INFORMATION TECHNOLOGY SECTOR: STOCK MARKET PERSPECTIVE

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ABSTRACT

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Title Information Technology Sector: stock market perspective	
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The purpose of this work is to find out how different industries in the IT sector have behaved in the stock market of the United States. The material to be used for research is from 2003 to 2021. The six industries in the IT sector are represented by the industry indices of companies listed on the S&P 500. The stocks are divided into industries according to The Global Industry Classification Standard. As expected, there is a strong correlation between industries, due to their interdependence in business activities. The stock market development of the industries has been studied with relevant indicators that also take risk into account. The most successful industry is technology hardware, storage & peripherals. The results show that the whole sector has done well in the 21st century and managed to achieve the highest weight in the S&P 500 index, and many of the world's most valuable companies come from the IT sector. The success of the IT sector and related factors have been comprehensively opened in the sector review.

In the study regression analysis is conducted to explain the success of the industry indices. The degree of explanation is tested against factor models. The factor models used in the study are Fama–French three-factor model, Carhart four-factor model, and Fama–French five-factor model. The study finds statistically significant alpha coefficients from the used factor models, but their statistical significance is low. As a result, factor models cannot be used to achieve excess returns in the selected industry indices. The explanatory rates of the models are close to each other and the addition of factors does not make a significant improvement in the explanatory rate of the model.

Key words
Stock market, United States, IT sector, factor model, regression analysis, VAR

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Tämän työn tarkoituksena on selvittää kuinka IT-sektorin eri toimialojen osakkeet ovat kehittyneet Yhdysvaltojen osakemarkkinoilla. Käytettävä aineisto on vuodesta 2003 vuoteen 2021 asti ja koostuu IT-sektorin sisältämistä kuudesta eri toimialasta. Toimialaindeksit pitävät sisällään S&P 500 listattuja osakkeita, jotka määritellään The Global Industry Classification Standardin mukaisesti kuuluvaksi tietylle toimialalle. Toimialojen välillä on odotetusti vahvaa korrelaatiota, koska toimialojen liiketoiminnat liittyvät toisiinsa ja ne täydentävät toisiaan tuotteiden sekä palveluiden osalta. Toimialaindeksien osakemarkkinakehitystä on tutkittu relevanteilla mittareilla jotka ottavat myös riskin huomioon. Toimialoista parhaiten on menestynyt technology hardware, storage & peripherals. Tuloksista huomataan, että koko sektori on menestynyt hyvin 2000-luvulla ja onnistunut saavuttaamaan suurimman painoarvon S&P 500 indeksissä. Tämän lisäksi moni maailman arvokkaimmista yhtiöistä tulee juuri IT-sektorilta. IT-sektorin menestystä ja siihen liittyviä tekijöitä on avattu kattavasti sektorikatsauksessa.

Tutkielmassa toteutetaan regressioanylyysi toimialaindeksien ja faktorimallien välillä, tarkoitus on tutkia kuinka paljon faktorimallit pystyvät selittämään eri toimialojen kehityksestä. Tutkimuksessa käytetyt faktorimallit ovat Faman ja Frenchin kolmen faktorin malli, Carhartin neljän faktorin malli ja Faman ja Frenchin viiden faktorin malli. Tutkimuksessa havaitaan tilastollisesti merkittäviä alphakertoimia käytetyillä faktorimalleilla, mutta niiden tilastollinen merkittävyys on heikolla tasolla. Täten faktorimallien avulla ei voida saavuttaa ylituottoa valituissa toimialaindekseissä. Eri mallien selitysasteet ovat hyvin lähellä toisiaan ja faktorien lisäämisellä ei saavuteta merkittävää parannusta mallin selitysasteeseen.

Asiasanat
Osakemarkkina, Yhdysvallat, IT-sektori, faktorimalli, regressioanalyysi, VAR

Säilytyspaikka
Jyväskylän yliopiston kirjasto

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1 INTRODUCTION

1.1 Motivation

The information technology (IT) sector is one of the fastest evolving business areas and it provides the basis for almost all other sectors. IT sector includes many different types of business models which allow great growth opportunities. According to the predictions before 2023 half of the worldwide GDP is generated by digitally transformed enterprises. (IDC FutureScape, 2019) The study conducted for the investment banking industry found out that the companies which invest heavily in IT innovations outperform their industry peers in the stock market. IT investments can streamline operations, reduce manual processes, and create savings. This effect has been visible in many different industries, especially in traditional business models where the amount of manual work has been bigger. (Boasson & Boasson, 2006)

The information technology sector has been one of the most successful sectors from year to year in terms of stock market development and weight in indices. In addition to this, it has developed existing services as well as created many new ones. With the development of the IT sector, the nature of the whole economy has changed. The development of the IT sector has automated many processes and entire jobs. However, according to forecasts, we are only at the beginning when artificial intelligence and machine learning will be able to take development considerably further than at present. While development will reduce jobs, it is not a negative thing, in the long run, the work shifts to different areas which are more complex. (Afonasova et al., 2019; IDC FutureScape, 2019)

1.2 Research questions

The purpose of the thesis is to go through the extensive field of the IT sector and its different industries, clarify their correlation and interdependence. The research examines the success of the industries and answers the research question: How have the industries performed in the IT sector during the past 18 years? The question is answered by getting acquainted with the stock exchange behavior of industries by many different indicators. The second research question addresses the explanatory power of factor models behind the success of industries. What is the degree of explanation of factor models behind the success of different industries in the sector? Factor models have a different number of explanatory factors thus in addition to this, it will be seen whether better results are obtained by increasing the number of explanatory factors. Factor models are also used to see whether the IT sector has achieved excess returns, taking into account the risks described by the factors. Besides factor models, research has been continued with vector autoregression to detect interdependencies between industries.

The thesis is done by presenting relevant theories from the area of finance, using them to interpret and evaluate the results. The source material is carefully selected based on its relevance to the study. Sources are estimated for example the number of citations, the reputation of the authors, and the publication journal's relevance is evaluated publication forum's significance level to each journal. In support of research questions, the IT sector and the interdependence of its industries are discussed extensively and internal factors in the IT sector are presented broadly.

1.3 The structure

The structure of the thesis is following, chapter two includes the framework for the study, the chapter opens the composition of the IT sector and dynamics between the actors. Chapter three presents the relevant theories related to the conducted study. Chapter four opens in more detail the used data set and methodology. Chapter five summarizes and interprets the results and examines the underlying causes.

