesis, the reaction of market prices to new information is instantaneous and unbiased. This has the effect that investors are not able to make profits out of new information.

[1] Fama (1965), pp. 36 and 90

One of the main arguments for the existence of efficient markets is the large number of investors operating in liquid markets where news is spread rapidly and each market participant has roughly the same access to information. Every trader or investor is trying hard to identify over-valued or under-valued in order to profit from the mispricing of the market. The more investors there are searching for such disequilibria, the faster they are spotted and corrected. In efficient markets there will be only a fraction of investors capable of spotting mispriced securities and those few fortunate ones will only be able to do so by chance. As the efficient market hypothesis argues, extra investments in additional analysis of information would not overweigh the desired payoff.

The efficient market hypothesis, however, has met with a lot of resistance in the world of finance and investments. Since it argues that on average, one cannot achieve higher returns than the market, it basically renders the work of investors useless. Their everyday job of trying to *beat the market* can only be reached by pure luck and never in the long run. Under the efficient market hypothesis, an investor is advised to build a portfolio by replicating the market instead of cherry-picking individual stocks that he thinks will outperform the market. Many professional investors have opposed to such claims including Warren Buffett (1984), one of the most successful investors of all time. He has written a humorous essay contradicting the efficient market hypothesis and going as far as naming their proponents the "Flat Earth Society". The critique of this hypothesis has of course been well received among practitioners. The academic community, however, isn't unanimous on this matter.

The most well-known academic critique on the efficient market hypothesis comes from Grossman and Stiglitz (1980). They argue that efficient markets are impossible and would simply collapse due to investors having no incentives to trade when there are no profit to be made from the gathering of information. Nevertheless, the efficient market hypothesis remains an important element of finance with a large volume of publications supporting its claims.[2] The importance of this theory can be summarized by the words of Eugene Fama (1991): *"Judged on how it has improved our understanding of the behavior of security returns, the past research on market efficiency is among the most successful in empirical economics."*[3]

2.1 Three forms of efficient markets

Ever since the efficient market hypothesis has first been introduced, there were numerous papers and studies published with the aim of refining and extending the theory. One of the most important findings is the differentiation of market efficiencies based on the range of the information set. Such concept was first introduced by Fama (1970) and it distinguishes three forms of market efficiencies: the weak-form efficiency, semi-strong-form efficiency and the strong form efficiency.

2.1.1 Weak-form efficiency

The weak-form market efficiency assumes that current market prices reflect only historical prices and returns. Nowadays, such information is freely and instantly available to anyone with access to internet. Several websites offer historical prices and trading volumes free of charge for users to download and analyze.[4] Such method of analyzing securities for investing purposes is known as technical analysis. Research has found evidence supporting the weak-form efficiency, which will be discussed in the next chapter.

[2] See chapter 1.2
[3] Fama (1991), p. 1576
[4] See finace.yahoo.com or www.google.com/finance

2.1.2 Semi-strong form efficiency

The semi-strong efficiency extends the weak-form by also taking into consideration all publicly available information. Apart from the previously mentioned historical prices, such information include all reported data like annual financial statements, quarterly earnings reports, publicized macroeconomic indicators, news reports as well as academic journals and papers. According to the semi-strong market efficiency theory, investors are unable to make profits from such information because it is already mirrored in market prices. Even if new information becomes public, markets react to it unbiased and instantaneously, giving investors no possibility to benefit from it.

2.1.3 Strong-form efficiency

The strong-form efficiency completes the list of three types of market efficiencies by assuming that market prices reflect all information – public as well as private. The latter type of information is also known as insider information. Under the strong-form efficiency theory investors are not able to profit from information which is at a given time not known to the public. Thus, the management of a company will not benefit from the purchase of their own company's stocks hours before they announce profitable quarterly earnings. The reasoning behind this assumption is the market has already priced the stock according to its balanced and objective forecasts which are more accurate than the biased estimates of the management. Additionally, in every developed country nowadays, security trading with the aim of taking advantage of private information is strictly forbidden. Investors caught doing such practices are facing high fines as well as imprisonment.[5]

[5] See Market Abuse Directive 2003/6/EG for EU insider trading prohibitions and Securities Act of 1933 for U.S. insider trading prohibitions.

The graphic below summarizes the three forms of market efficiencies. Each smaller information set (equivalent to the specific type of market efficiency) is presented as a subset of the larger information set.

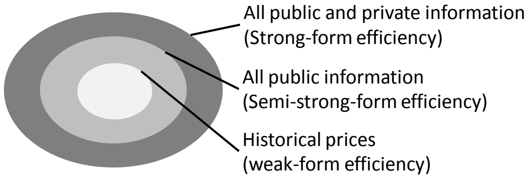


Figure I - Three forms of market efficiency
(Source: own representation)

2.2 Are markets efficient? - Disproving and verifying evidence

Ever since the efficient market hypothesis was first introduced, it has sparked a wave of academics writing numerous articles and research papers dedicated to this topic. Over the past 50 years a vast amount of knowledge has been gained showing both, evidence in favor of the efficient market hypothesis as well as proof which dismisses the theory altogether. The next subsections will discuss this dissent, beginning with an example of criticism from the side of real-world investors, following with a review of academic research dedicated to the three different types of market efficiencies, and finishing with closing remarks.

As mentioned earlier in the first chapter, the efficient market hypothesis has received a lot of criticism from academics like the Nobel Prize winner Joseph Stiglitz[6] as well as from many investors trying hard to create a portfolio capable of delivering better results than the market itself. Such negative reactions towards the hypothesis are understandable and expected as it dismisses the goals of investors for being impossible to achieve continuously in the long run. There are, however investors who have been able to beat the market for a longer period of time. Warren Buffett (1984), a successful

[6] See chapter 2

market beater himself, demonstrates on a sample of nine thriving funds that it is indeed possible to obtain superior returns to those of the market. Table I below showcases the exceptional results of the investment funds managed by Walter J. Schloss from 1956 to 1983, as presented by Buffett (1984).

Year	**S&P Overall Gain, Including Dividends (%)**	**WJS Ltd Partners Overall Gain per year (%)**	**WJS Partnership Overall Gain per year (%)**
1956	7.5	5.1	6.8
1957	-10.5	-4.7	-4.7
1958	42.1	42.1	54.6
1959	12.7	17.5	23.3
1960	-1.6	7.0	9.3
1961	26.4	21.6	28.8
1962	-10.2	8.3	11.1
1963	23.3	15.1	20.1
1964	16.5	17.1	22.8
1965	13.1	26.8	35.7
1966	-10.4	0.5	0.7
1967	26.8	25.8	34.4
1968	10.6	26.6	35.5
1969	-7.5	-9.0	-9.0
1970	2.4	-8.2	8.2
1971	14.9	25.5	28.3
1972	19.8	11.6	15.5
1973	-14.8	-8.0	-8.0
1974	-26.6	-6.2	-6.2
1975	36.9	42.7	52.2
1976	22.4	29.4	39.2
1977	-8.6	25.8	34.4
1978	7.0	26.6	48.8
1979	17.6	29.8	39.7
1980	32.1	23.3	31.1
1981	6.7	18.4	24.5
1982	20.2	24.1	32.1
1983	22.8	38.4	51.2
1984 1st quarter	2.3	0.8	1.1
Standard & Poor's 28¼ year compounded gain			887.2%
WJS Limited Partners 28¼ year compounded gain			6,678.8 %
WJS Partnership 28¼ year compounded gain			23,104.7%
Standard & Poor's 28¼ year annual compounded rate			8.4%
WJS Limited Partners 28¼ year annual compounded rate			16.1%
WJS Partnership 28¼ year annual compounded rate			21.3%
The difference between returns of the partnership and returns of the limited partners is due to allocations to the general partner management.			

Table I - Walter J. Schloss Limited Partners and Partnership Returns

(Source: Buffett (1984), reprinted in Graham and Zweig (2006), pp. 549-550)

The proponents of the efficient market hypothesis argue that *"the existence of a handful of successful investors… is an expected outcome in a completely random distribution of investors."*[7] They showcase their standpoint on a simple mathematical example where the odds of beating the market in a year are 50% by randomly picking stocks. Assuming such odds, the probability of being able to do so for a period of 10 years is close to 0.01%. The chance of having such a consecutively profitable investor in a sample of 1,000 investors is 63%. Increasing this sample by a ten-fold to 10,000 gives an almost certain 99.99% probability of finding at least one such investor. Thus, the more investors there are, the more likely it is to find investors able to beat the market, albeit by simple chance. Warren Buffett acknowledges this statistical fact, but counters it by arguing that long-term successful investors have one common investment strategy – value investing. Pioneered by Benjamin Graham and David Dodd, value investing is a strategy that seeks for discrepancies between the intrinsic value of a business and its price on the market.[8] In practice this means that one should look for obscure, out of fashion, distressed stocks with low price-to-earnings (P/E) and price-to-book (P/B) ratios.

A study by Lakonishok, Shleifer and Vishny (1994) has found supportive evidence for Buffett's claims. They have analyzed prices of stocks listed at the New York Stock Exchange (NYSE) and American Stock Exchange (AMEX) from 1963 to 1990. By comparing stocks with a low P/E and P/B ratio ("value portfolio") to stocks with high ratios ("glamour portfolio"), they were able to show that the value portfolio achieved a return of 22.1% per annum while the glamour portfolio only managed 11.7%. As shown in Table II, the average difference of 10.4 percentage points per year between those two portfolios cannot be justified by a disparity in their riskiness. Measured by their volatility, the standard deviation of returns stood at 24.1% and 21.6% for the value and glamour portfolio respectively.

---

[7] See Clarke, Jandik, Mandelker (2001), p. 133
[8] See Graham and Dodd (2008)

	Avg. annual return (in %)	Avg. annual standard deviation (in %)
Value portfolio	22.1%	24.1%
Glamour portfolio	11.7%	21.6%
	Δ 10.4%	Δ 2.5%

Table II - Comparison of low and high P/E and P/B stocks from 1963 to 1990 (Source: Lakonishok, Shleifer, Vishny (1994))

2.2.1 Evidence of weak-form market efficiency

As mentioned previously, the weak-form market efficiency assumes that market prices move independently and that on average one cannot profit from trends in price movements. Therefore the most widely used method for examining weak-form market efficiencies is done by analyzing the serial correlation of returns. Significant signs of positive or negative serial correlation of returns indicate a market's inefficiency and predictive patterns of price movements.

Fama (1965) conducted one of the first studies on serial correlation of returns by analyzing thirty U.S. stocks of the Dow Jones Industrial Average using daily closing prices from 1957 to 1962. His findings show statistically significant evidence of serial correlation which is, however, insignificant in real world due to high transaction costs, thus supporting the efficient market theory. Since then a vast amount of research has been conducted – dedicated to different types of markets (local or international, developed or undeveloped) and for different time periods.[9] In general, the findings of such research show mostly supportive evidence of the hypothesis in large, developed and liquid markets such as the U.S., U.K. or Germany. However, in less developed markets like Asia or Africa, the results aren't very conclusive. The Chinese stock market (Shanghai Stock Exchange and Shenzhen Stock Exchange) for example has been a relatively common test subject with contradictive results. While Lima and Tabak

[9] For a list of research see Lim and Brooks (2006)

(2004) show supportive evidence of weak-form efficiency in Chinese market, a different study conducted by Mookerjee and Yu (1999) demonstrates significant inefficiencies.

The U.S. market, however, is also subject to anomalies that are incoherent with the weak-form market efficiency. One such documented example of market inefficiency is the seasonality of returns. Cross (1973) has discovered that stock returns on Monday are on average lower than on other days. His findings were later confirmed by French (1980). Another unusual anomaly was found by Ariel (1990). He showcased that returns of U.S. stocks were nine to fourteen-times higher on trading days prior to holidays than on other days during the period from 1963 to 1982.

The "January effect" is another well-known seasonal return anomaly. This anomaly assumes that stock returns are on average higher in January than in any other month, especially in small stocks. Fama (1991) compares the average monthly returns of the S&P 500 index, the smallest quintile of the Center for Research in Security Prices stocks (CRSP small) and the DFA U.S. Small Cap Portfolio which invests in stocks of small U.S. companies.[10] His findings show that in January returns are indeed higher than on average. While the difference in the S&P 500 index is relatively small, both small stock portfolios show January returns that are as much as ten-times higher than average. A summary of the study is shown below in Table III.

Average Monthly Returns for January, February to December, and All Months

	1941-1981			1982-1990 (91 for January)		
Portfolio	Jan	Feb-Dec	All	Jan	Feb-Dec	All
S&P 500	1.34	0.92	0.96	3.20	1.23	1.39
CRSP Small	8.06	0.88	1.48	5.32	0.17	0.60
DFA Small	N/A	N/A	N/A	3.58	0.66	0.90

Table III: Comparison of Returns on the S&P 500, the Smallest Quintile of CRSP Stocks, and the DFA U.S. Small Cap Portfolio: 1941-81 and 1982-91

(Source: Fama (1991))

[10] See Fama (1991), pp. 1587-1588

Another type of anomaly, inconsistent with the weak-form market efficiency, is the over and under-reaction of investors as De Bondt and Thaler (1985) demonstrate. They have analyzed monthly returns of NYSE common stocks from 1926 to 1982 and discovered that stocks with poor past returns outperformed stocks with high past returns. By creating two portfolios, one consisting of 35 high-performing stocks, the second consisting of 35 low-performing stocks, De Bondt and Thaler (1985) were able to show that the latter portfolio surpassed the first by as much as 25% after 36 months. However, Fama and French (1996) have responded to the findings of De Bondt and Thaler (1985) by showcasing that their results were caused by inaccuracies in risk calculations.[11] The same inaccuracy also applies to the previously mentioned findings by Lakonishok, Shleifer and Vishny (1994). As soon as risk is measured by the method proposed by Fama and French (1996), the anomalies are no longer visible.

2.2.2 Evidence of semi-strong form efficiency

The semi-strong form market efficiency suggests that market prices reflect all publicly available information. As a consequence, investors react to the appearance of new information quickly and in an unbiased manner. The theory implies that when unforeseen news emerge (e.g. devastating earthquakes, businesses beating or missing predicted earnings), then markets immediately and objectively correct the prices of affected securities giving investors no chance to profit from such information.

One possibility of assessing the semi-strong form market efficiency is by looking at the performance of mutual funds where professional analysts and investors analyze all available information in order to build the best performing portfolio. Chapter 1.2 already showed an example of an extraordinarily outperforming fund, Malkiel (2003), however, reveals that it’s rather the exception than the rule. By comparing the performance of 355 large cap equity funds to the S&P 500 index, his findings reveal

[11] The risk calculation method used is known as the Fama-French three-factor model, see Fama and French (1996)

that the latter outperforms professionally managed funds on average by two percentage points. He also shows that only three of the 355 large cap equity funds were able to beat the S&P 500 index by more than 3% annually over a period of 31 years. Table IV and Figure II summarize his findings.

	10 years	15 years	20 years
Large Cap Equity Fund	10.98%	11.95%	13.42%
S&P 500 Index	12.94%	13.73%	15.24%

Table IV - Median Total Returns Ending 12/31/2011
(Source: Malkiel (2003))

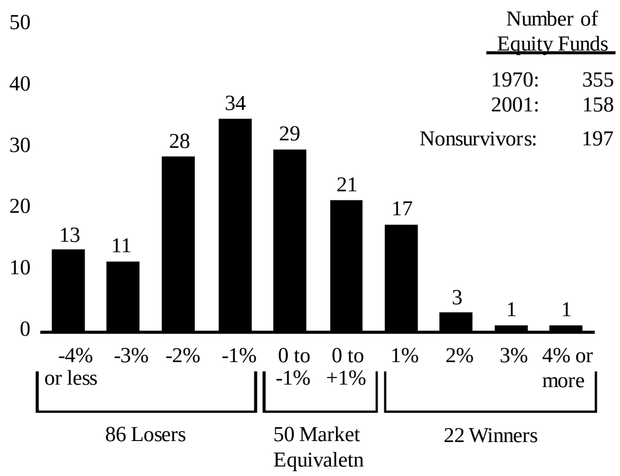


Figure II - The Odds of Success: Annual Returns of Surviving Mutual Funds vs. S&P 500, 1970-2001
(Source: Malkiel (2003))

The most dominant types of research dedicated to the semi-strong efficiency are however event studies. They analyze the effects of new information on security's prices, how much it affects them and how fast. Over the years, numerous event studies have been conducted, covering various topics and financial markets.[12] In this subsection, however, only a few notable findings will be discussed. Dodd (1980) has discovered

[12] For a review of event study findings see Fama (1991), pp. 1599-1602

that public announcements of merger proposals move stock prices of affected companies up. Subsequent approvals of such proposals additionally increase stock prices while denials have negative effects on prices. His findings give supportive evidence in favor of the semi-strong market efficiency.

Event studies have also shown that some finance theories are not consistent with how real markets behave, thus proving them empirically wrong. One example is the event study conducted by Charest (1978). He shows that unforeseen increases in dividend payments cause increases in stock prices and vice versa. This contradicts with the Modigliani-Miller theorem which claims that stock prices are not affected by the dividend policy.[13] All in all, event studies in finance have greatly improved the understanding of market behaviors.[14] Fama (1991) summarizes their importance as: *"…the cleanest evidence we have on efficiency… With few exceptions, the evidence is supportive."*[15]

One such exception is the "post-earnings-announcement drift", another example of market's over- and under-reactions. It was first discovered by Ball and Brown (1968), when they've demonstrated that stock prices have the tendency to move (drift) up for over a year after unexpectedly positive earnings are reported. The opposite holds to stocks with surprisingly negative earnings reporting. More recently, Bernard and Thomas (1990) published a study with similar results. They have shown that investors tend to expect the same quarterly earnings as those reported a year ago. Bernard and Thomas (1990) concluded this inexplicable phenomenon with: *"Why markets as competitive as the NYSE or AMEX would behave as if they are influenced by naïve earnings expectations is difficult to understand."*[16]

[13] See Modigliani and Miller (1958)
[14] See Fama (1991), p. 1600
[15] See Fama (1991), p. 1602
[16] See Bernard and Thomas (1990), p.338

2.2.3 Evidence of strong-form efficiency

Research on strong-form market efficiency is focused on analyzing profit opportunities from private information. In this subsection, three studies with three different findings are presented.[17]

The first one is the frequently cited paper by Jaffe (1974). He shows evidence contradicting the strong-form market efficiency. His findings reveal that insider information is indeed not included in the pricing of securities, giving insiders extra profit opportunities. Additionally, he demonstrates that outsiders aren't excluded from such profit opportunities since they can successfully replicate the behavior of insiders once the information about insider trading is publicly disclosed.

A study by Seyhun (1986) confirms Jaffe's (1974) findings that insiders have advantageous profit possibilities, but disapproves with claims that outsiders are also in such a position. Seyhun's findings reveal that outsiders returns are negative when taking into account bid-ask spreads and commission fees.

The final evidence presented here is a study by Rozeff and Zaman (1988). Their findings also reveal that outsiders are not able to profit from insiders' trading. However, contrary to Sehyun (1986) and Jaffe (1974), they argue that insiders' abnormal returns of 3% to 3.5% are economically insignificant and essentially diminish if transaction costs are higher than 2%.

2.2.4 Closing remarks on the evidence of efficient markets

As showcased, the evidence on efficient markets is rather inconclusive. There are findings that both support and dismiss the theory in each of the three forms of market efficiencies. However, over the past two decades, several new theories have been

[17] For additional findings see Fama (1991), pp. 1603-1607

introduced. Their principal goal is to overcome the flaws of the efficient market hypothesis and give an explanation to previously inexplicable market anomalies.

Lo (2008) proposes a change from the binary, black-and-white measurement of efficiency (efficient or not efficient) to a relative one. He borrows his idea from the measurement of power efficiency in physics, which is a ratio of useful work out and useful work done. According to his proposal, it is more meaningful to quantify the market efficiency relative to a different market or alternatively to an artificial, perfectly efficient, market. Unfortunately, a formula for such a calculation is not presented.