2 FRAMEWORK

S&P Dow Jones Indices have created S&P 500 stock market index in 1957. S&P 500 tracks the stocks of 500 large-cap United States (U.S.) companies. It is a float-adjusted market-cap-weighted index that is widely regarded and provides the comprehensive benchmark of the stock market in the United States. The total market capitalization for the S&P 500 companies is 33,4 trillion USD as of December 31, 2020. S&P 500 index is generally seen as the market portfolio for the U.S. market. Individual investors and mutual funds are comparing performance to the index. From 1957 to 2020 it has had nominal annual returns of 11,79%. (S&P Dow Jones Indices, 2021)

In 1999, MSCI and S&P Dow Jones Indices developed the Global Industry Classification Standard (GICS). According to GICS, there are four different levels of hierarchy in the classification, presented in figure 1. The purpose of the GICS is to provide a clear and efficient tool for investment uses and for following the evolution of sectors. Companies are classified into the categories quantitatively and qualitatively. Each company can be only part of one sub-industry according to its principal business activity. Factors that affect each company's position in the classification are revenue by segments, earnings, and market perception. Profiling companies to individual categories is challenging because many of the companies from the IT sector are growing rapidly and trying to expand their product and/or service portfolio to the other industries in the sector. Classifications are revised annually and updated if necessary. (The Global Industry Classification Standard, 2021)

Figure 1 Global Industry Classification Standard (The Global Industry Classification Standard, 2021)

2.1 Information technology sector

Information technology is based on an older term electronic data processing (EDP), during the 21st-century computers have become so close to our everyday lives that this has become new normal. It is rare that information is handled, processed, and stored manually in 2021. From electronic data processing society is moved to an era of information and communications technology (ICT). The ways to communicate have evolved during recent decades and communication via electronic devices has become part of everyday life. This leads to the term information technology (IT) which is the most common term to describe the nature of the sector.

Under the GICS there are 11 sectors, in this study, the information technology sector is the subject of research. The IT sector is divided into industry groups and industries which specify the business areas into more exact categories, presented in table 1. In the conducted study, these six industries from the IT sector are the key elements.

Table 1 The information technology sector (The Global Industry Classification Standard, 2021)

Sector	Industry group	Industry
Information technology	Software & services	IT services
		Software
	Technology hardware & equipment	Communications equipment
		Technology hardware, storage & peripherals
		Electronic equipment, instruments & components
	Semiconductors & semiconductor equipment	Semiconductors & semiconductor equipment

Industries are divided into sub-industries which are represented in table 2. When the industry's line of business is wide it can include several sub-industries. The sub-industry is the lowest level of GICS classification for the individual stocks. For the IT sector, there are 13 different sub-industries, names of the sub-industries specify the industries to more specific categories which help to understand the overall picture.

Table 2 IT Industries (The Global Industry Classification Standard, 2021)

Industry	Sub-industry
IT Services	IT Consulting & Other Services Data Processing & Outsourced Services Internet Services & Infrastructure
Software	Application Software Systems Software
Communications Equipment	Communications Equipment
Technology Hardware, Storage & Peripherals	Technology Hardware, Storage & Peripherals
Electronic Equipment, Instruments & Components	Electronic Equipment & Instruments Electronic Components Electronic Manufacturing Services Technology Distributors
Semiconductors & Semiconductor Equipment	Semiconductor Equipment Semiconductors

Each sub-industry has specific rules on what kind of stocks it can include. Definitions for sub-industries are shown in table 3. The table also provides information on how wide the IT sector it is. GICS has found clear processes for stock classification, and this system provides specific information for stock market purposes comprehensively.

Table 3 Sub-industry definitions (The Global Industry Classification Standard, 2021)

Sub-industry	Definitions
IT Consulting & Other Services	Providers of information technology and systems integration services not classified in the Data Processing & Outsourced Services Sub-Industry. Includes information technology consulting and information management services.
Data Processing & Outsourced Services	Providers of commercial electronic data processing and/or business process outsourcing services. Includes companies that provide services for back-office automation.
Internet Services & Infrastructure	Companies providing services and infrastructure for the internet industry including data centers and cloud networking and storage infrastructure. Also includes companies providing web hosting services. Excludes companies classified in the Software Industry.
Application Software	Companies engaged in developing and producing software designed for specialized applications for the business or consumer market. Includes enterprise and technical software as well as cloud-based software. Excludes companies classified in the Interactive Home Entertainment Sub-Industry. Excludes companies classified in the Home Entertainment Software Sub-Industry. Also excludes companies producing systems or database management software classified in the Systems Software Sub-Industry.
Systems Software	Companies engaged in developing and producing systems and database management software.
Communications Equipment	Manufacturers of communication equipment and products, including LANs, WANs, routers, telephones, switchboards and exchanges. Excludes cellular phone manufacturers classified in the Technology Hardware, Storage & Peripherals Sub-Industry.

Technology Hardware, Storage & Peripherals	Manufacturers of cellular phones, personal computers, servers, electronic computer components and peripherals. Includes data storage components, motherboards, audio and video cards, monitors, keyboards, printers, and other peripherals. Excludes semiconductors classified in the Semiconductors Sub-Industry.
Electronic Equipment & Instruments	Manufacturers of electronic equipment and instruments including analytical, electronic test and measurement instruments, scanner/barcode products, lasers, display screens, point-of-sales machines, and security system equipment.
Electronic Components	Manufacturers of electronic components. Includes electronic components, connection devices, electron tubes, electronic capacitors and resistors, electronic coil, printed circuit board, transformer and other inductors, signal processing technology/components.
Electronic Manufacturing Services	Producers of electronic equipment mainly for the OEM (Original Equipment Manufacturers) markets.
Technology Distributors	Distributors of technology hardware and equipment. Includes distributors of communications equipment, computers & peripherals, semiconductors, and electronic equipment and components.
Semiconductor Equipment	Manufacturers of semiconductor equipment, including manufacturers of the raw material and equipment used in the solar power industry.
Semiconductors	Manufacturers of semiconductors and related products, including manufacturers of solar modules and cells.

In table 4 industry representation is presented, it shows the number of stocks and the market values of the indices. All the stocks are constituents of the S&P500 index. The period for this is 01.05.2003–20.01.2021. It is remarkable how much the balances of the industries have been varying over time. Considering the number of shares, at the moment IT services are representing the majority but the semiconductor industry has had the largest weight during the period. Measured at market value the software industry has been the most dominant, its highest value, average value, and the latest value are the largest among the industries. The size differences between the industries are huge, representation of smaller industries corresponds to only about one-tenth of the largest. According to the latest numbers, electronic equipment and communications are the least represented, and the weight of electronic equipment is the lowest of the industries in general over the period. The communications industry is steady in size throughout the period while in turn, the size of others has grown, and they are currently well above average. Market values are presented in billions of USD.