The most vocal theory opposing the efficient market hypothesis is behavioral finance. It is defined as a study which combines behavioral and cognitive psychology with conventional economics and finance.[18] It seeks to find answers to market anomalies by utilizing recent findings in psychology and explaining that investors occasionally may behave irrationally. A large amount of literature about behavioral finance has been written over the past 20 years.[19]

More recently Lo (2005) presented a theory, the adaptive market hypothesis, which tries to bridge the gap between the original efficient market hypothesis and behavioral finance. It is based on the principle of evolution, meaning that market participants learn and adapt to an ever-changing environment. By doing so, they occasionally show signs of behavioral bias like overreactions. Market efficiency is thus determined by the current state of the environment like the number of market participants, their adaptability and the amount of profit opportunities. The adaptive market hypothesis is a relatively new theory and it remains to be seen how it further develops.

There is, however, no sign that the dispute around efficient market hypothesis will soon be solved. Fortunately, this enduring dissent doesn’t necessarily mean a bad thing

[18] See Baker and Nofsinger (2010), p. 3
[19] See Sewell (2010)

for finance, or as Lo (2008) has written: *"...despite the lack of consensus in academia and industry, the ongoing dialogue has given us many new insights into the economic structure of financial markets.*"[20]

[20] See Lo (2008), p. 21

3 How to conduct research on market efficiency

The previous chapter discussed the principles of efficient market hypothesis and outlined the findings of major research studies. This chapter extends the previous by discussing the most common methods used for conducting studies on market efficiency. The first part focuses on methodologies for weak-form market efficiency, the second part on semi-strong efficiency and event studies. The third and last part briefly illustrates specific features of strong-form efficiency research studies.

3.1 Weak-form efficiency research methodology

The principle element in assessing weak-form market efficiencies is to analyze whether prices of securities follow a random walk.[21] This means testing for independence of prices in a predetermined time series. The null and alternative hypotheses are thus:

H_0: Returns are random over a predetermined time period.

H_a: Returns are not random over a predetermined time period.

The length of the time period differs depending on the subject of the study and availability of data. The same applies to the intervals in time series, ranging from monthly to intraday prices. Since there are multiple ways of assessing the independence of prices in a time series, the following chapters will discuss the most frequently used ones.

[21] See Awad and Daraghma (2009)

3.1.1 Descriptive statistics

Descriptive statistics include basic statics data, like the number of observations (e.g. number of observed returns over a predetermined period), arithmetic average of returns, median, and the maximum and minimum return observed. Furthermore, information about the distribution of returns is also usually provided. This includes standard deviation, skewness, kurtosis, and the Jarque-Bera test.[22] The Jarque-Bera test is used for testing whether data is normally distributed. It is defined as

$$(1) \qquad JB = \frac{n}{6}\left(S^2 + \frac{(K-3)^2}{4}\right)$$

where n is the number of observations, S represents skewness and K kurtosis.[23] It follows that

$$(2) \qquad JB \sim \chi_2^2$$

or that the Jarque-Bera test is asymptotically chi-squared distributed with two degrees of freedom.[24] The null-hypothesis (normal distribution) is therefore rejected for $JB > 4{,}6$ at a significance level $\alpha = 0{,}1$ and $JB > 5{,}99$ at a significance level $\alpha = 0{,}05$.

3.1.2 Autocorrelation

Autocorrelation, or alternatively serial correlation, is a term meaning "correlation with itself". In economics and finance, autocorrelation is used to measure the serial correlation of error terms. In practice, this represents an analysis for evidence that returns from one period may be dependent on returns from previous periods. It is an

[22] See Hamid, Suleman, Ali Shah and Akash (2010), p. 128
[23] See Thadewald, Büning (2004), p. 5
[24] See Thadewald, Büning (2004), p. 5

essential tool for measuring weak-form market efficiency because it tests for predictable patterns of returns in time series. It thus evaluates whether prices follow a random walk or not. The general mathematical equation for autocorrelation is defined as

$$(3) \qquad \rho_k = \frac{\sum_{t=n-k}^{n}(r_t - \bar{r})(r_{t-k} - \bar{r})}{\sum_{t=1}^{n}(r_t - \bar{r})^2}$$

where ρ_k is the serial correlation coefficient of returns of lag k, $\bar{r}$ the mean return over the entire observed period and r_t and r_{t-k} the returns over the appropriate periods t and $t-k$.[25] The k number of lags represents the "depth" of the test statistics, or alternatively, the number of previous periods to analyze for correlation. In studies focused on weak-form market efficiency, autocorrelation is sometimes calculated individually for up to 32 legs.[26] Depending on the result of serial correlation, observed data can possess one of three attributes as presented below.

$0 < \rho_k \leq 1$	Positive serial correlation – indicating that an increase in return will be followed by a further increase and a decrease by a further decrease.
$0 > \rho_k \geq -1$	Negative serial correlation – indicating that an increase in return will be followed by a decrease in return and a decrease by an increase.
$\rho_k = 0$	No serial correlation – indicating no pattern. Returns follow a random walk, thus supporting weak-form market efficiency.

The Ljung-Box test is a frequent method used for analyzing the statistical significance of the serial correlation coefficient. Its main advantage against the serial correlation equation presented above, is that the randomness is tested for all k numbers of lags simultaneously instead of individually for each lag. It is defined as

[25] See Dritsaki (2011), p. 35
[26] See Dritsaki (2011), p. 49

$$(4) \qquad Q = n(n+2)\sum_{k=1}^{m}\frac{\rho_k^2}{n-k}$$

where n is the number of observations, m the number of lags and ρ_k the serial correlation coefficient of lag k.[27] Under the Ljung-Box test, randomness of a data series is rejected when

$$(5) \qquad Q > \chi_m^2$$

with m degrees of freedom.

It should be noted that the standard test for serial correlation defined in equation (3) and the Ljung-Box test from equation (4) are both parametric tests. As a result both tests assume normal distribution of data series.

3.1.3 Runs test

In contrast to the two tests discussed in the previous chapter, runs test is a non-parametric test that doesn't assume normal distribution of data. It distinguishes observed data (total number of observation denoted as n) into two categories. In the case of market prices – returns greater than mean (denoted as n_1) and returns smaller than mean (n_2), and evaluates whether these two categories successively appear at random. The test statistics z is approximately normally distributed

$$(6) \qquad z = \frac{r - \mu_r}{\sigma_r} \approx N(0,1)$$

with mean μ_r and variance σ_r

[27] See Ljung and Box (1978), p. 297

$$(7) \qquad \mu_r = \frac{2n_1n_2}{n} + 1$$

$$(8) \qquad \sigma_r = \sqrt{\frac{2n_1n_2(2n_1n_2 - n)}{n^2(n-1)}}$$

and r as the number runs calculated by summing up the number of successive sequences of n_1 and n_2.[28]

Runs test are, however, relatively loose test, meaning that an analysis of returns from an inefficient market could still fail to reject randomness.[29] Therefore, additional test which are discussed below should be conducted.

3.1.4 Unit Root Test

As discussed previously, efficient market hypothesis assumes that stock prices follow a random walk. In statistics, random walk is also identified as a non-stationary unit root process.[30] The characteristics of such a process are that they are unpredictable, with varying variances and means for different periods. Another attribute of non-stationary unit root processes is that shocks (e.g. market crash) have permanent effects with unpredictable future prospects. On the other hand, stationary processes have the exact opposite characteristics. They are marked with a constant mean and variance resulting in shocks having only temporary effects before returning back to previous state. When a time series has such characteristics, then it is also said to be mean reverting.[31] In practice, this would mean that a crash of a "stationary" stock market would cause prices to fully recover to pre-crash levels. Such a property, however, is inconsistent with the efficient market hypothesis because it allows for predictability and abnormally high return possibilities. Therefore unit root tests are utilized for assessing whether data is

---

[28] See Büning, Trenkler (1994), Chapter 4.5
[29] See Li, (2008), p. 20
[30] See Libanio, (2005), p. 146
[31] See Libanio (2005), p. 146

stationary or non-stationary. Discussed below are the most frequently used unit root tests.

3.1.4.1 Augmented Dickey-Fuller unit root test

The augmented Dickey-Fuller (ADF) test is a parametric test based on the regression model

$$(9) \qquad Y_t = \mu + \beta t + \rho Y_{t-1} + \epsilon_t$$

where t is the time series index, Y the observed variable, μ a constant intercept also known as drift, β the coefficient on a time trend, ϵ the noise and ρ is the process root coefficient.[32] Alternatively equation (9) can also be stated as[33]

$$(10) \quad \Delta Y_t = \mu + \beta t + (1-\rho)Y_{t-1} + \sum_{j=1}^{p}((\rho_j - 1)\,\Delta Y_{t-j}) + \epsilon_t$$

when Y_{t-1} is subtracted from both sides of the equation and p number of lags are introduced. A t test is then used for testing the null-hypothesis $H_0\colon \rho = 1$. Rejecting the null-hypothesis is equivalent to rejecting non-stationary characteristic of observed data, which is essential to the efficient market hypothesis.

A critical point when conducting ADF tests is the insertion or exclusion of regressors μ and β as well as the number of lags p. In general, the less regressors and lags are included, the higher the probability of not rejecting the stationary character of observed

[32] See Dickey and Fuller (1979), p. 428
[33] See Ryan and Giles (1998), Chapter 2

data.[34] Schwert (1989) proposes a method for choosing an appropriate number of maximum lags with the equation

$$(11) \qquad p_{max} = int\left[12\left(\frac{T}{100}\right)^{\frac{1}{4}}\right]$$

where T is the number of observations and $int\,[x]$ the integer part of x.[35] Other alternatives for assessing the appropriate number of lags include the Akaike information criterion, Schwarz information criterion and the Bayesian information criterion.[36]

3.1.4.2 Other methods for unit root testing

This subsection will further discuss other frequently used methods for unit root testing. In contrast to the previous chapter on the ADF test, here only a brief description of the tests will be given.

The Phillips-Peron (PP) test is a frequently used test for validating stationary or non-stationary data.[37] Its main advantage over the ADF test is that it does not require a specification of the number of lags. Furthermore, the PP test is a non-parametric test, meaning that no assumption about the distribution of data is necessary.

When performing unit root tests by utilizing both, the ADF and the PP tests, it can occur that one test will reject non-stationarity and the other won't. In such case, the Kwiatowski-Phillips-Schmidt-Shin (KPSS) test can be a useful complementary tool. In

[34] See Libanio (2005), p. 149
[35] See Schwert (1989), p. 151
[36] See Maddala, Kim (1999), Chapter 3.6
[37] See Phillips and Perron (1988)

contrast to the AFD and the PP test, the KPSS test assumes that an observed data series is stationary under the null hypothesis.[38]

Other unit root tests include the Elliott, Rothenberg & Stock (ERS) unit root test, also known as the Dickey-Fuller generalized least square (DF-GLS) test[39] and the Ng Perron (NGP) test[40].

3.1.5 Closing remarks on weak-form efficiency testing

To sum up the methodology of weak-form market efficiency tests, one usually first begins with descriptive statistics in conjunction with a Jarque-Bera test used for analyzing the normal distribution of observed data samples. Then, tests on serial correlation are performed, which include a non-parametric runs test and/or a parametric Ljung-Box test. The appropriateness of the latter test depends on the results from the Jarque-Bera test. Following these tests, analysis of non-stationarity is performed using one, or a series of the unit root tests discussed above. The combination of all these tests should give a good answer to whether the observed market is weak-form efficient or not. Additionally, as proposed by Lo and MacKinley (1988), a variance ratio test can also be performed in order to give a more decisive answer. A closer description of this test is however beyond the scope of this thesis.

3.2 Semi-strong form efficiency research methodology

As mentioned in subsection 1.2.2, there are two general approaches to analyzing the semi-strong form market efficiency. The first one is a relatively simple one and is done by comparing the returns of large indices (e.g. S&P 500 or Wilshire 5000) to

[38] See Kwiatkowski, Phillips, Schmidt and Shin (1992)
[39] See Elliott, Rothenberg and Stock (1996)
[40] See Ng and Perron (2001)

professionally managed mutual funds with comparable risk and asset allocation. If the returns of mutual funds are significantly larger than those of indices, then the market is assumed to be inefficient. The second option for analyzing semi-strong market efficiency is through event studies. Since the methodology behind event studies is relatively broad and complex, the following chapters will discuss the mechanics of event studies more thoroughly.

3.2.1 Event Studies

Event study is the research methodology to choose when analyzing how and whether certain events affect studied objects. In the case of finance, studied objects are usually stock prices and the corresponding events represent earnings announcements[41], stock splits[42], dividend changes[43] and likes. Event study is a well known research tool among academics with a long and rich history of utilization. The first know event study was published by Dolly (1933). He examined the effects of 95 stock splits on nominal prices. His methodology was, however, rather simple and didn't match the sophistication of today's standards. The groundwork for modern event studies was laid by Ball and Brown (1968) and Fama, Fisher, Jensen and Roll (1969). They have created a methodology for event studies that remained practically unchanged throughout the years. An important insight into the statistical implications of event study methodology is given by Brown and Warner (1980, 1985). They show technical issues of event study implementations for monthly closing prices[44] as well as for daily closing prices[45].

Over the past 40 years, event studies have become a very popular research methodology. Apart from being frequently used in finance, they have also been successfully used in law and political studies (e.g. effect of political parties on defense

[41] See Ball, Brown (1968)
[42] See Lamoureux and Poon (1987)
[43] See Charest (1978)
[44] See Brown and Warner (1980)
[45] See Brown and Warner (1985)

spending[46], effect of trade legislation interests[47]). The popularity of event studies is shown by Khotari and Warner (2004). They have quantified the number of published event studies in five leading U.S. journals from 1974 to 2000. Their results show that the amount of event studies had risen from 5 to 11 annually published event studies in the seventies to around 30 in the nineties. The five U.S. journals thus published over 500 event studies in 36 years. This number, however, represents only the lower bound of the grand total as only a fraction of all journals were considered. Table V below shows the results of Khotari's and Warner's study in detail.

Year	Journal of Business	Journal of Finance	Journal of Financial Economics	Journal of Fin. and Quant. Analysis	Review of Financial Studies	Total
1974	2	0	2	1	-	5
1975	0	2	2	1	-	5
1976	0	5	1	1	-	7
1977	0	5	5	1	-	11
1978	1	5	4	1	-	11
1979	0	7	0	2	-	9
1980	3	4	2	2	-	11
1981	1	3	4	2	-	10
1982	1	6	2	1	-	10
1983	2	14	18	4	-	38
1984	0	5	5	1	-	11
1985	2	4	7	2	-	15
1986	2	7	14	4	-	27
1987	0	7	18	1	-	16
1988	1	4	7	5	1	18
1989	0	11	11	1	1	24
1990	5	17	7	6	2	37
1991	5	17	2	4	1	29
1992	4	13	9	4	1	31
1993	5	7	5	5	3	25
1994	1	10	10	5	0	26
1995	1	8	14	11	2	36
1996	1	7	10	5	3	26
1997	3	8	12	3	0	26
1998	1	14	11	3	0	29
1999	1	7	12	1	4	25
2000	2	15	13	5	2	37
Total	44	212	207	82	20	565

Table V - Event studies by year and journal excluding survey and methodological papers

Source: Khotari, Warner (2004), p. 47

[46] See Roberts (1990)
[47] See Schwert (1981)

3.2.1.1 Structure of an event study

The outline of every event study can be summarized in a series of seven consecutive steps as shown below.[48]

Step 1 – Event definition:

The first thing to do when conducting an event study is to define and specify the studied events. This includes a clear description of the type of events (e.g. earnings announcements, stock splits, new product introduction, etc). It is essential to define an event as precisely as possible in order to minimize biases.[49] It is also important that events aren't anticipated and that they are based on the first publicly available information. In the case of events being anticipated, it is advised to also analyze days prior to the actual event, thus extending the event window by additional days.[50]

One important aspect when conducting event studies is the knowledge of confounding events. These are events that happen within hours in succession and have opposite affects on prices.[51] One such example is shown below in figure IV. Let's assume that event 1 represents an unexpected new product announcement of company A. Event 1 thus triggers sharp stock price increase of company A. Let's further assume that event 2 also represents an unexpected new product announcement, but from company B which is a company A's main competitor. However, company B's new product is by far superior to company A's new product causing the stock price of company A to tumble.

---

[48] See Campbell, Lo and MacKinlay (1996), chapter 4.1
[49] See Görke (2009), pp. 2-3
[50] See Görke (2009), p. 3
[51] See Görke (2009), pp. 4-5

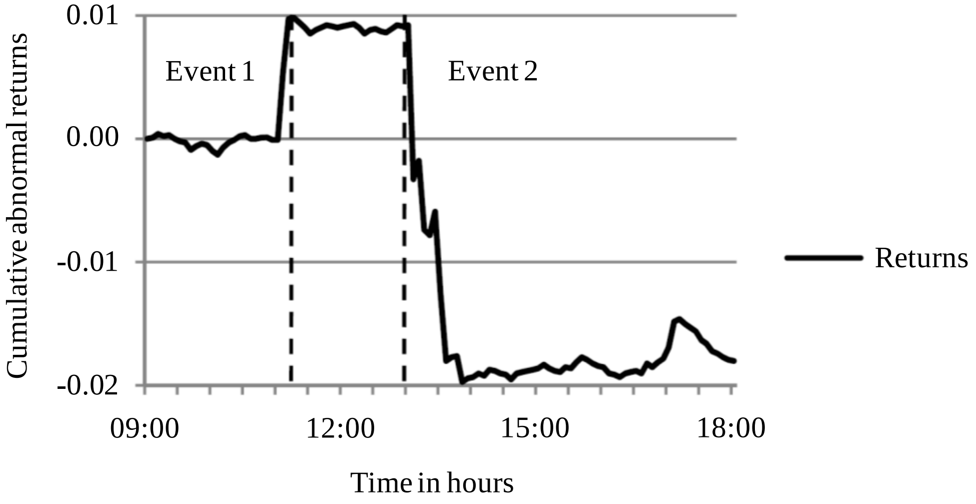


Figure III - Returns development during confounding events

Source: Görke (2009), p. 5

Görke (2009) proposes two alternatives to counter the problems of confounding events.[52] The first option is to use smaller time intervals like hours instead of days. The second option is to eliminate confounding events altogether from the study. The latter solution, however, is only viable when a small number of confounding events are present in a study.

Step 2 – Selection criteria:

The next step involves putting restrictions on the elements that are subject of study. This is a necessary procedure due to the enormous amount of information available. It has to be decided from which sources will the information about studied events be gathered (e.g. Wall Street Journal, Yahoo Finance). Additionally, a reference for security prices is also needed. Depending on the scope of the event study, these can represent indices, listed stocks on certain stock exchanges or stocks of a certain industry.

[52] See Görke (2009), pp. 4-5

Step 3 – Selection of normal and abnormal returns calculation method:

The key concept of event studies is to find out whether returns around certain events are statistically different from those returns that are generated outside of the event window. In practice, this means comparing abnormal returns generated during events to normal returns "*that would be expected if the event did not take place*"[53]. The equation for normal and abnormal returns is given as

$$(12) \qquad AR_{it} = R_{it} - NR_{it}$$

where AR_{it} and R_{it} are the abnormal and actual returns for security i at time period t. Normal returns for security i at time period τ are denoted as NR_{it}.[54] Several methods for calculation of normal and thus abnormal returns have been developed. The next subsection covers the most frequently used ones and discusses the advantages and shortcomings of each method.

Step 4 – Estimation of model parameters

After a method for the calculation of normal and abnormal returns has been selected, it is necessary to define the time parameters for the entire time line of the event study. As shown in figure IV, the time line of an even study can be divided into three separate time windows – estimation window, event window and post-event window.[55]

[53] See Campbell, Lo and MacKinlay (1996), Chapter 4.1
[54] See Campbell, Lo and MacKinlay (1996), Chapter 4.1 and De Jong (2007), Chapter 2.2
[55] See Campbell, Lo, MacKinlay (1996), Chapter 4.4

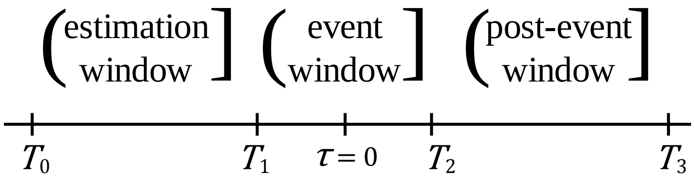


Figure IV - Time line of an event study

Source: Cambell, Lo and MacKinlay (1998), Chapter 4.4

The estimation window reaching from period T_0 to T_1 is the time period usually used for calculating normal returns. The event window is situated between the time point T_1 and T_2 and includes the actual event at time $t = 0$. As mentioned previously in step 1, an event window does not have to include only the event itself. It often spreads a couple of days before the event happens and continues a couple of days after. The event window is the time frame where abnormal returns are expected to appear. The final part of the time line is the post-event window, which spreads from T_2 to T_3. The post-event window is relevant for the analysis of price developments after events. There isn't any given or standardized length of these three time windows. The lengths of each time window will vary depending on the scope and aim of every individual event study. Subsection 2.2.1.3 discusses the parameter settings for time windows.

Step 5 – Calculation and testing

The next step includes the calculation of normal and abnormal returns and the defining of a null hypothesis for statistical testing. One important element of the calculation of returns is the aggregation of each individual firm. Subsection 2.2.1.4 discusses the methodology of abnormal return aggregation.

Step 6 – Presentation of results

The presentation of empirical results and findings is part of the second to last step. Several types of graphical and analytical methods of showing results have been developed over time. Subsection 2.2.1.5 shows examples of the most frequently used ones. In this step, it is also advised to disclose potential biases of the study.[56]

Step 7 – Analysis of results and conclusions

The final step is dedicated to interpreting and explaining of results. The goal is to give new insight into the functioning and behavior of markets. Additionally, findings of the event study can be compared and expanded by previous studies.

3.2.1.2 Methods for calculating normal and abnormal returns

Methods for calculating normal and abnormal returns can be summarized in two general categories – statistical models and economic models. While statistical models are constructed around statistical assumptions, economic models are based primarily on investors' behavior.[57] The following four chapters will discuss the tree most frequently used methods for normal and abnormal returns calculations. The last chapter provides an overview of additional calculation methods.

3.2.1.2.1 Mean-adjusted returns model

The mean-adjusted returns model is a statistical model and represents one of the simplest of all return models. It is based around the idea of a company`s average returns in the estimation window. The equation for the mean-adjusted return model is denoted as

[56] See Campbell, Lo and MacKinlay (1996), Chapter 4.1
[57] See Campbell, Lo and MacKinlay (1996), Chapter 4.3

$$NR_{it} = \frac{1}{T}\sum_{s=T_0}^{T_1} R_{it} \qquad (13)$$

where NR_{it} and R_{it} are the normal returns and actual returns of security i and time period t. T is the number of time periods calculated as

$$T = T_1 - T_0 + 1 \qquad (14)$$

where T_0 is the beginning of the estimation window and T_1 the end of the estimation window.[58] The normal returns in this model are thus constant over time.

The mean-adjusted return model may be one of the most straight-forward methods of calculating normal returns, but surprisingly Brown and Warner (1985) suggest that they show equally good result as the more complex ones.[59]

3.2.1.2.2 Market-adjusted returns model

Just like the mean-adjusted returns model, the market-adjusted model is also a statistical model. It assumes that normal returns are equal to the returns of a benchmark market. It is defined as

$$NR_{it} = R_{mt} \qquad (15)$$

where NR_{it} is the normal return of security i and time period t and R_{mt} the market return at time period t.[60] A benchmark for market returns is not specified. Popular

[58] See de Jong (2007), Chapter 2.2.1
[59] See Brown and Warner (1985), Chapter 4.2.1
[60] See Brown and Warner (1985), Chapter 3.2

choices, however, are the CRSP equally weighted and value weighted indices[61] as well as the S&P 500 index[62].

The advantage of the market-adjusted return model over the mean-adjusted model is the difference how market-wide price changes that coincidentally occur at event dates are treaded in each individual model. A mean-adjusted model with constant normal returns would most likely register abnormal returns in such situations even though they aren't event-specific. The market-adjusted model however would not.

3.2.1.2.3 OLS market-adjusted returns model

The market-adjusted return implicitly assumes that the beta of every stock is equal to one. This shortcoming tries to overcome the ordinary least square (OLS) market-adjusted model by using residuals of the market-adjusted model. It is denoted as

$$NR_{it} = \hat{a}_i + \hat{\beta}_i R_{mt} \tag{16}$$

where NR_{it} is the normal return of security i and time period t, R_{mt} the market return at time period t and $\hat{a}_i$ and $\hat{\beta}_i$ the OLS estimates of the regression coefficients of company i. The benchmark choices for market returns R_{mt} in OLS market-adjusted models are the same as in standard market-adjusted models.

2.2.1.2.4 Further normal returns calculation models

Over the past 40 years several other models for calculation of normal returns have been developed. One such example is the multifactor model proposed by Sharpe, Alexander and Bailey (1999).[63] They suggest extending the single factor market-adjusted model with other factors like industry sectors. Alternatively, Campbell, Lo and

---

[61] See Brown and Warner (1985), Chapter 3.1
[62] See Campbell, Lo and MacKinlay (1996), Chapter 4.3.2
[63] See Sharpe, Alexander and Bailey (1999), Chapter 10.3.2

MacKinlay (1996) propose the use of a group of ten similar sized (measured by their market equity value) companies.[64]

In addition to the three statistical models covered in the previous chapters, two economic models have also been developed. This first one is based around the capital asset pricing model (CAPM) and the second one around the arbitrage pricing theory (APT). A closer discussion of these two models is, however, beyond the scope of this thesis.[65]

3.2.1.3 Time line parameter setting

The fact that there isn't a universal parameter setting for the three components (estimation window, event window and post-event window) of the entire event study time line has already been briefly mentioned above in subsection 3.2.1.1. Here, a brief overview of length examples based on several studies is presented.

Campbell, Lo and MacKinlay (1996) advocate the use of a one-year (250 trading days) estimation window and a 41-day event window with 20 pre-event and 20 post-event days. The two windows don't overlap and follow in succession.[66] Alternatively they propose a 120-day estimation window for the market-adjusted model.[67] Fama, Fisher, Jensen and Roll (1969) analyze stocks from 1926 to 1960 and use all available prices of that period for the estimation window. The length of the estimation period thus ranges from 14 months to more than 300 months. The length of the event window is set for 60 months with a one-month long event period, 29-months pre-event duration and 30-month post-event duration.[68] Brown and Warner (1985) use a total of 250 daily observations. The first 239 trading days form the estimation window. The remaining 11

[64] See Campbell, Lo and MacKinlay (1996), Chapter 4.3.3
[65] See de Jong (2007), Chapter 2.2.3 and Campbell, Lo and MacKinlay (1996), Chapter 4.3.3
[66] See Campbell, Lo and MacKinlay (1996), Chapter 4.2
[67] See Campbell, Lo and MacKinlay (1996), Chapter 4.1
[68] See Fama, Fischer, Jensen and Roll (1969), pp. 5 and 8

days represent the event window with 5 pre-event days and 5 post event days.[69] Görke (2009) also proposes similarly long windows – a one-year long estimation window and a 10 to 20-days long symmetrical event window.[70] An interesting concept is presented by Geyskens, Gielens, and Dekimpe (2002). They propose a 25-day long lag between the end of the estimation window (219 days) and the beginning of the event window (11 symmetrical days). The reason for such discontinuity is the attempt to neutralize effects of leaked information on the results of the study.[71] Table VI summarizes the results presented above.

Authors	Data frequency	Field of Study	Estimation window length	Event window length (pre / event / post)	Estimation and event window relationship	Post-event window length
Campbell, Lo, MacKinley (1998)	Daily	Earnings announ-cements	250 days (Alt. 120 days)	20 / 1 / 20 days	In succession	N/A
Fama, Fisher, Jensen, Roll (1969)	Monthly	Stock-splits	Up to 34 years	29 / 1 / 30 months	Overlapping	N/A
Brown, Warner (1985)	Daily	Metho-dology	239 days	5 / 1 / 5 days	In succession	N/A
Görke (2009)	Daily	Metho-dology	250 days	10 to 20 days (symmetrical)	In succession	N/A
Geyskens, Gielens, Dekimpe (2002)	Daily	Marketing operations	219 days	5 / 1 / 5 days	25 days lag	N/A

Table VI - Event study time line parameter settings

(Source: own representation)

Additionally, Krivin et al. (2003) discuss in detail the optimal length of event windows for US stocks. They divide events into three types (earnings announcements, class action lawsuits, and events that are both earnings announcements) and use three different methodologies to identify abnormalities (abnormal daily returns, abnormal volatility, and abnormal trading volume). Depending on the methodology used for

[69] Brown and Warner (1985), Chapter 3.1
[70] See Görke (2009), Chapter 3.3.3
[71] See Geyskens, Gielens and Dekimpe (2002), p. 112

measuring abnormalities, their suggested optimal event window length for earnings announcements ranges from 0.32 to 0.86 days, form 1.11 to 2.56 days for class action lawsuits. Optimal event window for events that are both earnings announcements and class action lawsuits spread from 1.57 to 3.21 days. A summary of these results is shown in table VII below.

	Average window length (in days)		
	Abnormal return method	Abnormal volatility method	Abnormal turnover method
Earnings announcements	0.321	0.522	0.862
Class action lawsuits	1.113	1.532	2.565
Earnings announcements and class action lawsuits	1.571	2.000	3.214

Table VII - Average event window length

Source: Krivin et al. (2003), p. 13

3.2.1.4 Aggregation and presentation of abnormal returns

The methodology of abnormal return aggregation is the same for each normal returns model presented previously in subsection 2.2.1.2. The reason for this is that equation (12) is universally used for the calculation of abnormal returns. This subsection will in succession show how abnormal returns are aggregated on different levels of aggregation.

At a certain point when conducting event studies, one will have a matrix

$$(17) \qquad \begin{pmatrix} AR_{1,T_1} & \cdots & AR_{N,T_1} \\ \vdots & & \vdots \\ AR_{1,-1} & \cdots & AR_{N,-1} \\ AR_{1,0} & \cdots & AR_{N,0} \\ AR_{1,1} & \cdots & AR_{N,1} \\ \vdots & & \vdots \\ AR_{1,T_2} & \cdots & AR_{N,T_2} \end{pmatrix}$$

of abnormal returns $AR_{i,t}$ where i represents the event from a total number of N events and t the time period of the event window ranging from T_1 to T_2.[72] The actual event occurs at time $t = 0$. It should be noted that the total number of events N consists of the number of events observed for every security multiplied by the number of securities.

From matrix (17) it can be seen that there are three possible ways of aggregation. The first one is the aggregation by a certain time period, which is horizontal. Vertically, one can achieve the aggregation by event. The final option is the overall aggregation by both time and event.

Aggregation by a certain time period is expressed by the unweighted cross-sectional average of abnormal returns, with the equation

$$(18) \qquad AAR_t = \frac{1}{N}\sum_{i=1}^{N} AR_{it}$$

where AR_{it} is the abnormal return at time t of event i and N the number of events.[73] Calculating AAR_0 would show the average abnormal return at exactly the event time period and across all events. Results that substantially deviate from zero would indicate that events notably affect prices.

Often, however, it is more useful to know how abnormal returns during events accumulate over time. For this purpose, one can calculate a sample's cumulative abnormal return expressed as

$$(20) \qquad CAR_i(t_1, t_2) = \sum_{t=t_1}^{t_2} AR_{it}$$

[72] See de Jong (2007), Chapter 2.3
[73] See de Jong (2007), Chapter 2.3

where the variable designations are the same as in equation (18).[74] The downside of equation (19) is that it only aggregates abnormal returns of a single event. By combining equation (19) with the cross-sectional average abnormal returns equation (18), it is possible to calculate the cumulative average abnormal return aggregated by both time and event. It is denoted as

$$(21) \qquad CAAR(t_1, t_2) = \sum_{t=t_1}^{t_2} AAR_t$$

with the same variable designations as used in equation (18).[75] Alternatively, the cumulative average abnormal return can be also calculated from the cumulative abnormal return equation (20). By plugging equation (20) into equation (21) we receive

$$(21) \qquad CAAR(t_1, t_2) = \frac{1}{N} \sum_{i=1}^{N} CAR_i(t_1, t_2).$$

Gradually calculating cumulative abnormal returns from the beginning of an event window (with $CAAR(t_1, t_1)$ and $t_1 = T_1$) until the end of an event window (with $CAAR(t_1, t_2)$, $t_1 = T_1$ and $t_2 = T_2$) will result in a series of data which show how returns evolve over time during events. Presentation of average abnormal returns as well as cumulative average abnormal returns can be seen in part II of this thesis, in figures VI to XIV

[74] See Campbell, Lo and MacKinlay (1996), Chapter 4.4.3
[75] See Campbell, Lo and MacKinlay (1996), Chapter 4.4.3

3.2.1.5 Testing for abnormal returns

Graphical presentation of abnormal results is often helpful in giving the first evidence of how events affect prices. The next step, however, consists in calculating whether these effects are statistically significant or not. The null hypothesis of event-study tests is that expected abnormal returns around events are zero, meaning that events have no influence on prices. Expressed in equations, the null hypothesis and the alternative hypothesis are

$$H_0: E(AR_{it}) = 0$$
$$H_a: E(AR_{it}) \neq 0.$$

When assuming that abnormal returns are independently and identically distributed, that event windows don't overlap, and that a large number of observations is present, then it can be shown that the test statistic for abnormal average returns is Z-test given by the equation

$$Z = \frac{AAR_t}{\sigma} \approx N(0,1) \tag{22}$$

where variable designations are the same as in equation (18).[76] The problem with this equation is that the exact standard deviation of average abnormal returns is usually not known. Therefore it is necessary in practice to use an estimate when conducting such test statistics. MacKinlay (1997) suggests using the variance of returns from the OLS market-adjusted returns model as a proxy for the standard deviation. The equation for the standard deviation is

[76] See MacKinlay (1997), Chapter C

$$(23) \qquad \sigma_{AAR} = \sqrt{\frac{1}{N^2}\sum_{i=1}^{N}\sigma_{\epsilon}^2}$$

with the variance of the OLS residuals from the market adjusted model denoted as

$$(24) \qquad \sigma_{\epsilon}^2 = \frac{1}{L_1 - 2}\sum_{t=T_0+1}^{T_1}(R_{it} - \hat{a}_i - \hat{\beta}_i R_{mt})^2$$

where L_1 is the length of the estimation window, and the rest of variables using the same notations as equation (16).[77]

Finally, using the two standard deviation proxies discussed above, the test statistic for average abnormal returns is a t-test with $L_1 - 2$ degrees of freedom

$$(25) \qquad T = \frac{AAR_t}{\sigma_{AAR}},$$

where σ_{AAR} is standard deviation from equation (23) and AAR_t the average abnormal return at time t from the equation (18).[78]

The t-tests for average abnormal returns show significant deviations for only one time period. Often, however, exact events dates are not known, appear gradually, or are scattered around multiple dates within an estimation window. In such case it is necessary to test for significance of the cumulative average abnormal return. Fortunately these tests are performed similarly as the tests for average abnormal returns using a t-test with $L_1 - 2$ degrees of freedom

[77] See MacKinlay (1997), Chapter C
[78] See MacKinlay (1997), Chapter C

(26) $$T = \frac{CAAR}{\sigma_{CAAR}},$$

where σ_{CAAR} is a proxy for the standard deviation.[79]

Just as with the standard deviation of average abnormal returns, it is necessary to use estimators for the standard deviation of cumulative average abnormal returns σ_{CAAR}. Similarly to equation (23), MacKinlay (1997) proposes the use of the OLS residuals as in equation (24) and derives the standard deviation as

(27) $$\sigma_{CAAR} = \sqrt{\sum_{t=T_1}^{T_2} {\sigma_{AAR2}}^2},$$

where σ_{AAR} is the standard deviation of the abnormal average return from equation (23).

3.2.1.6 Problems, modifications and alternatives to tests

The previous subsection discussed test statistics for abnormal returns under assumptions that are rather restrictive. In practice when performing event studies, the analyzed data rarely has characteristics of the assumptions mentioned before. Throughout the years however, several modifications and alternatives to the tests shown in equations (25) and (26) have been made. The following subsections will discuss the most widely used test modifications and show their applications. Detailed analyses of the tests modifications discussed below as well as various other alternatives were conducted by Corrado (2010), Serra (2002) and Binder (1998).

[79] See MacKinlay (1997), Chapter C

3.2.1.6.1 Standardization of abnormal returns

It is generally known that some stocks are more volatile than others just as some industries are more volatile than others. However, the previous test statistics assumed that abnormal returns are identically distributed and that their variance at a specific time period (cross-section) is equal. In practice however, this is not the case. In order to overcome this shortcoming Patell (1976) uses a standardization procedure by which abnormal returns are weighted according to their standard deviation.[80] The equation for standardized abnormal returns is

$$(28) \qquad SAR_{it} = \frac{AR_{it}}{s_i},$$

where s_i is the variance estimate of firm i calculated by

$$(29) \qquad s_i = \sqrt{\frac{1}{T_1 - T_0} \sum_{t=T_0}^{T_1} (AR_{it} - \overline{AR}_i)^2},$$

and the average abnormal return of the time series $\overline{AR}_i$ as

$$(30) \qquad \overline{AR}_i = \frac{1}{T-1} \sum_{t=T_0}^{T_1} AR_{it}.$$

The so-called "Patell T-test" for standardized abnormal returns is then

$$(31) \qquad T_P = \frac{1}{\sqrt{N}} \sum_{i=1}^{N} SAR_{it},$$

[80] See Patell (1976), Chapter 4

which using a large sample size approximately follows a standard normal distribution.[81] The mechanics shown above can be similarly used with cumulative abnormal returns.