Table 4 Industry representation

Number Of Equities	Communications	IT Services	Software	Hardware	Electronic Equipment	Semiconductors	S&P 500 IT Sector
Average	7,98	14,25	13,48	8,83	5,93	17,33	72,61
Min	4	10	11	6	3	15	65
Max	14	22	17	12	10	20	83
Latest	5	20	15	7	9	18	74

Market value in billions	Communications	IT Services	Software	Hardware	Electronic Equipment	Semiconductors	S&P 500 IT Sector
Average	267	513	742	694	65	483	3088
Min	167	62	230	294	16	140	1030
Max	397	1741	2805	2281	203	1784	8862
Latest	259	1690	2718	2208	203	1784	8862

In the IT Services industry correlation between the number of companies and stock market performance has been high, shown in figure 2. The number of equities has risen in line with price development. This does not apply to other industries equally. When competition is fierce many industries have negative correlations, which comes to the number of equities and stock market performance.

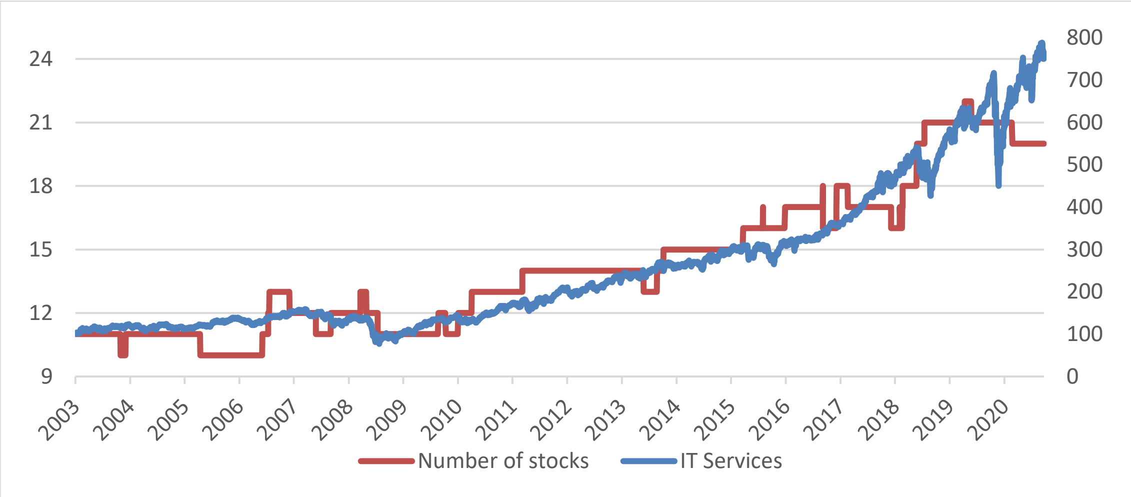

Figure 2 IT Services performance and number of stocks

The IT sector has grown through global megatrends throughout the 21st century. The weight of the IT sector in the S&P 500 index has risen by more than 10 percentage points over the last 18 years. This change is significant and reflects the strong growth of the sector in the economy. At the end of 2020, the weight of the IT sector in the S&P 500 index was 27,61%. The weight of the IT sector has been the highest of all sectors since 2008. The growth of the IT sector is visualized in figure 3, the period is from 2002 to the end of 2020. (S&P Dow Jones Indices, 2021)

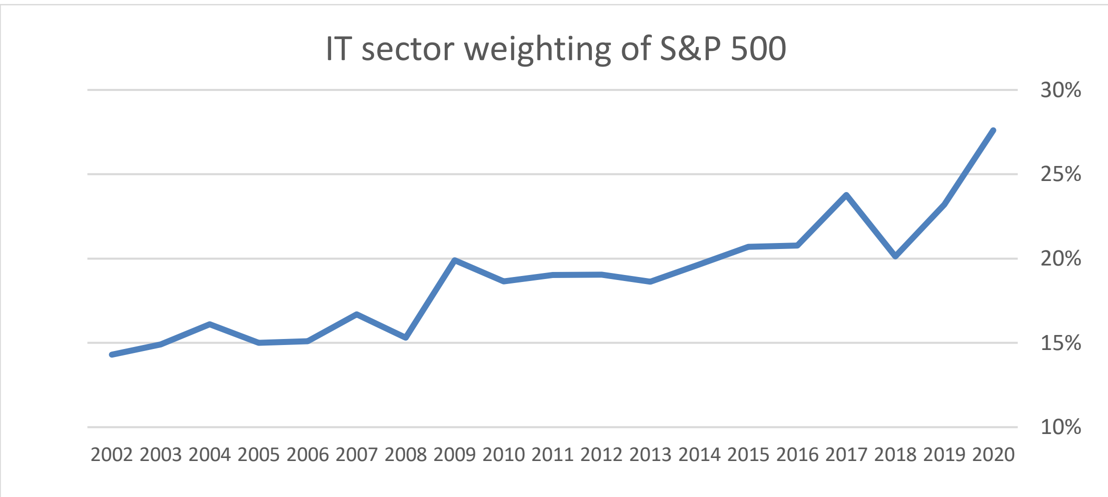

Figure 3 IT Sector representation (S&P Dow Jones Indices, 2021)

2.1.1 Development of the sector

The statistic in figure 4 shows global IT spending is increasing from 2005 to 2022. A growth slowdown is visible in 2020 due to the economic impact of the global coronavirus pandemic. In 2020, however, not all actors reduced their IT budgets, as remote working created new and unexpected demands on companies' IT capabilities. Global IT spending includes software, devices, services, data center systems, and communication services. The red trendline indicates how the slope of the growth will continue. Information technology worldwide spending forecast from 2005 to 2022 in a billion U.S. dollars, years 2021 and 2022 are forecasted spending. (Gartner, 2021)

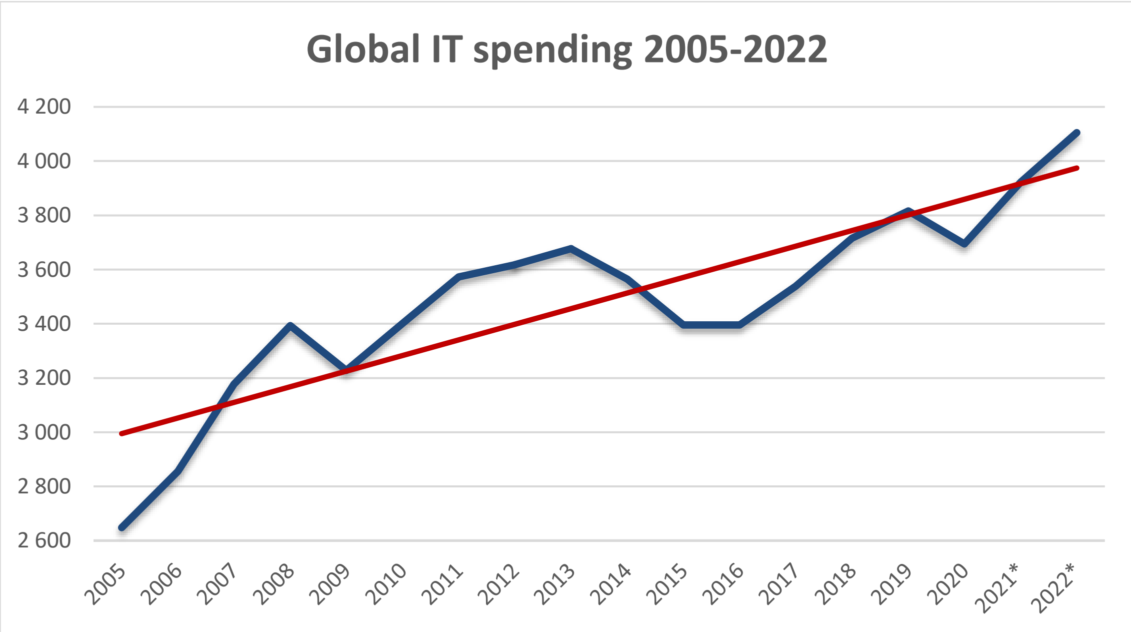

Figure 4 Global IT spending (Gartner, 2021)

2.1.2 From the end of the 20th century to the present day

According to the study by (Hagberg et al., 2016), digitalization is one of the most significant ongoing transformations of contemporary society. It affects business models and human everyday behaviour. Transformation is developing many processes to a more efficient and scalable business model. Ways of consumption are changing, and retailers try to provide consumers different kinds of digital products and services. Society is transforming many different areas, but an aging demographic in the developed countries slows down the change a bit. (Hagberg et al., 2016)

The most visible transformation related to IT is the change in business models. With internet-based infrastructure, it is possible to provide new kinds of services to the customers. These kinds of new business models are sharing economy and platform economy. On the internet-based business winner takes it all mentality is a familiar term, first successful vendors manage to gain big market shares and create a competitive edge that is hard to compete against. Initial operators have a strong position in the market, and they buy competitors aggressively within the early stage. (IDC FutureScape, 2019) Digital technology has significantly changed the speed of operation in the economy. In the 2020s customers expect all the services to be available immediately. (Afonasova et al., 2019)

The platform economy will change the nature of work and the structure of the economy, sounds like a strong statement, but the argument is justified according to Kenney and Zysman, 2016. New services are based on the application of big data, algorithms, and cloud computing which impresses the end user. Companies that are known for platforms are for example Amazon, Etsy, Facebook, Google, eBay. Their business is based on offering that platform for users to connect with others via their service. Depending on the platform, the purpose can be social or commercial. Usually, the purpose is to connect supply and demand in new ways, easier, faster, and cheaper. Existing jobs are being redefined and reorganized with these technologies in the future. Digital platforms also enable so-called mini entrepreneurship. These professions are the most popular coveted professions for children, such as blogging, social media influencer, or YouTubers. Under the platform economy is rising the idea of sharing economy. The aim is to streamline existing processes and maximize the utilization of the products and services. Globally known operators in the field are for example Uber and Airbnb. (Kenney & Zysman, 2016)

Estimating consumer behavior changes are the key factor for corporates to achieve the best possible customer satisfaction which leads to the success of the company in the longer run. The relationship between supply and demand is the key factor, to create value for customers. Managing to identify an inefficient process and provide an effective solution to it is the business idea. The pattern also works the other way around, that first a service is created and interest in it creates demand. In the digital world, the standards for products have changed dramatically since the previous century. A well-known story is the transition of video rental companies to the Internet. Previously, the customer drove to pick up one movie from the store for a loan, looked at it and returned on time, paid for the unit. By digitization of the above process has been achieved significantly better customer satisfaction. Digitization will lead to better availability, a wider choice, a lower price, a simpler process. The efficiency benefits the most the end-user, the paying customer. The best-known operator in the field is Netflix. (Lobato, 2019)

As a result of globalization, people around the world are beginning to use the same services as the benefit of many services is based on the number of other users in the service. Currently, the most widespread services have origins in the United States. Technology giants operate in almost every country in the world. A good example of these is the FAANG companies which are Facebook, Amazon, Apple, Netflix, and Alphabet. In addition to these, Microsoft plays also a significant role in the global IT sector. Recently, concerns have arisen about the power of individual companies. Huge corporates have more power than states. For example, Apple's market capitalization is more than Swiss, Stockholm, South Korea, or Frankfurt stock exchange. However, individual stock exchanges hold several hundreds of different stocks. The change of the economy will be on our hands and is determined by the social, political, and business choices we make. (Kenney & Zysman, 2016)

Development and success are not all positive, IT sector is known for tough competition, which drives employers to offer unfavourable working conditions for employees. According to the study, which is focused on India, IT workers are pushed to do unusual working hours. This means weekly working hours are more than other sectors and working hours can be demanded to do for different time zone. These factors have founded to have affect employee's health and stress. The study found out that the situation is not on a sustainable basis, and it is spreading to the other sectors as well which is concerning. In the IT sector, this is a consequence of offshoring operations and operating with uncertain market conditions. (Ghatak et al., 2016) The same situation does not apply in the developed countries, the IT sector is known as one of the most permissive for flexible working hours. When the complexity of the work increases the importance of the work-life balance increases at the same relationship to remain productivity at the required level. In the developed countries IT sector companies keep key positions and headquarter in the operative country, but many underlying processes are moved to lower labor cost countries as above-mentioned India. Companies from the IT sector are capable to pay salaries over the specific country's average level which leads to pushing workers to unfavorable working conditions. (Costa et al., 2004)