3.2.1.6.2 Crude Dependence Adjustment

Another problem with the assumptions discussed in subsection 2.2.1.5 is that in practice event windows occasionally overlap. The implication of this is that the assumed correlation of abnormal returns of two different firms is zero, e.g. $cov\left(AR_{it}, AR_{jt}\right) = 0$. Unfortunately, this isn't always the case in reality. Examples include quarterly earnings reports that are usually disclosed within few days apart. It is thus very probable that a quarterly earnings report of one company will affect the abnormal returns of a different company, especially if they are competitors or major suppliers of one another. One recent example of cross sectional dependence was observed in October 2012 when event surrounding the social network Facebook and game developer Zynga, which develops games almost exclusively for Facebook, had mutual effects on their corresponding stock prices.[82]

To counter these deficiencies Brown and Warner (1980) use a method called Crude Dependence Adjustment to perform the test statistics.[83] The major difference to the standard model discussed before is that the standard deviation of average abnormal returns is estimated using the average abnormal returns of the entire time series instead of using individual firm-specific abnormal returns. The equation for standard deviation estimate of the Crude Dependence Adjustment method is

$$(32) \qquad s_{CDA} = \sqrt{\frac{1}{T-1}\sum_{t=T_0}^{T_1}(AAR_t - AR^*)^2},$$

[81] See Corrado (2010), p. 7 and Ahren (2009), p. 481
[82] See Pepitone (2012)
[83] See Brown and Warner (1980), p. 251

with

$$(33) \qquad AR^* = \frac{1}{T}\sum_{t=T_0}^{T_1} AAR_t.$$

The test statistics is a t-test

$$(34) \qquad T_{CDA} = \frac{AAR_t}{s_{CDA}},$$

with $L_1 - 1$ degrees of freedom.[84]

3.2.1.6.3 Sign test

The sign test discussed in this chapter is the non-parametric test developed by Corrado and Zivney (1992) whose aim was to counter the restrictions of parametric tests. These include the poor performance of parametric tests for small sample sizes and the implicit assumption about normal distribution of abnormal returns. Corrado and Zivney (1992) base their test on the regular sign test, but instead of assuming a median of zero for abnormal returns, they propose a calculation of the median from the event window for sign determination.[85] The equation for test statistics is

$$(35) \qquad Z_{Sign} = \frac{1}{\sqrt{N}}\sum_{i=1}^{N} \frac{G_{it}}{s_G},$$

where

$$(36) \qquad G_{it} = sign\big(AR_{it} - median(AR_i)\big),$$

[84] See Brown and Warner (1980), p. 251
[85] See Corrado and Zivney (1992), p. 465

thus allowing G_{it} to be either +1, 0, or -1 depending on whether $AR_{it} - median(AR_i)$ is positive, zero, or negative.[86] The equation for the standard deviation is

$$(37) \qquad s_G = \sqrt{\frac{1}{T-1}\sum_{t=T_0}^{T_1}\left(\frac{1}{\sqrt{N}}\sum_{i=1}^{N} G_{it}\right)^2}\,.$$

3.2.1.6.4 Rank test

The rank test is another non-parametric test and can be viewed as an extension to the previously discussed sign test. The major difference between these two tests is, that the sign test does not account for the magnitude of abnormal returns (as a reminder G_{it} can only be zero or +/- 1), while the rank test does. The equation for the rank test statistics is

$$(38) \qquad T_{Rank} = \frac{1}{\sqrt{N}}\sum_{i=1}^{N}\frac{\left(U_{it} - \frac{1}{2}\right)}{s_U},$$

where

$$(39) \qquad U_{it} = \frac{rank(AR_{it})}{1 + T_1 - T_0}.$$

The standard deviation is[87]

$$(40) \qquad s_G = \sqrt{\frac{1}{T-1}\sum_{t=T_0}^{T_1}\left(\frac{1}{\sqrt{N}}\sum_{i=1}^{N}\left(U_{it} - \frac{1}{2}\right)\right)^2}\,.$$

[86] See Corrado and Zivney (1992), p. 468
[87] See Corrado and Zivney (1992), p. 467

Corrado and Zivney (1992) compare the performance of the rank and sign test as well as the standardized t-test discussed in subsection 2.2.1.6.1. They conclude that the non-parametric tests show better performance than the parametric standardized t-test.[88] A comparison to the Crude Dependence Adjustment model is not performed.

3.2.2 Closing remarks on semi-strong form efficiency testing

Testing for semi-strong form efficiency is conducted almost exclusively through event studies. Thanks to the numerous contributions to this topic over the past 40 years, we have gained much knowledge about the mechanics of event studies. Not only do we know what types of methodological approaches for conducting event studies there are, but we also have very good understanding of their performance and statistical properties.[89]

Additionally to the methodology covered in the previous chapters, procedures for conducting event studies that have long-term effects have also been developed.[90] The main issues in such studies are the correct measurement of risk and expected returns – problems which don’t have a substantial effect on event studies that cover only a couple of days.

Event studies have been extensively used in the past four decades to better understand the effects of events on securities’ prices and for analyzing semi-strong market efficiency. They are well understood, relatively simple to conduct, and are capable of bringing valuable results.

[88] See Corrado and Zivney (1992), p. 477

[89] Among the principle contributions to understanding the performance of event studies are Brown and Warner (1980, 1985) and Corrado and Zivney (1992)

[90] See Khotari and Warner (2004), Chapter 4

3.3 Strong form efficiency research methodology

Analyzing strong-form market efficiency bears the inherent problem of assessing insider trading – secret information that is hidden from the public. As logic follows, one cannot conduct scientific research on information that is not obtainable. However, since 1934, corporate insiders are obliged to report to the Securities Exchange Commission (SEC) every insider trade (see SEC forms 3, 4, and 5). Similar rules apply to other countries around the world.[91] The filings reported to the SEC are then publicly disclosed at their Electronic Data Gathering, Analysis and Retrieval system (EDGAR) website. Additionally, several commercial third-party websites have facilitated the search for insider trades, by giving users the ability to quickly and easily make specific search queries on insider trades filed with the SEC.[92] These SEC disclosures are basically the only source of information about insider trading available. The problem, however is, that reports on insider trades can be easily, albeit unlawfully, bypassed or ignored altogether.

Most studies on strong-form market efficiency, like the ones discussed in chapter 2.2.3 rely exclusively on the SEC disclosures and use very similar approaches to analyze the data. The core principle is to compare abnormal returns of portfolios constructed using the SEC insider trading filings to normal market returns while also considering transaction fees like brokerage costs and exchange fees. Strong-form market efficiency is then rejected if returns of the insiders' portfolio are significantly higher than market returns.

In this thesis however, a detailed methodology for conducting strong-form market research will not be covered. This is due to the fact that existing studies on strong-form

[91] See Market Abuse Directive (2003/6/EG) for insider trading regulations in the European Union
[92] See for example insider-monitor.com, or www.gurufocus.com/InsiderBuy.php.

market efficiency are inconclusive.[93] Additionally, the inherent lack of information regarding undocumented insider trades produces rather biased results.

[93] See chapter 2.2.3

PART II:

Empirical analysis of the video game industry for market efficiency

5 Introduction to the video game industry

What began as a hobby activity of a US physicist more than a half century ago has grown into a multi-billion dollar industry attracting millions of customers around the world. The video game industry is estimated to produce almost $60 billion of revenues worldwide and is predicted to surpass $80 billion by 2015 - a figure that would make the video game industry almost four times the size of the music industry.[94] Video games today are no longer just toys that boys play with. According to the Entertainment Software Association, the average age of a US gamer is 30, while 47% of all gamers are women.[95]

The first video games used to be developed by a handful of friends. Today's leading games, however, can take several years to develop, requiring the work of more than a 1000 professionals and a budget surpassing $100 million.[96] Figures like these can help explain why the fastest selling entertainment product isn't a blockbuster film or bestselling book, but a video game. The much anticipated and heavily promoted game Call of Duty: Black Ops II hit $1 billion in revenues in just 15 days and beat the previous record holder Call of Duty: Modern Warfare 3, which is also a video game, by one day. For comparison, Avatar, the fastest selling movie of all times movie needed 17 days.[97]

The goal of this thesis is to give more insight into the video game industry from the academic point of view. The following chapters will assess the market efficiency of the video game industry by utilizing the approaches discussed previously in the first part of this thesis. Starting with the weak form market efficiency, daily returns of video game companies are analyzed for randomness. Then, as part of the semi-strong form

[94] See http://www.economist.com/node/21541164
[95] See http://www.theesa.com/facts/index.asp
[96] See http://www.gamesindustry.biz/articles/gta-iv-most-expensive-game-ever-developed
[97] See http://www.forbes.com/sites/insertcoin/2012/12/05/black-ops-2-sells-1b-in-15-days-ties-modern-warfare-3-record/

efficiency, an event study on video game-related events is conducted. These include new game announcements, major release delays, and stock price movements around release dates as well as around the leading games exhibitions. A study on corporate actions such as stock splits, mergers, and dividend announcements will not be performed as the effects of such events are generally well understood.[98] The focus in this thesis is put on events which previously haven't been studied. An analysis of strong-form market efficiency, however, is omitted due to its inherent complexity, as well as inconclusive results from previous studies.[99]

[98] See chapter 2.2.2.
[99] See chapter 2.2.3.

6 Scope of the study

Before proceeding with the actual analysis, it is necessary to define what the video game industry in the sense of this study is. Since the entire industry is comprised of thousands of business directly or indirectly employed with video games, it is almost impossible to account for all of them. Therefore, the following three restrictions have been made in order to select companies for analysis in this study:

1. The company has to make at least 50% of its revenues from video games, or video game related hardware such as consoles (arcade and gambling machines are excluded)
2. The company has to be publicly traded on a regulated market
3. The time frame of the study ranges from January 3rd 2005 to November 30th 2012.

The result of these three restrictions is a list of 28 companies from the US, UK, Japan, South Korea, France, Germany, Italy and Austria. The majority of the companies are video game publishers, with just four specializing in other activities, such as video game retail stores, console manufacturing and video game development. A detailed list of included companies is shown in table VIII below.

Company	Ticker	Country	Founded	Defunct	Market cap (in $M)	Description
Atari SA	ATA:FP	France	1983	-	464	Publisher
Activision Blizzard Inc	ATVI	USA	1979 (merged with Blizzard 2008)	-	11.291	Publisher
Capcom Co Ltd	9697:JT	Japan	1983	-	1.168	Publisher
cdv Software Entertainment AG	OGG1.F	Germany	1989	-	60	Publisher
D3 Inc	4311:JP	Japan	1992	2009 (acquired by Namco Bandai)	26	Publisher
Digital Bros SpA	DIB.MI	Italy	1989	-	53	Publisher
Eidos PLC	EID:LN	UK	1990	2009 (acquired by Square Enix)	707	Publisher
Electronic Arts Inc	EA	USA	1982	-	10.529	Publisher

Funcom NV	FUNCO M.OL	Norway	1993 (public since 2005)	-	146	Publisher
Game Group PLC	GMG:LN	UK	1991	2012 (acquired by OpCapita)	468	Retailer
GameStop Corp	GME	USA	1984	-	3.092	Retailer
JoWooD Entertainment AG	JWD:AV	Austria	1995	2011	48	Publisher
Koei Co Ltd	9654:JT	Japan	1978	2009 (merged with Tecmo Ltd)	569	Publisher
Konami Corp	9766:JT	Japan	1969	-	3.093	Publisher
Marvelous AQL Inc	7844:JT	Japan	2011	-	226	Publisher
Majesco Entertainment Co	COOL	USA	1986	-	81	Publisher
Midway Games Inc	MWYG Q:US	USA	1988	2009 bankruptcy declared	354	Publisher
NCsoft Corporation	036570. KS	South Korea	1997	-	2.734	Publisher
Nexon Co Ltd	3659:JT	South Korea	1994 (public since 2011)	-	832	Publisher
Nintendo Co Ltd	7974:JT	Japan	1889	-	33.873	Hardware / Publisher
Square Enix Holdings Co Ltd	9684:JT	Japan	2003 (merger of Square and Enix)	-	2.571	Publisher
Take-Two Interactive Inc	TTWO	USA	1993	-	1.402	Publisher
Tecmo Ltd	9650:JT	Japan	1967	2009 (merged with Koei Co Ltd)	208	Publisher
Tecmo Koei Holdings Co Ktd	3635:JT	Japan	2009 (merger of Tecmo and Koei)	-	659	Publisher
THQ Inc	THQI	USA	1989	-	926	Publisher
Ubisoft Entertainment SA	UBI.PA	France	1986	-	1.239	Publisher
Webzen Inc	069080. KQ	South Korea	2000	-	431	Publisher
Zynga Inc	ZNGA	USA	2007 (public since 2011)	-	4.016	Developer
Company	**Ticker**	**Country**	**Founded**	**Defunct**	**Market cap (in $M)**	**Description**

Market cap calculated as the average from daily market caps between January 2005 and November 2012. Historical currency rates for each corresponding date were used for currency conversions.

Table VIII - List of video game companies included in the study

However, due to the restrictions several important players of the industry are left out of this study. Microsoft Corporation and Sony Corporation, both important console manufacturers and video game publisher, are not included because their video game related revenues are less than 50% of their entire revenues. The same applies to Namco Bandai Games Inc, Videndi SA, Warner Bros. Entertainment Inc, Sega Sammy Holdings and Tomy Co Ltd, which sales are mainly generated from business activities different from video games.[100] The decision not to include such companies can be justified by minimizing unwanted influences from outside of the video game industry.

The second restriction is a logical necessity since privately held companies have no real-time market value. Although this omits important video game companies such as Valve Corporation (owner of Steam, the largest digital distribution platform for PC games[101]) and ZeniMax Media Inc (publisher and video game developer of critically acclaimed games like Fallout 3 and Elder Scrolls V: Skyrim), an inclusion would not be possible due to missing daily market prices. Additionally, the condition that a company has to be traded on a regulated market was imposed in order to avoid illiquid stocks that are traded on over the counter markets. This includes companies such as SouthPeak Interactive Corp and indiePub Entertainmet Inc.

The year 2005 was chosen as the starting period for this study because it's the year when Xbox 360, the first video game console of this generation, was introduced. Sony and Nintendo followed in late 2006 with PlayStation 3 and Wii. Over the course of the past 7 years, these three consoles have sold globally 240.62 million units with additional 8.729 million games.[102] These numbers, however, represent only the lower bound of the total gaming hardware/software units sold as they don't include sales of portable consoles, older generation consoles and their corresponding games as well as PC, smartphone, and tablet games.

[100] See the corresponding financial statements.
[101] See http://www.gamasutra.com/php-bin/news_index.php?story=26158#.UNBnzXfkJwE
[102] See platform totals at VGChartz, http://www.vgchartz.com/analysis/platform_totals/

7 Weak-form efficiency analysis of the video game industry

In this chapter all the video game companies from table VIII are tested for weak form market efficiency by using the methods and techniques discussed previously in chapter 3.1. In short, this means analyzing each individual company's daily returns for randomness. Rejection of randomness would indicate inefficiencies caused by predictable market patterns.

In order to analyze the video game industry as a whole, an index named Video Game Industry Global Index (VGIGI) is constructed and assessed for randomness. It covers all 28 video game companies and is calculated as

$$VGIGI_t = \frac{\sum_{i=1}^{N} SO_{i,t} * p_{i,t} * FX_t}{100000000}, \qquad (41)$$

where $SO_{i,t}$ are the shares outstanding of company i at time t, $p_{i,t}$ is the corresponding share price and FX_t the exchange rate to USD. In order to neutralize unwanted exchange rate interferences, two VGIGI indices are created – the VIGIG Var with variable exchange rates where FX_t corresponds with the actual exchange rate of a given day, and the VGIGI Const utilizing a constant exchange rate calculated as the average of the observation period.

Below in figure V is a comparison of the two VIGIGI indices with the S&P Global 1200 index. As can be seen from the chart, both, the global market as well as the video game industry were heavily hit by the recent financial crisis in 2008. While the S&P index managed to recover some of its losses, the video game industry remained relatively stable around the 600 mark. Small differences resulting from currency rate fluctuations are also evident.

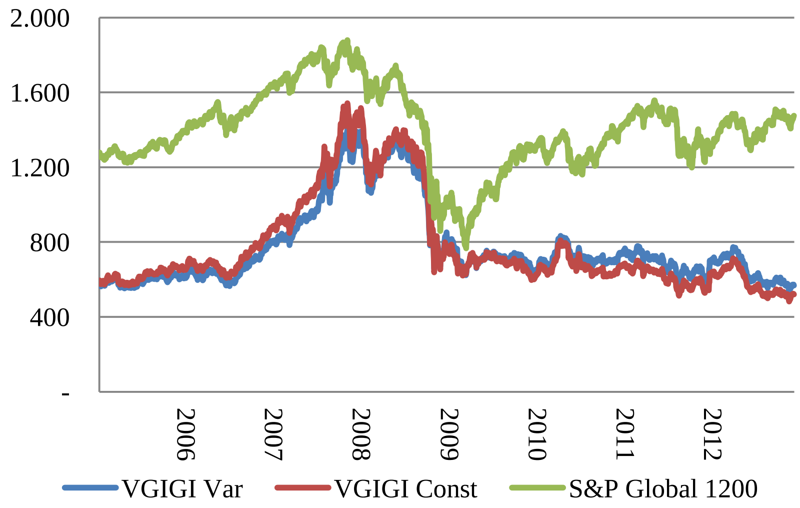


Figure V - Video Game Industry Global Index and S&P 500 Global 1200 comparison

The basis for calculations of all statistics in this chapter is the returns of closing daily prices. Calculation of daily returns are done using the continuously compounded returns formula

$$r_{i,t} = ln\left(\frac{p_{i,t}}{p_{i,t-1}}\right), \tag{42}$$

where $r_{i,t}$ is the return of company i at time t, and $p_{i,t}$ the end of day share price of company i at time t.

7.2 Descriptive statistics of the video game industry

As part of the descriptive statistics, daily continuously compounded returns of all 28 companies and two indices ranging from January 2005 to November 2012 are used to calculate the mean, maximum and minimum daily return, standard deviation, skewness, and excess kurtosis. Additionally, a Jarque-Bera test is used for analysis of the distribution of returns.[103]

Ticker	Mean p.a.	Max p.a.	Min p.a	Standard deviation	Skewness	Excess Kurtosis	Observ.	Jarqe-Bera
VGIGI Var	-1,7E-05	0,098	-0,094	0,015	-0,235	4,972	2064	2132,0
VGIGI Const	-6,5E-05	0,084	-0,097	0,015	-0,359	5,165	2064	2325,0
ATA:FP	-1,7E-03	0,491	-0,316	0,046	1,954	19,039	2064	32326,8
ATVI	3,7E-04	0,210	-0,170	0,024	0,194	9,238	2064	7312,1
9697:JT	3,0E-04	0,182	-0,178	0,024	0,151	7,509	2064	4829,6
OGG1.F	-3,7E-03	2,303	-2,303	0,166	0,025	71,922	2064	442670,8
4311:JP	-1,1E-03	0,168	-0,188	0,035	0,310	5,139	1183	1306,9
DIB.MI	-3,6E-04	0,238	-0,152	0,026	1,089	10,010	2064	8978,7
EID:LN	-1,6E-03	0,819	-0,774	0,055	0,623	83,699	1121	324336,2
EA	-6,8E-04	0,155	-0,197	0,025	-0,243	6,649	2064	3800,7
FUNCOM.OL	-1,5E-03	0,354	-0,736	0,051	-2,030	36,195	1817	99864,4
GMG:LN	-1,5E-03	0,602	-1,009	0,051	-4,270	124,016	1881	1204656,2
GME	4,5E-04	0,161	-0,168	0,027	-0,091	5,335	2064	2436,2
JWD:AV	-2,6E-03	0,320	-0,321	0,044	0,701	14,543	1643	14518,1
9654:JT	-7,4E-04	0,114	-0,112	0,021	-0,055	4,903	1102	1092,1
9766:JT	-3,4E-06	0,116	-0,210	0,024	-0,808	8,544	2064	6467,1
7844:JT	-6,0E-04	0,213	-0,290	0,033	-0,250	9,860	2017	8146,3
COOL	-1,4E-03	0,304	-0,685	0,053	-1,817	28,295	2064	69637,0
MWYGQ:US	-4,9E-03	0,560	-0,734	0,084	-0,554	14,485	1421	12401,2
036570.KS	3,2E-04	0,140	-0,162	0,030	-0,154	2,931	2064	741,8
3659:JT	-1,3E-03	0,097	-0,281	0,033	-3,055	22,706	252	5578,0
7974:JT	-3,6E-05	0,122	-0,139	0,024	-0,310	4,437	2064	1716,0
9684:JT	-4,3E-04	0,133	-0,156	0,022	-0,358	6,015	2064	3137,4
TTWO	-3,1E-04	0,438	-0,344	0,032	-0,260	31,455	2064	84683,7
9650:JT	-1,2E-04	0,132	-0,146	0,026	0,184	4,557	1102	10620,6
3635:JT	8,8E-06	0,130	-0,174	0,019	-0,686	13,297	961	7074,9
THQI	-2,2E-03	0,322	-0,700	0,044	-2,881	46,373	2064	186872,8
UBI.PA	7,6E-04	1,352	-0,657	0,050	10,335	325,564	2064	9107770,0
069080.KQ	-5,6E-04	0,140	-0,162	0,037	0,246	3,907	2064	1325,1
ZNGA	-5,4E-03	0,156	-0,468	0,051	-2,934	26,414	250	7323,0
Ticker	**Mean**	**Max**	**Min**	**Standard deviation**	**Skewness**	**Excess Kurtosis**	**Observ.**	**Jarqe-Bera**

Table IX - Descriptive statistics of the video game industry

[103] See chapter 3.1.1.