2.1.3 Industry clusters

Companies from the same industry tend to cluster to the same geographical area, this has been beneficial for all parties. It generates sophisticated knowledge about their industry and a chance to gain a competitive edge. Companies perform better than average when they are surrounded by companies from the same industry. The reason for this can be found in the collaboration in the manufacturing chain. The area generates an attractive atmosphere for the parties as labor pooling, proximity to suppliers, localized knowledge. One of the most famous clusters is located in Silicon Valley, U.S., it got its name from the semiconductor industry in 1950. Close to 100 companies from the semiconductor industry entry to the area and five of them were among the ten largest industry operators. The population of the area multiplied, and a skilled workforce came to stay. (Klepper, 2010)

This movement made the basis for the Silicon Valley that we know today, market leaders from the IT sector are linked strongly to this specific area. Entry-level to the IT sector is low compared to many other industries. New firms are founded in the area by employees who have gained experience in working with market leaders. Clusters do not work out without disadvantages, IT sector is well-known for its tough competition, which leads to a situation where companies from start-ups to multibillion companies are fighting against each other to get the best labor to work for them. Which leads to the growth of salary level and prices of the whole area. (Klepper, 2010)

In the operations of today's IT companies, there is a noticeable concentration in certain areas these are called tech hubs. Major factors influencing the hubs' birth are the number of experts available, modern infrastructure, research-intensive universities, and the number of investors. Currently, well-known hubs from the IT sector are Silicon Valley, Singapore, Tokyo, Shanghai, Rhine-Main-Neckar (Germany), Bengaluru (India), Tel Aviv, London, and Amsterdam. The same Silicon beginning is repeated in the calling name of hubs, which speaks its own language of copying unique conditions. However, the location of IT hubs does not relocate all businesses to the same area, large IT companies locate their headquarters in different locations because their location is often affected by tax issues. (KPMG, 2020)

2.1.4 Importance of the IT investments

The availability and use of information systems and new technologies have been growing year by year and they are merging to the part of the core business. Many areas of business demand that the companies have working and updated systems in use. (Dewett & Jones, 2001) According to the study, innovative IT investments have positive effects on the company's stock price. However, it does not mean that all IT investments are positive for the company. With innovative IT investment, the company can achieve a competitive advantage which causes a positive stock price reaction. In the current environment, the choice is more challenging than ever before because the number of available systems and solutions has increased significantly. In the competitive market, it is necessary to have the latest technologies in the use, otherwise, the company gives away a competitive advantage to the competitors. (Santos et al., 1993)

IT investments have become part of the company's strategy. With a successful system choice, it is possible to gain an edge in the market. This effect can be found for example from lower costs, increased quality, or efficiency. The biggest effect on competitive positioning comes from companies' enterprise resource planning (ERP) systems. It is linked to ERP's holistic nature which affects market positioning. With suitable systems responsiveness with the customer is on their own level which reflects the success. (Santos et al., 1993) The other study by (Bessen, 2017) finds that the level of IT systems is set by the top four firms in each industry. This leads to a situation where few major players in the industry set the level of the whole industry's profit margins.

Technological innovations are not alone the way to success in the business, they are powerful tools to support the company's business and optimize the processes to the latest level. The same kind of companies can face different kind of reality what comes to utilizing the same IT system. Organizations come from different types of backgrounds which causes differences in the success of the system integration. IT systems are seen as a weapon, correctly used they are really powerful but misused they can cause damage to the organization. (Powell & Dent-Micallef, 1997)

When the companies from the other sectors are investing in IT to utilize it in their business activities, it has had a positive effect on the value of the firm. The positive effect has been bigger with innovative IT investments. Although the investments are zero net present value still, they are positive for companies' valuation. (Santos et al., 1993) IT investments are seen as support of the core business, investments to the IT have a strong positive relationship with sales, assets, and equity, but not with net income. (Sircar et al., 2000)

The financial effects of the ERP system are in the center but due to complexity measuring the financial effects reliably is difficult. Studies find conflicting results on impacts, as ERP systems definition often becomes a problem. Large ERP vendors as SAP and Oracle are able to provide all features by adding different modules. Often companies have several different types of software for their core needs. For example, SAP provides 25 different modules as financial accounting, controlling, sales and distribution, production planning, materials management, quality management, human capital management, treasury, supply chain management, customer relationship management. Because of this, comparisons are very difficult when companies have a very different number of modules at their disposal. The study found an interesting fact that the longer ago an ERP was initially implemented, the higher the overall firm performance was. This tells about the complexity and as time goes on the usage becomes more efficient. (Nicolaou & Bhattacharya, 2006; SAP, 2020, Wieder et al., 2006) One of the most well-known failures in ERP selection is conducted by Lidl, they spent several years and an estimated 500 million euros on SAP deployment, however, canceling it in the end because it was not ready, and customization did not match what they wanted.

2.1.5 Investing in the IT sector

Stock market development for the industry indices from the IT sector are presented in figure 5, indices are presented as total returns. A total return index means the overall performance of the period, all cash distributions are reinvested back to the underlaying stock, the most common of these is the dividend. The period is from 01.05.2003 to 20.01.2021. The best index hardware has returned 2305,05 % during the period. While the worst return was at electronic equipment 309,82 %. S&P 500 listed stocks from the IT sector provided 1079,89 % returns when the whole S&P 500 was returning 502,62 %. All the returns are total return series and do not include adjustments for inflation. In addition to electronic equipment, only communications were returning under the overall market. As a whole can be concluded that the IT sector has been doing well throughout the 21st century.

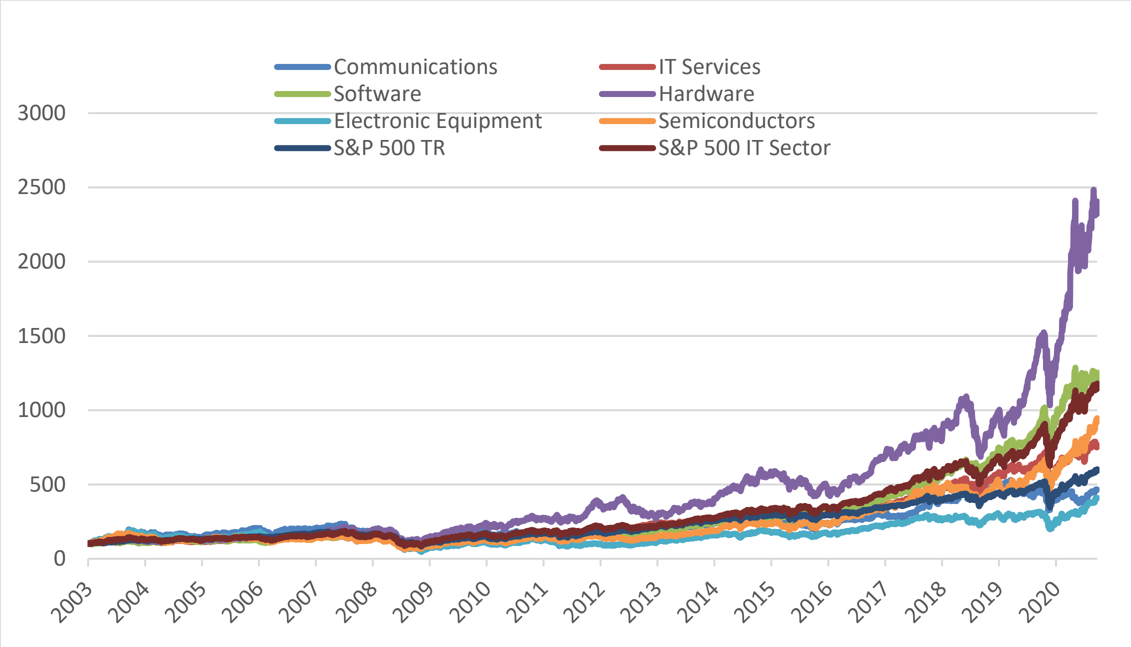

Figure 5 Stock market development of the IT sector industries

One reason the hardware index's success relative to other industries can be interpreted is due to Apple's rise. Companies can be listed only in one industry, even though their business activities have spread widely. As the hardware portfolio has been performing the best, it can be discussed how much the effect Apple has had. Individual success stories can distort whole industries. Apple's share has grown from a very small to the most valuable company in the world during the period under review. This reflects the IT sector's winner takes it all mentality. Figure 6 presents Apple's stock price versus hardware index, the chart is adjusted with two X-axis. These two charts appear to be strongly correlated, with unity throughout the period.

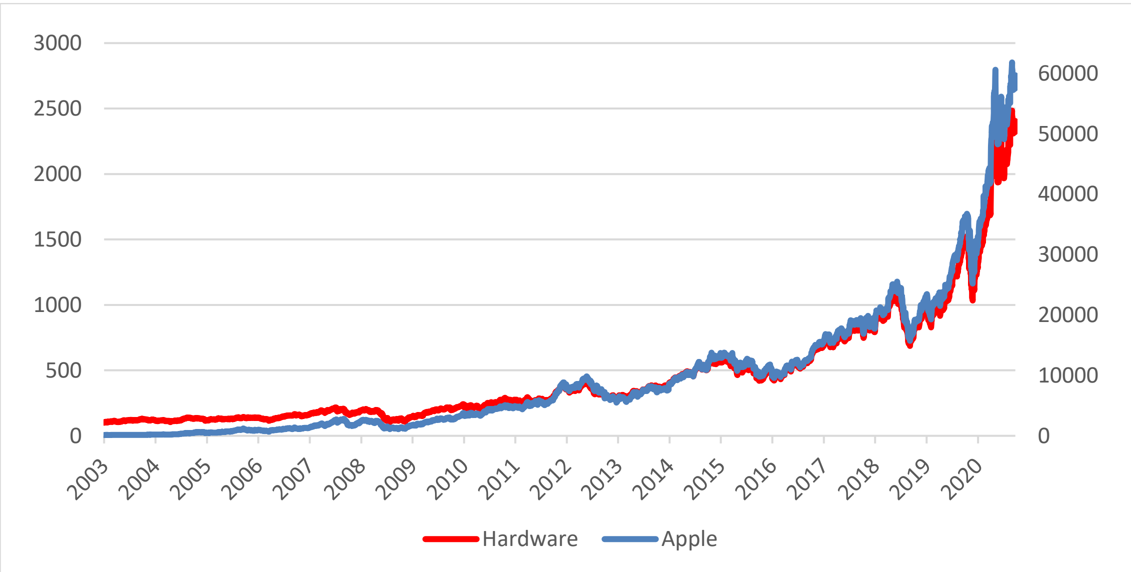

Figure 6 Apple's stock performance

In table 5 the correlation between the sectors is presented. Data is based on monthly returns from 1990 to 2017, according to GICS there are 11 sectors but only 10 of them are represented because the real estate sector was part of the financials until 2016. IT sector has the highest correlation with consumer discretionary and the lowest with utilities. These differences can be interpreted by differences between sectors. The IT sector is classified as a sensitive sector with moderate correlations with business cycles. In turn, the consumer discretionary sector is cyclical, which means highly sensitive to business cycle peaks and troughs. The utility sector is defined as defensive and thus its demand is weakest correlated with the IT sector. (Morningstar, 2011) Products in the IT sector are important but still strongly correlated with discretionary products. From this, we can interpret that the development of the IT sector is favorable when the economy is doing well, but in a downturn, these are deducted, unlike the utility sector. Connection to Maslow's Hierarchy of Needs is recognizable from the cross-sectoral correlation.

Table 5 S&P 500 Sector correlation (S&P Dow Jones Indices, 2021)

Sector	Information Technology
Consumer discretionary	0,71
Consumer staples	0,30
Energy	0,35
Financials	0,52
Health care	0,39
Industrials	0,66
Materials	0,54
Communication services	0,47
Utilities	0,16

Figure 7 presents a stock market development for the sectors mentioned earlier information technology, consumer discretionary, and utilities. On the other X-axis are presented U.S. Covid-19 deaths. The first death from corona in the U.S. was recorded on February 6, 2020, where the significant stock market reaction starts. At the beginning of the series, deaths seem to grow slowly as the scale is on thousands, but the reaction is strong. The number of deaths was increasing, and the sectors were dropping. Surprisingly, the utility sector initially suffered slightly more than the more sensitive IT and consumer discretionary sectors. After the first shock, the sectors started to revive, although deaths continue to grow at the same slope. At the beginning of the recovery period, the difference is noticeable, the utility sector does not recover well as the more sensitive industries. However, the situation concerned the whole market but at the beginning, the IT sector could have taken a harder hit as the IT sector stocks are priced with higher valuables than the average on the market. IT sector's stock prices already include high growth expectations. (Sehgal & Pandey, 2009) But on the reverse side and behind a good recovery, the coronavirus epidemic benefited the IT sector, people who could move to remote work did it and this led to the value of all digital services rose to unpredictable value. Services developed at a rapid pace when the need was enormous, but it continues to keep pace with the changing world. There was also a significant development in the share prices of the companies that develop and enhance teleworking, the companies' potential and need were realized in an instant. Examples of these are applications that enable video conferencing, remote authentication, and virtual private network services.