Table IX above reveals that the maximum number of observations is 2064, which represents all workdays from the beginning of January 2005 till the end of November 2012. Some components, however, have a much smaller observation period. This is caused either by delisting (GMG:LN, JWD:AV, 9654:JT, MWYGQ:US, 9650:JT) or by going public at some later point during the observation period (FUNCOM.OL, 3659:JT, 3635:JT, ZNGA). High skewness and especially excess kurtosis numbers give first indications that daily returns of video game companies are not normally distributed. This is confirmed by the high Jarque-Bera test results which are clearly above the critical value of 5.9644 for components with 2064 observations and 5.7343 for ZNGA, component with the least amount of observations. The closest to normal distribution of daily returns isn't one of the VGIGI indices, but rather the Korean 036570.KS with a Jarque-Bera test of 741.8. This value, however, still misses the test of normal distribution by a large margin.

7.3 Parametric tests for randomness

The Jarque-Bera test has revealed that none of the 30 components in this study show daily returns that are normally distributed. Nevertheless, parametric tests for randomness such as autocorrelation coefficients and Ljung-Box tests (for up to 20 lags) are performed in order to give a better understanding of the relationship between successive returns.[104]

	Autocorrelation coefficient							Ljung-Box	
Ticker	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5	Lag 10	Lag 20	p-Value	H*
VGIGI Var	0,097	-0,003	-0,075	-0,025	0,030	-0,011	-0,011	3,01E-08	1
VGIGI Const	0,141	0,001	-0,082	-0,037	0,017	-0,004	-0,018	2,15E-14	1
ATA:FP	-0,007	-0,017	-0,022	0,045	-0,046	-0,013	0,004	0,254651	0
ATVI	-0,077	-0,044	0,023	-0,019	-0,001	-0,022	-0,005	0,0089	1
9697:JT	0,079	-0,050	-0,031	-0,024	0,015	0,001	-0,033	0,0018	1

[104] See chapter 3.1.2.

OGG1.F	-0,387	0,028	-0,080	0,005	-0,008	0,021	0,013	0	1
4311:JP	0,119	-0,025	-0,009	0,001	-0,006	-0,018	0,021	0,0523	0
DIB.MI	-0,098	-0,020	-0,001	-0,020	0,005	0,001	-0,011	0,0156	1
EID:LN	0,158	0,011	-0,076	-0,061	-0,093	0,049	0,085	8,8E-09	1
EA	-0,034	-0,031	-0,050	0,030	-0,068	-0,009	0,017	0,0017	1
FUNCOM.OL	0,070	-0,049	-0,007	0,047	0,001	-0,014	0,022	1,25E-05	1
GMG:LN	0,163	-0,174	-0,147	0,048	0,063	-0,033	0,029	0	1
GME	0,016	-0,053	-0,041	-0,001	-0,053	-0,010	0,015	0,0816	0
JWD:AV	0,185	-0,092	-0,067	-0,033	0,002	0,000	0,012	9,15E-14	1
9654:JT	0,010	0,001	0,073	0,004	0,015	-0,068	0,016	0,0289	1
9766:JT	0,006	-0,020	-0,025	0,001	0,003	0,020	0,069	0,0161	1
7844:JT	0,110	-0,025	-0,039	-0,059	-0,014	-0,046	0,014	1,25E-05	1
COOL	-0,025	0,013	-0,042	0,020	-0,019	0,018	-0,025	0,0776	0
MWYGQ:US	-0,079	-0,095	-0,059	0,090	-0,105	0,030	0,007	4,43E-12	1
036570.KS	0,059	-0,017	-0,004	-0,024	0,016	0,041	-0,007	0,0763	0
3659:JT	0,150	-0,059	0,025	-0,032	-0,115	-0,021	0,014	0,1841	0
7974:JT	0,050	-0,016	-0,053	-0,031	-0,002	0,033	-0,009	0,0025	1
9684:JT	-0,004	0,010	-0,039	-0,052	0,016	0,008	0,007	0,0689	0
TTWO	0,009	0,022	0,018	0,001	-0,004	0,018	0,011	0,2038	0
9650:JT	0,105	0,079	-0,068	-0,021	-0,045	0,005	-0,034	7,22E-15	1
3635:JT	-0,010	-0,016	0,002	-0,052	-0,017	0,009	-0,020	0,8012	0
THQI	0,018	0,041	-0,017	0,053	0,010	0,015	0,027	0,122	0
UBI.PA	0,027	-0,065	-0,008	0,004	-0,014	-0,014	0,008	0,5638	0
069080.KQ	0,073	-0,021	-0,058	-0,046	-0,032	-0,003	0,011	0,0082	1
ZNGA	-0,007	-0,015	-0,056	-0,028	0,074	0,089	0,055	0,9198	0
	Lag 1	Lag 2	Lag 3	Lag 4	Lag 5	Lag 10	Lag 20	p-Value	H*
	Autocorrelation coefficient							**Ljung-Box**	

* Values H = 0 indicate failure of rejecting the null-hypothesis of no autocorrelation and values H = 0 indicate rejection of no autocorrelation at a 5% confidence level.

Table X - Autocorrelation tests of the video game industry

The Ljung-Box test reveals that only 12 components (marked red) in the sample show no signs of autocorrelation. The most evident indication of autocorrelation can be observed in OGG1.F and GMG:LN. This, however, can be explained by the financial difficulties of the two companies followed by subsequent delisting on stock exchanges. An interesting finding is the relatively high level of autocorrelation in both indices. The VGIGI Var index shows lower levels of autocorrelation then VGIGI Const, but in both cases, the Ljung-Box test statistic p-value is too low to support the null hypothesis of no autocorrelation.

7.4 Non-parametric tests for randomness

In this chapter, two non-parametric tests are conducted on all 30 components of this study. The first one is the runs test, which tests for randomness based on whether successive returns, larger or greater than the average, appear at random.[105] The second test is the Phillips-Perron which analyzes the unit root of a given sample.[106]

	Runs test		Phillips-Perron	
Ticker	**p-Value**	**H***	**p-Value**	**H****
VGIGI Var	0,0052	1	0	1
VGIGI Const	1,18E-05	1	0	1
ATA:FP	0,6772	0	0	1
ATVI	0,4942	0	0	1
9697:JT	0,0051	1	0	1
OGG1.F	9,40E-05	1	0	1
4311:JP	1,07E-06	1	0	1
DIB.MI	0,000194	1	0	1
EID:LN	0,0015	1	0	1
EA	0,8087	0	0	1
FUNCOM.OL	0,6809	0	0	1
GMG:LN	0,0047	1	0	1
GME	0,21	0	0	1
JWD:AV	0,00025	1	0	1
9654:JT	0,0278	1	0	1
9766:JT	0,2426	0	0	1
7844:JT	0,0206	1	0	1
COOL	0,3095	0	0	1
MWYGQ:US	0,0013	1	0	1
036570.KS	0,0228	1	0	1
3659:JT	0,021	1	0	1

[105] See chapter 3.1.3.
[106] See chapter 3.1.4.

7974:JT	0,0011	1	0	1
9684:JT	0,3717	0	0	1
TTWO	0,0115	1	0	1
9650:JT	9,81E-65	1	0	1
3635:JT	0,0088	1	0	1
THQI	0,0194	1	0	1
UBI.PA	0,5141	0	0	1
069080.KQ	0,0631	0	0	1
ZNGA	0,579	0	0	1
Ticker	**p-Value**	**H[*]**	**p-Value**	**H[**]**
	Runs test		**Phillips-Perron**	

[*] Values H = 0 indicate failure to reject the null-hypothesis that daily returns appear at random order at a 5% confidence level and H = 1 indicate rejection of the null-hypothesis.

[**] Values H = 0 indicate failure to reject the null-hypothesis of a unit root in the time series at a 5% confidence level and H = 1 indicate rejection of the null hypothesis.

Table XI - Non-parametric tests of the video game industry

Results of the runs test from table XI above reveal similar results as the previous parametric test for autocorrelation. Only nine components from the sample indicate randomness (marked red). Just as with the parametric tests performed previously, both indices do not pass the runs test, hence indicating predictive patterns of stock price movements.

The biggest surprise, however, is that not a single component out of the 30 in this sample passes the Phillips-Perron test. This fact points toward a pattern in which stock prices of video game industry companies have the tendency to return to a predetermined level following shocks.[107] Such finding, however, conflicts with the principles of weak form market efficiency.

[107] See chapter 3.1.4.

7.5 Summary of weak-form efficiency tests

The previous chapters have shown that the video game industry does not pass the tests of weak-form market efficiency over the time period from January 2005 till November 2012. Neither the video game industry as a whole, nor a single video game company passes all of the three conducted tests. Although there are limited signs of stock prices following a random walk for some individual video game companies, the overall failure of the unit root test leads to the final conclusion that the video game industry is weak-form inefficient. A final summary of all tests is showcased below in table XII with passed tests marked red.

Are the weak-form market efficiency tests passed?

Ticker	**Ljung-Box**	**Runs test**	**Phillips-Perron**
VGIGI Var	No	No	No
VGIGI Const	No	No	No
ATA:FP	Yes	Yes	No
ATVI	No	Yes	No
9697:JT	No	No	No
OGG1.F	No	No	No
4311:JP	Yes	No	No
DIB.MI	No	No	No
EID:LN	No	No	No
EA	No	Yes	No
FUNCOM.OL	No	Yes	No
GMG:LN	No	No	No
GME	Yes	Yes	No
JWD:AV	No	No	No
9654:JT	No	No	No
9766:JT	No	Yes	No
7844:JT	No	No	No
COOL	Yes	Yes	No
MWYGQ:US	No	No	No
036570.KS	Yes	No	No
3659:JT	Yes	No	No
7974:JT	No	No	No
9684:JT	Yes	Yes	No

TTWO	Yes	No	No
9650:JT	No	No	No
3635:JT	Yes	No	No
THQI	Yes	No	No
UBI.PA	Yes	Yes	No
069080.KQ	No	Yes	No
ZNGA	Yes	Yes	No
Ticker	**Ljung-Box**	**Runs test**	**Phillips-Perron**

Table XII - Summary of weak form efficiency tests of the video game industry

8 Semi-strong form efficiency analysis of the video game industry

After revealing rather negative results for the weak form market efficiency, the next step is to look at how markets react to new information in the video game industry. This test is done in form of an event study as discussed previously in chapter 3.2. The following chapters will take a closer look at what happens to the prices of video game companies when certain games-related events happen.

8.1 Event study of the video game industry

The goal of this event study is to give insight into how markets react to certain video-games-related events and see whether these reactions are in line with the semi-strong efficiency theory. The structure of this event study is build after guideline set forth in subsection 3.2.1.1.

8.1.1 Event definition

Essential part of every event study is an exact definition of the event itself. In this study, the effects of the following four video game-related events will be studied:

1. new video game announcements,
2. video game release delays,
3. video game release dates,
4. video game exhibitions.

The first three event types represent a natural development process of a video game. At some point during the development, a new video game is officially announced either by the developer or a publisher. Often times as part of the announcement, a release date prediction is also disclosed. Then in case of development set-backs, statements about a delay of the release are announced. The final part is the day when the game is officially released. Effects of these events are analyzed onto the video game company to which they relate. For example: abnormal daily returns of company Y are analyzed during announcements, delays (if existent), and release dates of the video game X published by company Y.

8.1.2 Selection criteria and restrictions

Since there are hundreds of video games that are announced and released each year as well as several video game exhibitions organized annually, the following restrictions are made in order to make this study more streamlined and meaningful:

1. only video games from publishers with an average market cap of more than $1 billion as presented in table VIII are included,
2. only video games released between January 2006 and November 2012 are included,
3. only the first 8 highest selling (by number) video games for each publisher are included, excluding video games that are released on an annual basis (e.g. EA Sports' FIFA, NFL, etc. series)[108],
4. only video games that have sold more than 2 million units (cumulative for all platforms) till the end of November 2012 are included,
5. only release delays of more than 6 months are included,

[108] For number of sold units, see game totals at VGChartz, http://www.vgchartz.com/gamedb/

6. only the three leading video game conventions Electronic Entertainment Expo, Gamescom (formerly Games Convention) and Tokyo Games Show are considered,
7. cases of confounding events are discarded.[109]

These seven restrictions presented above may seem at first very limiting, especially to those who aren't well informed of the video game industry, but they can be easily justified and explained. The first restriction is imposed in order to study only liquid stocks and to neutralize the effects of financially distressed companies such as ATA:FP, OGG1.F, EID:LN, JWD:AV, and THQI. The second restriction is similar to the one imposed in the weak-form efficiency test.

The third and fourth restriction is imposed with the aim to cover only important and well known video games, which are more likely to affect their publishers than video games with only marginal sales. It might be tempting to disregard these two restrictions in a way that they disadvantage video games which have been released closer to the end of the observation period and as such haven't had the opportunity to generate enough sales. It has been shown, however, that video game sales over time roughly follow a rational function $= \frac{1}{t}$, where y is the number of sales at time t.[110] This means that the majority of total video game sales are generated in the first few weeks.

Among the confounding events identified, the most important are the omissions of Nintendo's Wii Sports and Wii Play, as well as the release date of Activision's Guitar Hero World Tour. Both of Nintendo's video games were launch titles for their console Wii. An inclusion of these two games would have meant analyzing an event of a much larger scale than originally meant. The release of Guitar Hero World Tour on the other

[109] See chapter 3.2.1.1 step 1.
[110] See Beaujon (2012), chapter 4.4.2.

hand was plagued by reports of faulty hardware which was bundled with the game.[111] Announcement of the game, however, is included.

All in all, a total of 272 individual events are included in this study, covering eight video game publisher. Of those 168 are related to exhibitions (3 exhibitions spread over 7 years tested on 8 different publishers). The list of all events can be found in appendix A.

8.1.3 Abnormal returns calculation method

This study will make use of the same end of day prices employed in the weak form efficiency tests. The OLS-marked adjusted method (formula 16) as well as the mean-adjusted method (formula 13) is used for calculations of abnormal returns. Both results are displayed jointly for easier comparison. The S&P Global 1200 index is chosen as a benchmark for market returns in the OLS-market adjusted method.

8.1.4 Event time parameters

Parameters for the length of estimation windows and event windows were chosen according to Brown and Warner's (1985) settings.[112] This transforms into a 239 days-long estimation window and an 11 days-long event window which follow in succession. Event date is set at the 6th day of the event window.

In case of video game announcements, delays or releases occurring at weekend, the event day is put to the next available trading day. Video game conventions analyzed in this study are usually held across 3 days. The event day is therefore set at the central day of the convention.

[111] See http://www.shacknews.com/article/55601/activision-admits-flawed-guitar-hero
[112] See table IV.

8.1.5 Event study results

The following subsections will present the findings of this event study for each event type previously specified. Average abnormal returns (formula 18) and cumulative average abnormal returns (formula 21) are graphically displayed for both calculation methods. P-values of cumulative average abnormal returns using formula 26 are computed for the entire event window ($t_1 = -5, t_2 = 5$) as well as for three days ($t_1 = -1, t_2 = 1$) and five days ($t_1 = -2, t_2 = 2$). Critical value for the t-statistics is 1,960 for are 5% significance level and 1,645 for a 10% significance level. The null and the corresponding alternative hypotheses are:

H_0: Abnormal returns around events are statistically insignificant,
H_a: Abnormal returns around events are not statistically insignificant.

Announcements and release dates of video games are divided into two types of games: those that are rated for ages 16 and up and those who those who are suitable for younger audiences.[113] No such differentiation is made for release delays as only video games rated “18” are present in the sample.

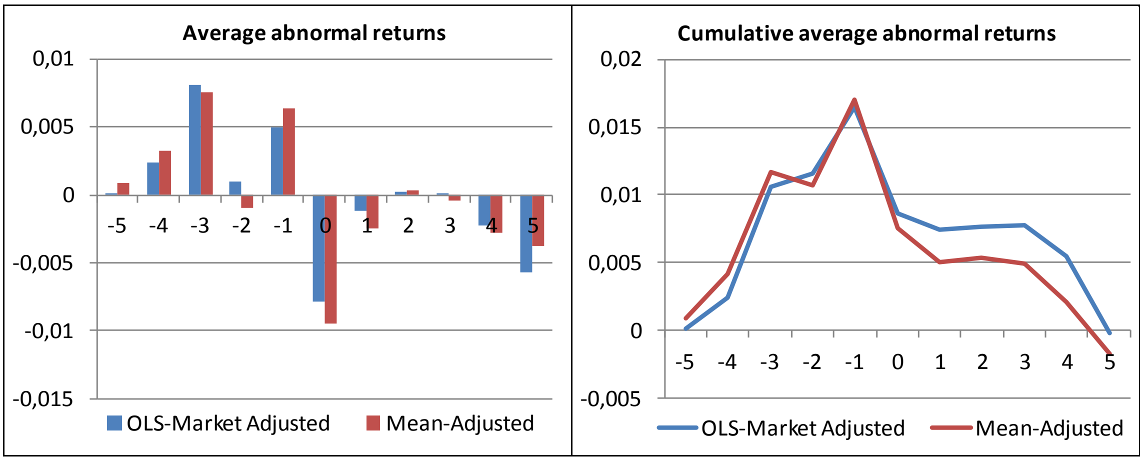
Abnormal returns around exhibitions are tested separately for all three exhibitions of the years 2006 to 2012.

8.1.5.1 Video game announcements

Video game announcements should in theory be rewarded by markets through price increases of the announcers corresponding stocks as long as they are unexpected. How

[113] Ratings by the Pan European Game Information (PEGI) were used primarily. In cases where video games have not been rated by PEGI, ratings by the Entertainment Software Rating Board were used.

markets react to announcements of video games rated below 16 (excluding) are presented below in figure VI.

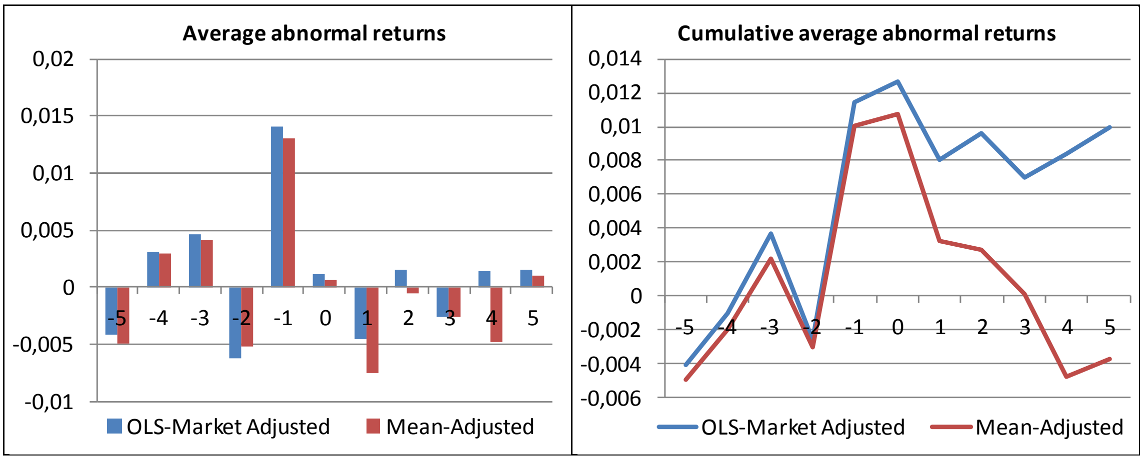


	P-values of CAARs		
	-5, +5	-2, +2	-1, +1
OLS-Market Adjusted	-0,1309	-0,2549	3,6242
Mean-Adjusted	-0,1002	3,9200	3,2799

Figure VI - Video game announcements (rating <16)

Results shown above reveal an interesting image of market's reaction. It indicates that announcements tend to leak to the public before the company officially announces them. At event date, stock prices abnormally drop by almost 1%. Observed cumulatively, these abnormal returns start to rise five days before the event, reaching more than 1.5% the day before the official announcement. Then, starting with the event date, negative abnormal returns are observed neutralizing all positive gains accumulated in the first five days. P-values of CAARs confirm this behavior. While the entire event window shows no signs of abnormal returns, the event and the two days surrounding it indicate highly significant abnormal returns. Difference between the OLS-market adjusted model and the mean-adjusted model are visible only in the p-values of CAARs of days -2 to +2, where the mean-adjusted model shows significant abnormalities and the OLS-market adjusted model doesn't.