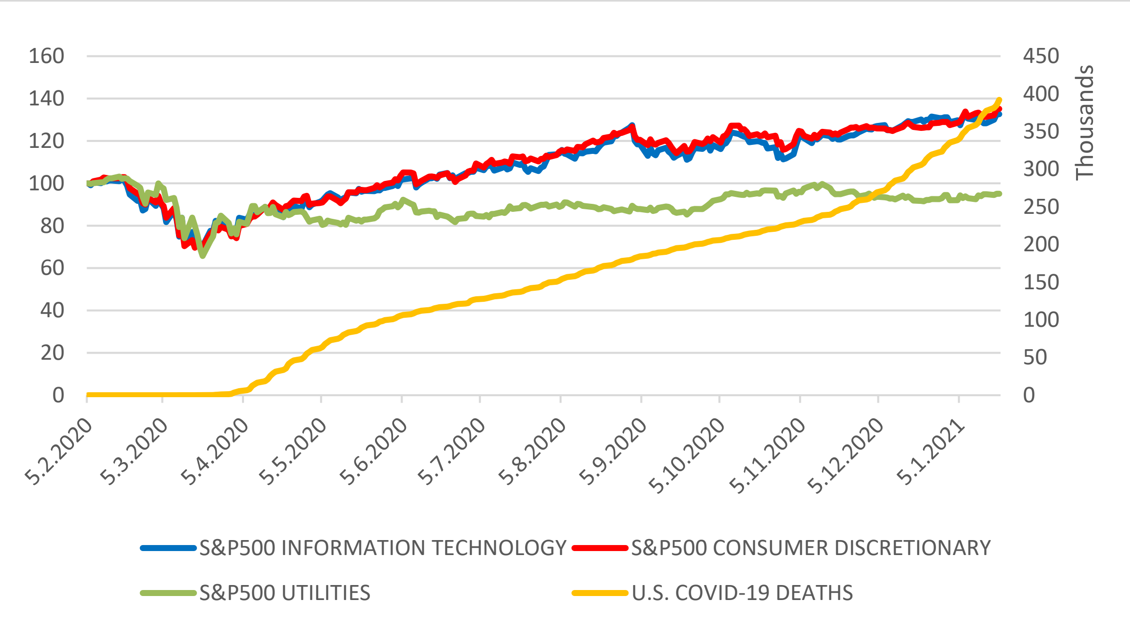

Figure 7 Coronavirus effect

The information technology industry is known for the aggressive use of employee stock options to compensate executives and other employees This incentive leads to motivation for extra work in the competitive industry. From the perspective of investors, this is usually a good sign to engage key person incentives to the performance of the company. But it is not unproblematic and might lead to bad decisions in the short term. The stock market information is regulated but occasionally abuse appears when the stock price is stimulated with speculative information. The use of the employee stock options is company-specific, and the information technology offers a good basis for this because the growth potential of digital products is great. In recent years we have witnessed as many fintech and software companies are capable to scale their product or service all over the world. In the best-case scenario, all parties from the end-user to owners benefit from this situation. (Anderson et al., 2000)

3 THEORY BACKGROUND

In an efficient market asset prices reflects all the available information. Prices are in equilibrium and investors are rational. In an efficient market, it is impossible to make excess returns continually. The efficient market hypothesis can be divided into three different levels:

Weak efficiency
- *Prices reflect historical information, trading volume, and previous earnings*

Semi-strong efficiency
- *Prices reflect all publicly available data.*

Strong efficiency
- *Prices reflect all information including insider information.*

This means that prices should not vary if anything new information does not appear. In Fama's optimal balance of the market, assets react immediately to the correct level, but usually, prices under- or overreact and find the correct level with a delay. This does not remove the market's effectiveness even though the price reaction is inefficient, but the delay allows investors to make excess returns. (Fama, 1970; Fama, 1998)

3.1 Portfolio performance evaluation

Portfolio's performance is the way to measure how the asset or portfolio is succeeding. Performance is usually measured annually and compared to the relevant comparison index. In the sophisticated evaluation, returns are adjusted with carried risk, used factors for the adjusted performance are usually risk-free rate and volatility. In addition to investment returns are often compared to major indexes as Standard & Poor's 500 (S&P 500) and Dow Jones Industrial Average (DJ30), overcoming these benchmarks repeatedly is a challenging task. Although they correspond to market returns, in recent years it has been observed that the index is raised by a few better-performing stocks and others return less than average. Making excess returns means that have managed to buy these excess returners which are the minority, this has not been easy for individual investors either for professionals without luck. (Grinblatt & Titman, 1989; Stutzer, 2000)

Portfolio's performance is divided into two dimensions: risk and return, thus low returns could be better than high returns if it is done with relatively lower volatility. When the return analysis is done for the long term the effect of chance decreases. (Jensen, 1967)

3.1.1 Capital asset pricing model

The capital asset pricing model (CAPM) is William Sharpe's theory from 1964 which is worth of Nobel Prize in 1990. Even decades later, the CAPM is still a widely used model in many financial applications. (Fama & French, 2004) Sharpe points out in his study that previous asset pricing techniques do not take account of risk. Estimating price behavior without risk aspect is closer to claims than fact. (Sharpe, 1964) CAPM can be calculated from equation 1.

$$E(R_i)=R_f+\beta_i[E(R_m)-R_f] \qquad (1)$$

$E(R_i)$ = Expected return of investment
R_f = Risk-free rate
β_i = Beta of the investment
$E(R_m)$ = Expected return of the market

Assumptions related to CAPM
All investors:

1. Aim to maximize economic utilities.
2. Are rational and risk-averse.
3. Are broadly diversified across a range of investments.
4. Are price takers, i.e., they cannot influence prices.
5. Can lend and borrow unlimited amounts under the risk-free rate of interest.
6. Trade without transaction or taxation costs.
7. Deal with securities that are all highly divisible into small parcels (All assets are perfectly divisible and liquid).
8. Have homogeneous expectations.
9. Assume all information is available at the same time to all investors. (Glen, 2015)

CAPM is based on the related risk and expected return. (Sharpe, 1964) introduced a model of the capital market line (CML), which indicates the most optimal balance between possible assets with efficient frontier. CML takes account of standard deviation which leads to a situation where the Sharpe ratio stays equal all the way of CML. In addition to that well-known model is the security market line (SML), which takes into account the beta ratio instead of standard deviation. In the SML Sharpe ratio decreases if the beta ratio is lowered. (Philip H. Dybvig & Stephen A. Ross, 1985; Sharpe, 1964) The security market line can be calculated with equation 2.