Announcements of 16+ rated video games show somewhat different results than those rated below 16. Indications of announcement leaks are less pronounced and show only a single hike of positive abnormal returns at day -1 of almost 1,5%. Abnormal returns at the day of the event are almost nonexistent. Depending on the model of abnormal returns calculation, CAARs either return to previous levels of day -5, or remain relatively stable after the abnormal return hike. P-values, however, reveal similar results for both rating classes. Results of video games (rated 16+) announcements are displayed below in figure VII.

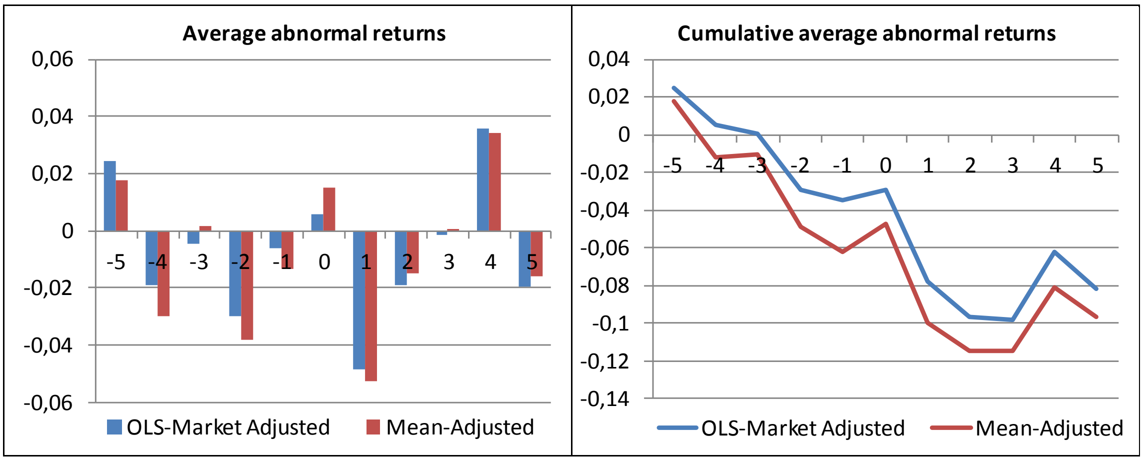


	P-values of CAARs		
	-5, +5	-2, +2	-1, +1
OLS-Market Adjusted	0,5642	0,4976	3,4741
Mean-Adjusted	-0,2117	1,9892	2,5995

Figure VII - Video game announcements (rating >=16)

8.5.1.2 Video game release delays

Delays in video games are negative news because they indicate difficulties during the development stage. Ceteris paribus, the longer the development takes, the higher the costs and the lower the profits are going to be. It is thus natural to assume that delays in video game development will cause stock prices to drop. This assumption is confirmed by the results of this analysis in figure VIII below.



	P-values of CAARs		
	-5, +5	-2, +2	-1, +1
OLS-Market Adjusted	-1,6221	-2,8735	-5,4081
Mean-Adjusted	-1,9217	-10,9914	-7,9638

Figure VIII - Video game release delays

The numbers above reveal that some information regarding the delay seem to leak before the official press release. The largest drops in stock prices, however, are recorded the day after the event – on average by almost 6%. Some of the losses are recuperated at the fourth day, but are not enough to offset previous losses. P-values confirm the negative impact of release delays. The impact is large enough to make almost the entire event window significant.

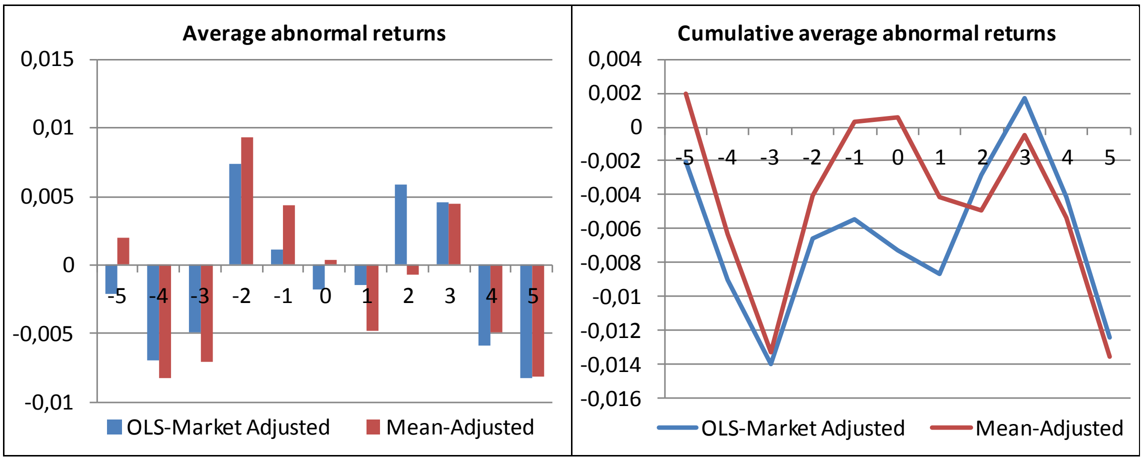
8.5.1.3 Video game release dates

The day when a video game is released can cause a lot of media attention, especially when it's a much expected title like Grand theft Auto IV or Call of Duty: Black Ops II. Video game retailers organize midnight launch sales events so that fans can buy a copy as early as possible.[114] In the eyes of the market, however, events like these aren't unexpected. Exact release dates are disclosed months before and the number of sales are

[114] See http://www.digitalspy.co.uk/gaming/news/a437706/black-ops-2-out-now-midnight-launch-images-at-hmv-game-blockbuster.html

predictable with a fair amount of accuracy.[115] Markets should therefore in theory have these numbers included in the pricing of the corresponding stocks. Hence, abnormal returns should only be recorded in case of unexpected events.

The first analysis of abnormal returns around release dates is presented for video games rated below 16, excluding annually released sports titles. Displayed in figure IX below, results reveal a somewhat negative reaction from the market, but not a particularly noteworthy one. Abnormal daily returns remain within +/-1% levels. P-values of CAARs show no significance for both model calculations in all event window lengths.



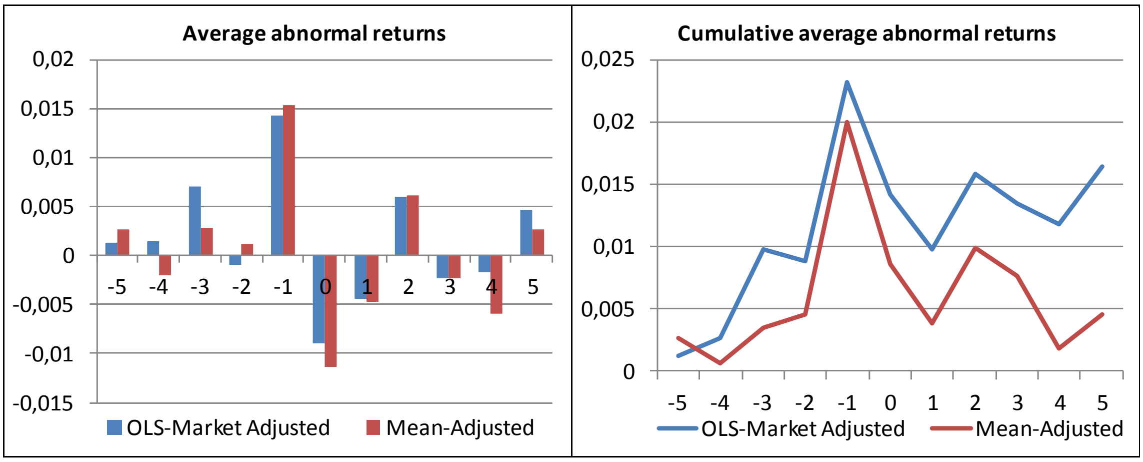
	P-values of CAARs		
	-5, +5	-2, +2	-1, +1
OLS-Market Adjusted	-0,4996	0,8918	-1,8209
Mean-Adjusted	-0,5287	-0,5307	-0,0251

Figure IX - Video game release dates (rating <16)

The next category of video games are those rated 16 and above. The results, shown in figure X below, interestingly reveal an anomaly where the day before the release, abnormally positive returns are observed followed by abnormally negative returns at the day of the event. Even though the returns are not as substantial as those caused by

[115] See Beaujon (2012)

delays, the findings are all the more remarkable because release dates are not unexpected events. P-values of CAARs the two days surrounding the event confirm the statistical significance of the event.

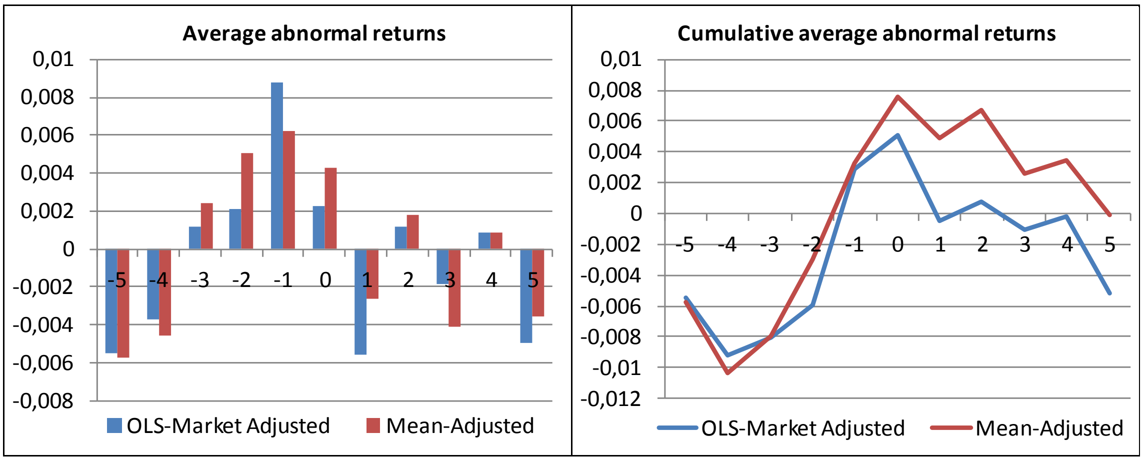


	P-values of CAARs		
	-5, +5	-2, +2	-1, +1
OLS-Market Adjusted	0,9831	0,5318	5,3934
Mean-Adjusted	0,2719	4,1689	3,7158

Figure X - Video game release dates (ratings >=16)

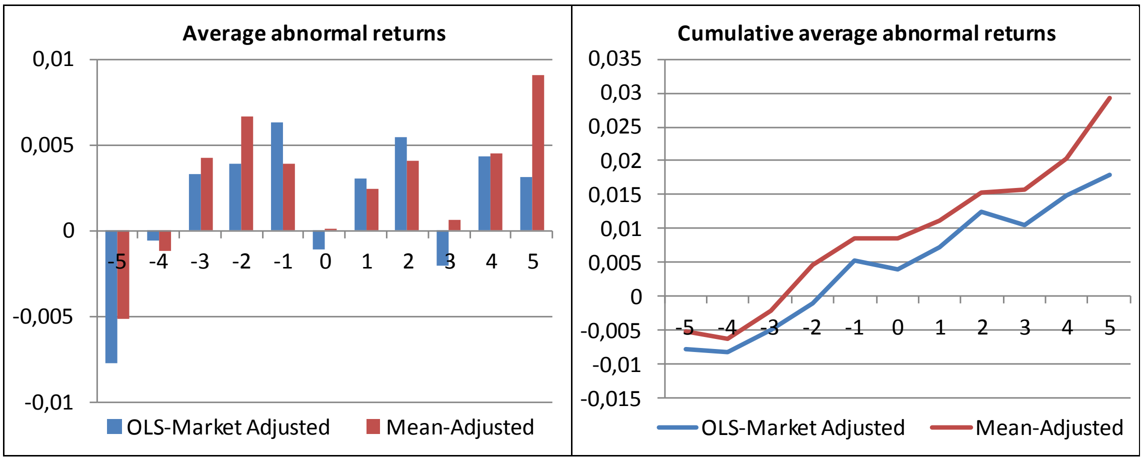
8.5.1.4 Video game exhibitions

Video game exhibitions are events where video game companies publicly present they're latest products. Journalists as well as visitors can get their first look on video games currently in development. Study of this event is somewhat complementary to video game announcements, as many video games are announced during conventions. Below in figures XI to XIII are the results of all three exhibitions from 2006 to 2012.



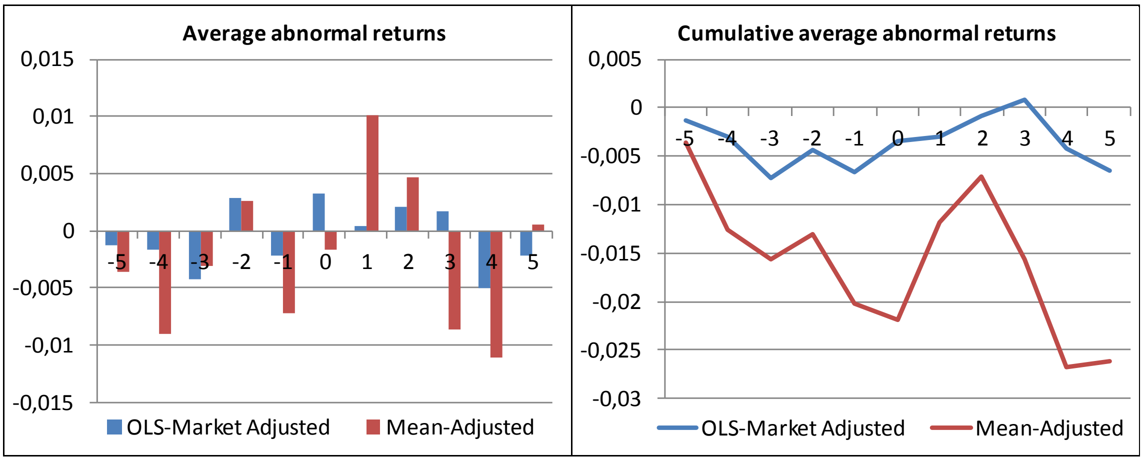
	P-values of CAARs		
	-5, +5	-2, +2	-1, +1
OLS-Market Adjusted	-0,4007	1,0083	1,1105
Mean-Adjusted	0,0055	2,2386	2,3316

Figure XI - Electronic Entertainment Expo 2006-2012



	P-values of CAARs		
	-5, +5	-2, +2	-1, +1
OLS-Market Adjusted	1,3781	1,9899	2,4169
Mean-Adjusted	2,2496	5,4866	4,1657

Figure XII - Gamescom (Games Convention) 2006-2012



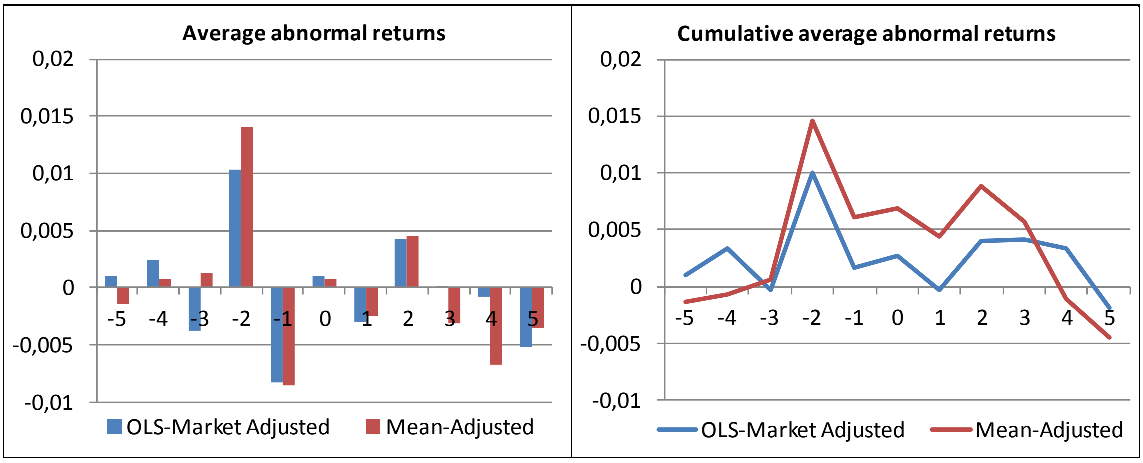
	P-values of CAARs		
	-5, +5	-2, +2	-1, +1
OLS-Market Adjusted	-0,5014	0,7290	-1,9248
Mean-Adjusted	-2,0291	-8,5151	-8,0100

Figure XIII - Tokyo Games Show 2006-2012

The findings reveal surprising results, showing three different market reactions for each convention. Electronic Entertainment Expo mimics to a certain extent the results found in video game announcements, however not to such significant levels.

Gamescom is accompanied by almost exclusively positive abnormal returns, making the entire event window significant when calculated with the mean-adjusted method. OLS-market adjusted method calculations are significant for the -2, +2 and -1, +1 event windows.

Tokyo Games Show, on the other hand, displays significantly negative results, especially when using the mean-adjusted calculation method. This, however, is caused by the 2008 Tokyo Games Show which was held in October, when the recent financial crisis was wreaking havoc across the globe. Results excluding year 2008 reveal a somewhat similar pattern to the Electronic Entertainment Expo. The findings are displayed below in figure XIV.



	P-values of CAARs		
	-5, +5	-2, +2	-1, +1
OLS-Market Adjusted	-0,1423	0,4945	0,6115
Mean-Adjusted	-0,3422	4,5884	2,5168

Figure XIV - Tokyo Games Show 2006-2012 (excluding 2008)

8.2 Summary of the video game industry event study

Findings revealed by this event study have shown an interesting behavior of video game industry stocks. While the results are mostly in line with the semi-strong form efficiency, meaning that negative unexpected event have negative impacts (release delays) and vice-versa (announcements, conventions). Expected events (release dates), however, produce significant results which contradict the efficient market hypothesis, especially with 16+ rated video games. An overview of events causing significant returns is shown below in table XIII. Fields marked with (+) show positive returns, and (-) negative returns.

Are video game-related event significant?

		Event window length		
		-5 +5	**-2 +2**	**-1 +1**
Video game announcement (rating <16)	OLS-market adj.	No (-)	No (-)	Yes (+)
	Mean-adj.	No (-)	Yes (+)	Yes (+)

Video game announcement (rating >=16)	OLS-market adj.	No (+)	No (+)	Yes (+)
	Mean-adj.	No (-)	Yes (+)	Yes (+)
Video game release delays	OLS-market adj.	No (-)	Yes (-)	Yes (-)
	Mean-adj.	No (-)	Yes (-)	Yes (-)
Video game release dates (rating <16)	OLS-market adj.	No (-)	No (+)	No (-)
	Mean-adj.	No (-)	No (-)	No (-)
Video game release dates (rating >=16)	OLS-market adj.	No (+)	No (+)	Yes (+)
	Mean-adj.	No (+)	Yes (+)	Yes (+)
Electronic Entertainment Expo 2006-2012	OLS-market adj.	No (-)	No (+)	Yes (+)
	Mean-adj.	No (+)	Yes (+)	Yes (+)
Gamescom (Games Convention) 2006-2012	OLS-market adj.	No (+)	Yes (+)	Yes (+)
	Mean-adj.	Yes (+)	Yes (+)	Yes (+)
Tokyo Game Show 2006-2012 (excl. 2008)	OLS-market adj.	No (-)	No (+)	No (+)
	Mean-adj.	No (-)	Yes (+)	Yes (+)
		-5 +5	**-2 +2**	**-1 +1**
			Event window length	

Table XIII - Summary of video game industry event study

9 Conclusion

At the beginning of this master's thesis, two goals were set: to give a compact overview of the efficient market hypothesis and to analyze the video game industry for market efficiency.

Over 80 different sources were compiled in order to achieve the first goal. Not only were the theoretical principles and major empirical findings presented, but also a guide on how to perform market efficiency studies. Special attention was paid on illustrating the different statistical test used for assessing weak-form market efficiency as well as explaining individual steps of conducting event studies.

By using the guidelines set forth in the first part, an empirical study of the video game industry was performed to answer the key question: Is the video game industry market efficient? Covering the years 2005 to 2012, both the weak-form efficiency test statistics and a broad event study were used. The overall results, however, indicate evidence which is somewhat contradicting to the efficient market hypothesis.

The weak-form efficiency tests have shown predictive patterns of video game industry's stock prices. Tests for autocorrelation and randomness of returns were passed by some individual companies, but it was failed by the video game industry as a whole. Results of the Phillips-Parron test for randomness also support the claim that the video game industry doesn't entirely follow a random walk. Neither a single company, nor the industry as a whole have passed this test.

The event study performed as part of the semi-strong form market efficiency analysis has brought somewhat similar results to those of the weak-form efficiency analysis. Unexpected video game announcements and release delays have shown significant abnormal returns surrounding the event which are in-line with the efficient market hypothesis. The most mind-boggling finding, however, has been the discovery of significantly abnormal returns which are observable around expected events such as release dates of 16+ rated video games. These results reveal that, on average, investors could have made statistically significant abnormal returns by following a simple investing pattern. The reason for such behavior, however, is unknown. More research has to be done in order to understand this anomaly. Perhaps an analysis of hourly returns surrounding the event could help to shed more light on this finding. Alternatively, the same analysis could also be performed in five years to see whether this anomaly persists. Overall, it is advised to perform further analysis of the video game industry in order to better understand its intricate behavior.

Appendix A

Date	Company	Type	Sales	Rating/Year	Description
08.11.2011	ATVI	Release	29,51	18	Call of Duty: Modern Warfare 3
09.11.2010	ATVI	Release	28,61	18	Call of Duty: Black Ops
10.11.2009	ATVI	Release	23,81	18	Call of Duty: Modern Warfare 2
13.11.2012	ATVI	Release	17,24	18	Call of Duty: Black Ops II
05.11.2012	ATVI	Release	17,12	16	Call of Duty 4: Modern Warfare
29.10.2007	ATVI	Release	16,02	12	Guitar Hero III: Legends of Rock
11.11.2008	ATVI	Release	14,59	18	Call of Duty: World at War
05.03.2009	9697:JT	Release	8,12	18	Resident Evil 5
27.03.2008	9697:JT	Release	5,36	12	Monster Hunter Freedom Unite
03.08.2009	9697:JT	Release	3,84	16	Monster Hunter Tri
02.10.2012	9697:JT	Release	3,63	18	Resident Evil 6
31.01.2008	9697:JT	Release	2,76	16	Devil May Cry 4
28.09.2010	9697:JT	Release	2,65	18	Dead Rising 2
15.02.2011	9697:JT	Release	2,12	12	Marvel vs. Capcom 3: Fate of Two Worlds
27.04.2010	9697:JT	Release	2,11	12	Super Street Fighter IV
25.10.2011	EA	Release	14,9	16	Battlefield 3
14.11.2007	EA	Release	8,27	3	Need for Speed: ProStreet
12.10.2010	EA	Release	8,13	18	Medal of Honor
02.06.2009	EA	Release	6,95	12	The Sims 3
30.10.2007	EA	Release	6,74	12	The Simpsons Game
02.03.2010	EA	Release	6,7	16	Battlefield: Bad Company 2
18.11.2008	EA	Release	6,29	12	Need For Speed: Undercover
12.06.2008	9766:JT	Release	5,71	18	Metal Gear Solid 4: Guns of the Patriots
27.10.2009	9766:JT	Release	2,23	10	Dance Dance Revolution X2
06.11.2007	9766:JT	Release	2,04	10	Dance Dance Revolution: Hottest Party
10.04.2008	7974:JT	Release	32,96	3	Mario Kart Wii
24.06.2009	7974:JT	Release	30,77	7	Wii Sports Resort
15.05.2006	7974:JT	Release	28,83	3	New Super Mario Bros.
16.11.2009	7974:JT	Release	26,21	3	New Super Mario Bros. Wii
21.05.2008	7974:JT	Release	22,73	3	Wii Fit
05.10.2009	7974:JT	Release	20,96	3	Wii Fit Plus
28.09.2006	7974:JT	Release	18,04	3	Pokémon Diamond / Pearl Version
18.11.2010	7974:JT	Release	14,53	3	Pokémon Black / White Version
17.12.2009	9684:JT	Release	6,83	16	Final Fantasy XIII

16.03.2006	9684:JT	Release	5,95	16	Final Fantasy XII
13.11.2007	9684:JT	Release	3,07	16	Crisis Core: Final Fantasy VII
23.03.2010	9684:JT	Release	3,03	18	Just Cause 2
15.12.2011	9684:JT	Release	2,85	16	Final Fantasy XIII-2
23.08.2011	9684:JT	Release	2,72	18	Deus Ex: Human Revolution
18.12.2008	9684:JT	Release	2,16	12	Dissidia: Final Fantasy
29.04.2008	TTWO	Release	20,22	18	Grand Theft Auto IV
18.05.2010	TTWO	Release	10,44	18	Red Dead Redemption
31.10.2006	TTWO	Release	5,74	18	Grand Theft Auto: Vice City Stories
17.05.2011	TTWO	Release	5,04	18	L.A. Noire
20.10.2009	TTWO	Release	4,93	18	Borderlands
20.10.2008	TTWO	Release	4,03	12	Midnight Club: Los Angeles
21.08.2007	TTWO	Release	3,92	18	BioShock
18.09.2012	TTWO	Release	3,68	18	Borderlands 2
07.10.2011	UBI.PA	Release	11,99	3	Just Dance 3
17.11.2009	UBI.PA	Release	10,52	18	Assassin's Creed II
13.11.2007	UBI.PA	Release	10,47	18	Assassin's Creed
12.10.2010	UBI.PA	Release	9,34	3	Just Dance 2
16.11.2010	UBI.PA	Release	9,11	18	Assassin's Creed: Brotherhood
15.11.2011	UBI.PA	Release	8,11	18	Assassin's Creed: Revelations
30.10.2012	UBI.PA	Release	7,21	18	Assassin's Creed III
17.11.2009	UBI.PA	Release	6,9	3	Just Dance
04.11.2010	ATVI	Announce	29,51	18	Call of Duty: Modern Warfare 3
30.04.2010	ATVI	Announce	28,61	18	Call of Duty: Black Ops
11.02.2009	ATVI	Announce	23,81	18	Call of Duty: Modern Warfare 2
09.02.2012	ATVI	Announce	17,24	18	Call of Duty: Black Ops II
25.04.2007	ATVI	Announce	17,12	16	Call of Duty 4: Modern Warfare
23.05.2007	ATVI	Announce	16,02	12	Guitar Hero III: Legends of Rock
23.06.2008	ATVI	Announce	14,59	18	Call of Duty: World at War
21.05.2008	ATVI	Announce	9,73	12	Guitar Hero: World Tour
07.02.2006	9697:JT	Announce	5,36	12	Monster Hunter Freedom Unite
19.01.2012	9697:JT	Announce	3,63	18	Resident Evil 6
06.09.2006	9697:JT	Announce	2,76	16	Devil May Cry 4
09.02.2009	9697:JT	Announce	2,65	18	Dead Rising 2
20.04.2010	9697:JT	Announce	2,12	12	Marvel vs. Capcom 3: Fate of Two Worlds
28.09.2009	9697:JT	Announce	2,11	12	Super Street Fighter IV
03.02.2011	EA	Announce	14,9	16	Battlefield 3
31.05.2007	EA	Announce	8,27	3	Need for Speed: ProStreet
05.05.2010	EA	Announce	8,13	18	Medal of Honor

19.03.2008	EA	Announce	6,95	12	The Sims 3
09.05.2007	EA	Announce	6,74	12	The Simpsons Game
05.02.2009	EA	Announce	6,7	16	Battlefield: Bad Company 2
18.06.2008	EA	Announce	6,29	12	Need For Speed: Undercover
11.06.2007	7974:JT	Announce	32,96	3	Mario Kart Wii
15.07.2008	7974:JT	Announce	30,77	7	Wii Sports Resort
21.02.2006	7974:JT	Announce	28,83	3	New Super Mario Bros.
02.06.2009	7974:JT	Announce	26,21	3	New Super Mario Bros. Wii
11.07.2007	7974:JT	Announce	22,73	3	Wii Fit
02.06.2009	7974:JT	Announce	20,96	3	Wii Fit Plus
29.01.2010	7974:JT	Announce	14,53	3	Pokémon Black / White Version
08.05.2006	9684:JT	Announce	6,83	16	Final Fantasy XIII
11.03.2010	9684:JT	Announce	2,85	16	Final Fantasy XIII-2
08.05.2007	9684:JT	Announce	2,16	12	Dissidia: Final Fantasy
09.05.2006	TTWO	Announce	20,22	18	Grand Theft Auto IV
03.02.2009	TTWO	Announce	10,44	18	Red Dead Redemption
10.05.2006	TTWO	Announce	5,74	18	Grand Theft Auto: Vice City Stories
25.09.2006	TTWO	Announce	5,04	18	L.A. Noire
14.09.2007	TTWO	Announce	4,93	18	Borderlands
16.05.2007	TTWO	Announce	4,03	12	Midnight Club: Los Angeles
02.08.2011	TTWO	Announce	3,68	18	Borderlands 2
06.06.2011	UBI.PA	Announce	11,99	3	Just Dance 3
16.04.2009	UBI.PA	Announce	10,52	18	Assassin's Creed II
03.05.2006	UBI.PA	Announce	10,47	18	Assassin's Creed
21.06.2010	UBI.PA	Announce	9,34	3	Just Dance 2
11.05.2010	UBI.PA	Announce	9,11	18	Assassin's Creed: Brotherhood
05.05.2011	UBI.PA	Announce	8,11	18	Assassin's Creed: Revelations
05.03.2012	UBI.PA	Announce	7,21	18	Assassin's Creed III
18.07.2007	9697:JT	Delay	8,12	18	Resident Evil 5
02.08.2007	TTWO	Delay	20,22	18	Grand Theft Auto IV
11.09.2007	TTWO	Delay	5,04	18	L.A. Noire
22.09.2006	ATVI	Exhibition	N/A	2006	Tokyo Games Show
22.09.2006	9697:JT	Exhibition	N/A	2006	Tokyo Games Show
22.09.2006	EA	Exhibition	N/A	2006	Tokyo Games Show
22.09.2006	9766:JT	Exhibition	N/A	2006	Tokyo Games Show
22.09.2006	7974:JT	Exhibition	N/A	2006	Tokyo Games Show
22.09.2006	9684:JT	Exhibition	N/A	2006	Tokyo Games Show
22.09.2006	TTWO	Exhibition	N/A	2006	Tokyo Games Show
22.09.2006	UBI.PA	Exhibition	N/A	2006	Tokyo Games Show

25.08.2006	ATVI	Exhibition	N/A	2006	Gamescom
25.08.2006	9697:JT	Exhibition	N/A	2006	Gamescom
25.08.2006	EA	Exhibition	N/A	2006	Gamescom
25.08.2006	9766:JT	Exhibition	N/A	2006	Gamescom
25.08.2006	7974:JT	Exhibition	N/A	2006	Gamescom
25.08.2006	9684:JT	Exhibition	N/A	2006	Gamescom
25.08.2006	TTWO	Exhibition	N/A	2006	Gamescom
25.08.2006	UBI.PA	Exhibition	N/A	2006	Gamescom
11.05.2006	ATVI	Exhibition	N/A	2006	E3
11.05.2006	9697:JT	Exhibition	N/A	2006	E3
11.05.2006	EA	Exhibition	N/A	2006	E3
11.05.2006	9766:JT	Exhibition	N/A	2006	E3
11.05.2006	7974:JT	Exhibition	N/A	2006	E3
11.05.2006	9684:JT	Exhibition	N/A	2006	E3
11.05.2006	TTWO	Exhibition	N/A	2006	E3
11.05.2006	UBI.PA	Exhibition	N/A	2006	E3
21.09.2007	ATVI	Exhibition	N/A	2007	Tokyo Games Show
21.09.2007	9697:JT	Exhibition	N/A	2007	Tokyo Games Show
21.09.2007	EA	Exhibition	N/A	2007	Tokyo Games Show
21.09.2007	9766:JT	Exhibition	N/A	2007	Tokyo Games Show
21.09.2007	7974:JT	Exhibition	N/A	2007	Tokyo Games Show
21.09.2007	9684:JT	Exhibition	N/A	2007	Tokyo Games Show
21.09.2007	TTWO	Exhibition	N/A	2007	Tokyo Games Show
21.09.2007	UBI.PA	Exhibition	N/A	2007	Tokyo Games Show
24.08.2007	ATVI	Exhibition	N/A	2007	Gamescom
24.08.2007	9697:JT	Exhibition	N/A	2007	Gamescom
24.08.2007	EA	Exhibition	N/A	2007	Gamescom
24.08.2007	9766:JT	Exhibition	N/A	2007	Gamescom
24.08.2007	7974:JT	Exhibition	N/A	2007	Gamescom
24.08.2007	9684:JT	Exhibition	N/A	2007	Gamescom
24.08.2007	TTWO	Exhibition	N/A	2007	Gamescom
24.08.2007	UBI.PA	Exhibition	N/A	2007	Gamescom
11.07.2007	ATVI	Exhibition	N/A	2007	E3
11.07.2007	9697:JT	Exhibition	N/A	2007	E3
11.07.2007	EA	Exhibition	N/A	2007	E3
11.07.2007	9766:JT	Exhibition	N/A	2007	E3
11.07.2007	7974:JT	Exhibition	N/A	2007	E3
11.07.2007	9684:JT	Exhibition	N/A	2007	E3
11.07.2007	TTWO	Exhibition	N/A	2007	E3

11.07.2007	UBI.PA	Exhibition	N/A	2007	E3
10.10.2008	ATVI	Exhibition	N/A	2008	Tokyo Games Show
10.10.2008	9697:JT	Exhibition	N/A	2008	Tokyo Games Show
10.10.2008	EA	Exhibition	N/A	2008	Tokyo Games Show
10.10.2008	9766:JT	Exhibition	N/A	2008	Tokyo Games Show
10.10.2008	7974:JT	Exhibition	N/A	2008	Tokyo Games Show
10.10.2008	9684:JT	Exhibition	N/A	2008	Tokyo Games Show
10.10.2008	TTWO	Exhibition	N/A	2008	Tokyo Games Show
10.10.2008	UBI.PA	Exhibition	N/A	2008	Tokyo Games Show
22.08.2008	ATVI	Exhibition	N/A	2008	Gamescom
22.08.2008	9697:JT	Exhibition	N/A	2008	Gamescom
22.08.2008	EA	Exhibition	N/A	2008	Gamescom
22.08.2008	9766:JT	Exhibition	N/A	2008	Gamescom
22.08.2008	7974:JT	Exhibition	N/A	2008	Gamescom
22.08.2008	9684:JT	Exhibition	N/A	2008	Gamescom
22.08.2008	TTWO	Exhibition	N/A	2008	Gamescom
22.08.2008	UBI.PA	Exhibition	N/A	2008	Gamescom
16.07.2008	ATVI	Exhibition	N/A	2008	E3
16.07.2008	9697:JT	Exhibition	N/A	2008	E3
16.07.2008	EA	Exhibition	N/A	2008	E3
16.07.2008	9766:JT	Exhibition	N/A	2008	E3
16.07.2008	7974:JT	Exhibition	N/A	2008	E3
16.07.2008	9684:JT	Exhibition	N/A	2008	E3
16.07.2008	TTWO	Exhibition	N/A	2008	E3
16.07.2008	UBI.PA	Exhibition	N/A	2008	E3
25.09.2009	ATVI	Exhibition	N/A	2009	Tokyo Games Show
25.09.2009	9697:JT	Exhibition	N/A	2009	Tokyo Games Show
25.09.2009	EA	Exhibition	N/A	2009	Tokyo Games Show
25.09.2009	9766:JT	Exhibition	N/A	2009	Tokyo Games Show
25.09.2009	7974:JT	Exhibition	N/A	2009	Tokyo Games Show
25.09.2009	9684:JT	Exhibition	N/A	2009	Tokyo Games Show
25.09.2009	TTWO	Exhibition	N/A	2009	Tokyo Games Show
25.09.2009	UBI.PA	Exhibition	N/A	2009	Tokyo Games Show
21.08.2009	ATVI	Exhibition	N/A	2009	Gamescom
21.08.2009	9697:JT	Exhibition	N/A	2009	Gamescom
21.08.2009	EA	Exhibition	N/A	2009	Gamescom
21.08.2009	9766:JT	Exhibition	N/A	2009	Gamescom
21.08.2009	7974:JT	Exhibition	N/A	2009	Gamescom
21.08.2009	9684:JT	Exhibition	N/A	2009	Gamescom

21.08.2009	TTWO	Exhibition	N/A	2009	Gamescom
21.08.2009	UBI.PA	Exhibition	N/A	2009	Gamescom
03.06.2009	ATVI	Exhibition	N/A	2009	E3
03.06.2009	9697:JT	Exhibition	N/A	2009	E3
03.06.2009	EA	Exhibition	N/A	2009	E3
03.06.2009	9766:JT	Exhibition	N/A	2009	E3
03.06.2009	7974:JT	Exhibition	N/A	2009	E3
03.06.2009	9684:JT	Exhibition	N/A	2009	E3
03.06.2009	TTWO	Exhibition	N/A	2009	E3
03.06.2009	UBI.PA	Exhibition	N/A	2009	E3
17.09.2010	ATVI	Exhibition	N/A	2010	Tokyo Games Show
17.09.2010	9697:JT	Exhibition	N/A	2010	Tokyo Games Show
17.09.2010	EA	Exhibition	N/A	2010	Tokyo Games Show
17.09.2010	9766:JT	Exhibition	N/A	2010	Tokyo Games Show
17.09.2010	7974:JT	Exhibition	N/A	2010	Tokyo Games Show
17.09.2010	9684:JT	Exhibition	N/A	2010	Tokyo Games Show
17.09.2010	TTWO	Exhibition	N/A	2010	Tokyo Games Show
17.09.2010	UBI.PA	Exhibition	N/A	2010	Tokyo Games Show
20.08.2010	ATVI	Exhibition	N/A	2010	Gamescom
20.08.2010	9697:JT	Exhibition	N/A	2010	Gamescom
20.08.2010	EA	Exhibition	N/A	2010	Gamescom
20.08.2010	9766:JT	Exhibition	N/A	2010	Gamescom
20.08.2010	7974:JT	Exhibition	N/A	2010	Gamescom
20.08.2010	9684:JT	Exhibition	N/A	2010	Gamescom
20.08.2010	TTWO	Exhibition	N/A	2010	Gamescom
20.08.2010	UBI.PA	Exhibition	N/A	2010	Gamescom
15.06.2010	ATVI	Exhibition	N/A	2010	E3
15.06.2010	9697:JT	Exhibition	N/A	2010	E3
15.06.2010	EA	Exhibition	N/A	2010	E3
15.06.2010	9766:JT	Exhibition	N/A	2010	E3
15.06.2010	7974:JT	Exhibition	N/A	2010	E3
15.06.2010	9684:JT	Exhibition	N/A	2010	E3
15.06.2010	TTWO	Exhibition	N/A	2010	E3
15.06.2010	UBI.PA	Exhibition	N/A	2010	E3
16.09.2011	ATVI	Exhibition	N/A	2011	Tokyo Games Show
16.09.2011	9697:JT	Exhibition	N/A	2011	Tokyo Games Show
16.09.2011	EA	Exhibition	N/A	2011	Tokyo Games Show
16.09.2011	9766:JT	Exhibition	N/A	2011	Tokyo Games Show
16.09.2011	7974:JT	Exhibition	N/A	2011	Tokyo Games Show

16.09.2011	9684:JT	Exhibition	N/A	2011	Tokyo Games Show
16.09.2011	TTWO	Exhibition	N/A	2011	Tokyo Games Show
16.09.2011	UBI.PA	Exhibition	N/A	2011	Tokyo Games Show
19.08.2011	ATVI	Exhibition	N/A	2011	Gamescom
19.08.2011	9697:JT	Exhibition	N/A	2011	Gamescom
19.08.2011	EA	Exhibition	N/A	2011	Gamescom
19.08.2011	9766:JT	Exhibition	N/A	2011	Gamescom
19.08.2011	7974:JT	Exhibition	N/A	2011	Gamescom
19.08.2011	9684:JT	Exhibition	N/A	2011	Gamescom
19.08.2011	TTWO	Exhibition	N/A	2011	Gamescom
19.08.2011	UBI.PA	Exhibition	N/A	2011	Gamescom
07.06.2011	ATVI	Exhibition	N/A	2011	E3
07.06.2011	9697:JT	Exhibition	N/A	2011	E3
07.06.2011	EA	Exhibition	N/A	2011	E3
07.06.2011	9766:JT	Exhibition	N/A	2011	E3
07.06.2011	7974:JT	Exhibition	N/A	2011	E3
07.06.2011	9684:JT	Exhibition	N/A	2011	E3
07.06.2011	TTWO	Exhibition	N/A	2011	E3
07.06.2011	UBI.PA	Exhibition	N/A	2011	E3
21.09.2012	ATVI	Exhibition	N/A	2012	Tokyo Games Show
21.09.2012	9697:JT	Exhibition	N/A	2012	Tokyo Games Show
21.09.2012	EA	Exhibition	N/A	2012	Tokyo Games Show
21.09.2012	9766:JT	Exhibition	N/A	2012	Tokyo Games Show
21.09.2012	7974:JT	Exhibition	N/A	2012	Tokyo Games Show
21.09.2012	9684:JT	Exhibition	N/A	2012	Tokyo Games Show
21.09.2012	TTWO	Exhibition	N/A	2012	Tokyo Games Show
21.09.2012	UBI.PA	Exhibition	N/A	2012	Tokyo Games Show
17.08.2012	ATVI	Exhibition	N/A	2012	Gamescom
17.08.2012	9697:JT	Exhibition	N/A	2012	Gamescom
17.08.2012	EA	Exhibition	N/A	2012	Gamescom
17.08.2012	9766:JT	Exhibition	N/A	2012	Gamescom
17.08.2012	7974:JT	Exhibition	N/A	2012	Gamescom
17.08.2012	9684:JT	Exhibition	N/A	2012	Gamescom
17.08.2012	TTWO	Exhibition	N/A	2012	Gamescom
17.08.2012	UBI.PA	Exhibition	N/A	2012	Gamescom
06.06.2012	ATVI	Exhibition	N/A	2012	E3
06.06.2012	9697:JT	Exhibition	N/A	2012	E3
06.06.2012	EA	Exhibition	N/A	2012	E3
06.06.2012	9766:JT	Exhibition	N/A	2012	E3

06.06.2012	7974:JT	Exhibition	N/A	2012	E3
06.06.2012	9684:JT	Exhibition	N/A	2012	E3
06.06.2012	TTWO	Exhibition	N/A	2012	E3
06.06.2012	UBI.PA	Exhibition	N/A	2012	E3

Bibliography

Ahren, Kenneth R., Sample selection and event study estimation, Journal of Empirical Finance, Volume 16, 2009, pp. 466-482

Androvich, Mark, GTA IV: Most expensive game ever developed?, 30.05.2008, Gamesindutstry.biz, http://www.gamesindustry.biz/articles/gta-iv-most-expensive-game-ever-developed

Ariel, Robert A., High Stock Returns before Holidays: Existence and Evidence on Possible Causes, The Journal of Finance, Volume 45, Issue 5, 1990, pp. 1611-1626

Awad, Ibrahim, Daraghma, Zahran, Testing the Weak-Form Efficiency of the Palestinian Securities Market, International Research Journal of Finance and Economics, Issue 32, 2009, pp. 7-16

Baker, H. Kent, Nofsinger, John R., Behavioral finance: investors, corporations, and markets, John Wiley & Sons, 2010, p. 3

Ball, Ray, Brown, Philip, An Empirical Evaluation of Accounting Income Numbers, Journal of Accounting Research, Volume 6, Number 2, 1968, pp. 159-178

Beaujon, W. S., Predicting Video Game Sales in the European Market, Vrije Universiteit Amsterdam, 2012, available at http://www.few.vu.nl/en/Images/werkstuk-beaujon_tcm39-264134.pdf

Bernard, Victor L., Thomas, Jacob K., Evidence That Stock Prices Do Not Fully Reflect the Implication of Current Earnings for Future Earnings, Journal of Accounting and Economics, Volume 13, 1990, pp. 305-340

Binder, John J., The Event Study Methodology Since 1969, Review of Qualitative Finance and Accounting, Volume 11, 1998, pp. 111-137

Brown, Stephen J., Warner, Jerold B., Measuring Security Prices Performance, Journal of Financial Economics, Volume 8, Issue 3, 1980, pp. 205-258

Brown, Stephen J., Warner, Jerold B., Using Daily Stock Returns: The Case of Event Studies, Journal of Financial Economics, Volume 14, Issue 1, 1985, pp. 3-31

Buffet, Warren E., The Superinvestors of Graham-and-Doddsville, 1984, reprinted in Graham, Benjamin, Zweig, Jason, The Inteligent Investor Revised Edition, HarperCollins Publishers, 2006, pp. 537-560

Büning, Herbert, Trenkler, Götz, Nichtparametrische statistische Methoden, 2. Auflage, Walter de Gruyter, 1994

Campbell, John Y., Lo, Andrew W., MacKinlay, A. Craig, The Econometrics of Financial Markets, Princeton University Press, 1996

Clarke, Jonathan, Jandik, Tomas, Mandelker, Gershon, The Efficient Market Hypothesis, in Expert Financial Planning: Advice from Industry Leaders, ed. Arffa, Robert C., Wiley & Sons, 2001

Charest, Guy, Dividend information, stock returns, and market efficiency – II, Journal of Financial Economics, Volume 6, Issues 2-3, 1978, pp. 297-330

Corrado, Charles J., Zivney, Terry L., The Specification and Power of the Sign Test in Event Study Hypothesis Test Using Daily Stock Returns, The Journal of Financial and Qualitative Analysis. Volume 27, Number 3, 1992, pp. 465-478

Corrado, Charles J., Event Studies; A Methodology Review, 2010, available at SSRN: http://ssrn.com/abstract=1441581

Cootner, Paul H., The Random Character of Stock Market Prices, M.I.T. Press, 1964

Cross, Frank, The behavior of stock prices on Fridays and Mondays, Financial Analysts Journal, Volume 29, Number 6, 1973, pp. 67-69

Cross, Tim, All the world's a game, The Economist, 10.12.2011, http://www.economist.com/node/21541164

De Bondt, Werner F. M., Thaler, Richard, Does the Stock Market Overreact?, The Journal of Finance, Volume 40, Number 3, 1985, pp. 793-805

De Jong, Frank, Event Studies Methodology, Telburg University, 2007, available at http://www.tilburguniversity.edu/research/institutes-and-research-groups/center/staff/dejong/preprints/eventstudies.pdf

Dickey, David A., Fuller, Wayne A., Distribution of Estimators for Autoregressive Time Series With a Unit Root, Journal of the American Statistical Association, Volume 74, Number 366, 1979, pp. 427-431

Dodd, Peter, Merger proposals, management discretion and stock holder wealth, Journal of Financial Economics, Volume 8, Issue 2, 1980, pp. 105-137

Dolly, James C., Common Stock Split-Ups Motives and Effects, Harvard Business Review, Volume 12, 1933, pp. 70-81

Dritsaki, Chaido, Random Walk Hypothesis and Correlation in the Visegrad Countries Emerging Stock Markets, The Romanian Economic Journal, Number 40, 2011, pp. 25-56

Elliott, Graham, Rothenberg, Thomas J., Stock, James H., Efficient Tests for an Autoregressive Unit Root, Econometrica, Volume 64, Number 4, 1996, pp. 813-836

Fama, Eugene F., The Behavior of Stock-Market Prices, The Journal of Business, Vol. 38, No. 1, 1965, pp. 34-105

Fama, Eugene F., Efficient Capital Markets: A Review of Theory and Empirical Work, The Journal of Finance, Volume 25, Issue 2, 1970, pp. 383-417

Fama, Eugene F., Efficient Capital Markets: II, The Journal of Finance, Volume 36, Number 5, 1991, pp. 1575-1617

Fama, Eugene F., Fisher, Lawrence, Jensen, Michael C., Roll, Richard, The Adjustment of Stock Prices to New Information, International Economic Review, Volume 10, Number 1, 1969, pp. 1-21

Fama, Eugene F., French, Kenneth R., Multifactor Explanation of Asset Pricing Anomalies, Journal of Finance, Volume 51, Issue 1, 1996, pp. 55-84

Faylor, Chris, Activision Admits Flawed Guitar Hero World Tour Drums, Shack News, 28.10.2008, http://www.shacknews.com/article/55601/activision-admits-flawed-guitar-hero

Fischer Black, Myron Scholes: The Pricing of Options and Corporate Liabilities. In: Journal of Political Economy. 81, 3, 1973, ISSN 0022-3808, pp. 637–654

French, Kenneth R., Stock returns and the weekend effect, Journal of Financial Economics, Volume 8, Issue 1, 1980, pp. 55-69

Geyskens, Inge, Gielens, Katrijn, Dekimpe, Marnik G., The Market Valuation of Internet Channel Additions. Jounral of Marketing, Volume 66, Number 2, 2002, pp. 102-119

Graft, Kris, Stardock Reveals Impulse, Steam Market Share Estimates, Gamasutra, 19.11.2009, http://www.gamasutra.com/php-bin/news_index.php?story=26158#.UNBnzXfkJwE

Graham, Benjamin, Dodd, David, Security Analysis: Sixth Edition, McGraw-Hill, 2008

Görke, Björn, Event Studies, Christian-Albrechts-Universität Kiel, 2009, available at: http://www.bwl.uni-kiel.de/bwlinstitute/grad-kolleg/new/typo3conf/ext/naw_securedl/secure.php?u=0&file=/fileadmin/publications/pdf/event_studies_goerke.pdf&t=1238628987&hash=3bd9cdc8bafc77dab254255a3480022c

Grossman, Stanford J., Stiglitz, Joseph E., On the Impossibility of Informationally Efficient Markets, The American Economic Review, Volume 70, Issue 3, 1980, pp. 393-408

Hamid, Kashif, Suleman, Mohammed T., Ali Shah, Syed Z., Imdad Akash, Rana S., Testing the Weak form of Efficient Market Hypothesis: Empirical Evidence from Asia-

Pacific Markets, International Research Journal of Finance and Economics, Issue 58, 2010, pp. 121-133

Jaffe, Jeffrey F., Special Information and Insider Trading, The Journal of Business, Volume 47, Number 3, 1974, pp. 410-428

Khotari, S. P., Warner, Jerold B., The Econometrics of Event Studies, 2004, available at SSRN: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=608601

Krivin, Dmitry, Patton, Robert, Rose, Erica, Tabak, David, Determination of the Appropriate Event Window Length in Individual Stock Event Studies, 2003, available at SSRN: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=466161

Kwiatkowski, Denis, Phillips, Peter C. B., Schmidt, Peter, Shin, Yongcheol, Testing the null hypothesis of stationarity against the alternative of a unit root, Journal of Econometrics, Volume 54, Issue 1-3, 1992, pp. 159-178

Lakonishok, Josef, Shleifer, Andrei, Vishny, Robert W., Contrarian Investment, Extrapolation, and Risk, The Journal of Finance, Volume 49, Number 5, 1994, pp 1541-1578

Lamoureux, Christopher G., Poon, Percy, The Market Reaction to Stock Splits, The Journal of Finance, Volume 42, Number 5, 1987, pp. 1347-1370

Li, Xiaofeng, Tests of Stock Market Efficiency in China and Japan, Masters's Thesis in Economics of Innovation and Growth in KTH, Stockholm, 2008, available at http://www.kth.se/polopoly_fs/1.169200!/Menu/general/column-content/attachment/Xiaofeng%20Li.pdf

Libanio, Gilberto A., Unit roots in macroeconomic time series: theory, implications and evidence, Nova Economia, Volume 15, Issue 3, 2005, pp. 145-175

Lim, Kian-Ping, Brooks, Robert D., The Evolving and Relative Efficiencies of Stock Markets: Empirical Evidence from Rolling Bicorrelation Test Statistics, SSRN Working Paper, 2006, available at http://papers.ssrn.com/sol3/papers.cfm?abstract_id=931071

Lima, Eduardo J. A., Tabak, Benjamin M., Tests of the random walk hypothesis for equity markets: evidence from China, Hong Kong and Singapore, Applied Economics Letters, Volume 11, Issue 4, 2004, pp. 255-258

Ljung, Greta M., Box, George E. P., On a measure of lack of fit in time series models, Biometrika, Volume 65, Issue 2, 1978, pp. 297-303

Lo, Andrew, MacKinley, Craig, Stock Markets Do Not Follow Random Walks: Evidence from a Simple Specification Test, Review of Financial Studies, Volume 1, Issue 1, 1988, pp. 41-66

Lo, Andrew W., Reconciling Efficient Markets with Behavioral Finance: The Adaptive Market Hypothesis, Journal of Investment Consulting, Volume 7, Number 2, 2005, pp. 21-44

Lo, Andrew W., Efficient Market Hypothesis, in Durlauf, Steven N., Blume, Lawrence E., The New Palgrave: A Dictionary of Economics, Palgrave Macmillan, 2008

MacKinlay, A. Craig, Event Studies in Economics and Finance, Journal of Economic Literature, Volume 35, Issue 1, 1997, pp. 13-39

Maddala, G. S., Kim, In-Moo, Unit Roots, Cointegration, and Structural Change, Cambridge University Press, 1st edition, 1999

Malkiel, Burton, A Random Walk Down Wall Street, W.W. Norton & Company Inc., 1973

Malkiel, Burton G., The Efficient Market Hypothesis and Its Critics, Journal of Economic Perspectives, Volume 17, Number 1, 2003, pp. 59-82

Modigliani, Franco, Miller, Merton H., The Cost of Capital, Corporation Finance and the Theory of Investment, The American Economic Review, Volume 48, Number 3, 1958, pp. 261-297

Mookerjee, Rajen, Yu, Qiao, An empirical analysis of the equity markets in China, Review of Financial Economics, Volume 8, Issue 1, 1999, pp. 41-60

Ng, Serena, Perron, Pierre, Lag length selection and the construction of unit root tests with good size and power, Econometrica, Volume 69, Number 6, 2001, pp. 1519-1554

Patell, James M., Corporate Forecasts of Earnings Per Share and Stock Price Behavior: Empirical Test, Journal of Accounting Research, Volume 14, Number 2, 1976, pp. 246-276

Pepitone, Julianne, Analysts sour on Facebook after Zynga's downbeat outlook, CNN Money, October 11, 2012, available at:
http://money.cnn.com/2012/10/11/technology/social/facebook-zynga/

Phillips, Peter C. B., Perron, Pierre, Testing for a unit root in time series regression, Biometrika, Volume 75, Issue 2, 1988, pp. 335-346

Reynolds, Matthew, Black Ops 2 out now: midnight launch images at HMV, GAME, Blockbuster, Digital Spy, 13.11.2012, http://www.digitalspy.co.uk/gaming/news/a437706/black-ops-2-out-now-midnight-launch-images-at-hmv-game-blockbuster.html

Roberts, Brian E., Political Institutions, Policy Expectations, and the 1980 Election: A Financial Market Perspective, American Journal of Political Science, Volume 34, Issue 2, 1990, pp. 289-310

Rozeff, Michael S., Zaman, Mir A., Market Efficiency and Insider Trading: New Evidence, Journal of Business, Volume 61, Number 1, 1988, pp. 25-44

Ryan, Kevin F., Giles, David E.A., Testing for Unit Roots in Economic Time-Series with Missing Observations, University of Victoria, 1998, available at: http://web.uvic.ca/econ/research/papers/wp98-02.pdf

Sharpe, William F., Alexander, Gordon J., Bailey, Jeffrey V., Investments, 6th international edition, Prentice Hall, 1999

Schwert, G. William, Using Financial Data to Measure Effects of Regulation, Journal of Law and Economics, Volume 24, Issue 1, 1981, pp. 121-158

Schwert, William G., Test for Unit Roots: A Monte Carlo Investigation, Journal of Business & Economic Statistics, Volume 7, Number 2, 1989, pp. 147-159

Serra, Ana Paula, Event Study Tests: A Brief Survey. Gestão.Org-Revista Electrónica de Gestão Organizacional, Volume. 2, Number 3, 2004, pp. 248-255. Available at SSRN: http://ssrn.com/abstract=1066816

Sewell, Martin, Behavioural Finance, University of Cambridge, 2010, available at http://www.behaviouralfinance.net/behavioural-finance.pdf

Seyhun, Nejat H., Insiders‘ Profits, Costs, of Trading, and Market Efficiency, Journal of Financial Economics, Volume 16, Issue 2, 1986, pp. 189-212

Tassi, Paul, Black Ops 2 Sells $1B in 15 Days, Beats Modern Warfare 3 Record, Forbes, 05.12.2012, http://www.forbes.com/sites/insertcoin/2012/12/05/black-ops-2-sells-1b-in-15-days-ties-modern-warfare-3-record/

Thadewald, Thorsten, Büning, Herbert, Jarque-Bera Test and its Competitiors for Testing Normalitiy – A Power Comparison, Diskusionsbeiträge des Fachbereichs Wirtschaftwissenschaft der Freien Universität Berlin, Nr. 2004/9, 2004, available at http://www.wiwiss.fu-berlin.de/verwaltung-service/bibliothek/diskussionsbeitraege/diskussionsbeitraege-wiwiss/files-diskussionsbeitraege-wiwiss/discpaper09_04.pdf

Martin Račko, BSc

Personal information

Place of birth:	Bratislava, Slovakia
Nationality:	Slovakia

Education

10/2010 – present	***Master's Degree Business Administration****,* University of Vienna
02/2009 – 06/2009	***Erasmus Student Exchange Program****,* Universidad de Alcalá, Spain
10/2006 – 06/2010	***Bachelor's Degree Business Administration****,* University of Vienna
09/1998 – 06/2006	**Mercury High School** in Bratislava

Work experience

05/2012 – present	**givemeabroker.com**, Co-founder, Web developer and designer
09/2011 – 03/2012	**Unitas Solidaris**, Internship – Audit assistant
10/2009 – 01/2010, **10/2007 – 01/2009**	**Faculty IT-Support**, Student assistent, University of Vienna

Academic honors and awards

Accenture Campus Challenge 2011

- Development of a company-wide sustainability program, 2nd place out of 75 teams from Germany, Switzerland and Austria

Excellence scholarship for the academic year 2006/2007, University of Vienna

Languages

Slovak	Mother tongue
German	Fluent
English	Fluent
Spanish	Advanced