$E(R_i) = R_f + \beta_i [E(R_m) - R_f]$ *(2)*

$E(R_i)$ = Expected return of investment
R_f = Risk-free rate
β_i = Beta of the investment
$E(R_m)$ = Expected return of the market
R_m = Return of the market

The security market line visually represents the capital asset pricing model, presented in figure 8. The market portfolio's beta is exactly 1, the expected return is dependent on the amount of risk-free rate. Usually, the interest rate on a three-month U.S. Treasury bill is seen as risk-free. If the individual stock price variance is higher than market portfolios it gets a beta ratio over 1, which indicates higher expected returns. (Sharpe, 1964)

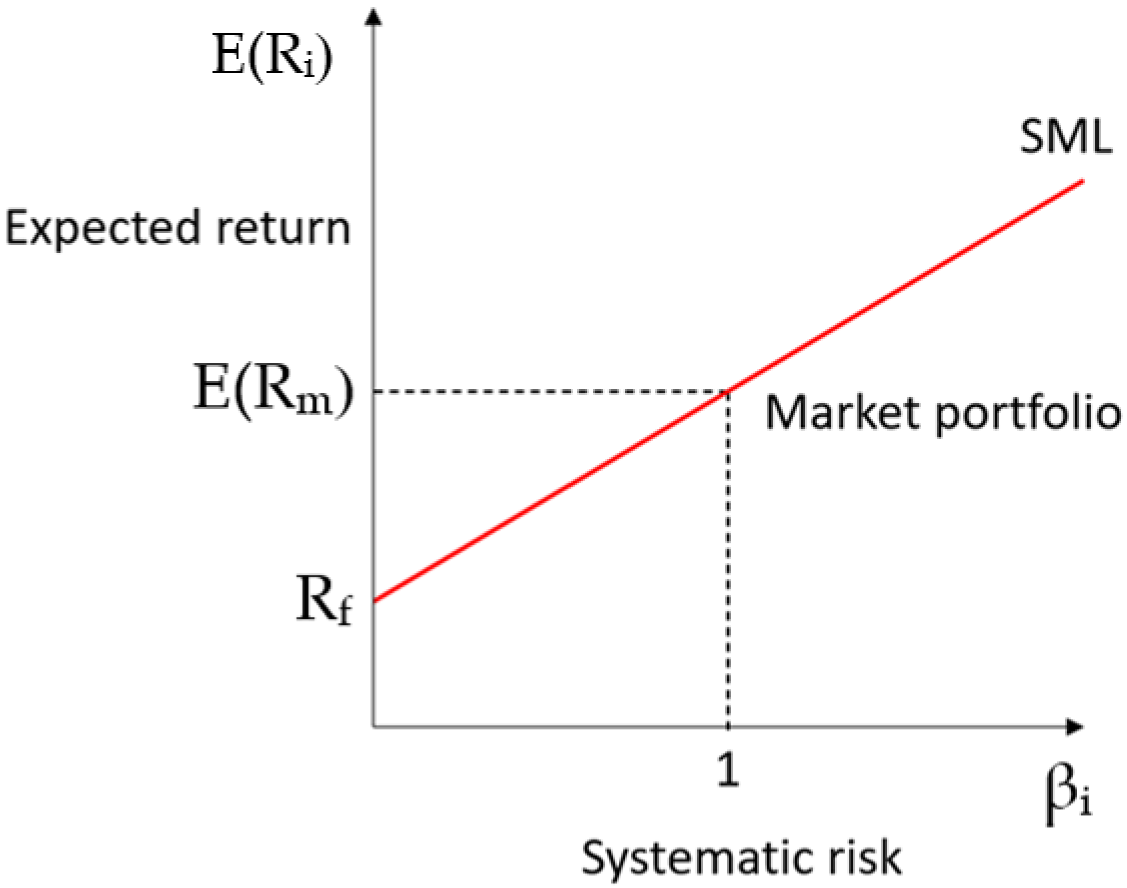

Figure 8 Security market line, based on (Philip H. Dybvig & Stephen A. Ross, 1985)

CAPM is a controversial model in the area of finance, and it causes discussion. "The CAPM is about an expected return. If you find a formula for expected returns that works well in the real markets, would you publish it? Before or after becoming a billionaire?"(Fernandez, 2015). However, Sharpe pointed out in the original paper in 1964, it is clear for everyone that assumptions are unrealistic, and it is only theory. (Sharpe, 1964) The aspect which is criticized at CAPM is the basis of beta. The beta ratio is based on historical behavior, and as stated in Fama's efficient market hypothesis, prices included all historical information and patterns do not exist.

Despite the critics, the popularity of the capital asset pricing model keeps high. The model is efficient to evaluate and predict risk compared to return. It is widely used for estimating the cost of capital and evaluating the performance of managed portfolios. Besides, it is the most common asset pricing model even though it has a poor empirical record of successful predictions. Bad success might be a result of unrealistic assumptions but still, it is used because there are few successful options. (Fama & French, 2004)

According to the studies the beta factor seems to be an important determinant of security returns. The higher beta ratio does not straightforward offer higher returns, but the expected returns are higher concerning the risk. (Jensen et al., 1972) CAPM is seen as an important factor when making investment decisions but not the only one.

3.1.2 Sharpe ratio

The Sharpe ratio is a financial term for a formula invented by William Sharpe to measure the risk-adjusted returns. It can be used for expected returns or historical performance. It compares return over risk-free rate compared to volatility. Usually, investors are talking about absolute returns which can be easily compared to the comparison index or other investors. Absolute returns are not as informative as risk-adjusted ones, this means that assets can make high returns but if the level of risk is higher than the particular returns demand, the probability to do it many years in a row decreases significantly. The Sharpe Ratio can be calculated with the following equation number 3, return of investment minus risk-free rate divided by the standard deviation of the investment's excess return. (Sharpe, 1966; Sharpe, 1994)

$$\text{Sharpe Ratio} = (R_i - R_f) / \sigma_p \qquad (3)$$

R_i = Return of investment
R_f = Risk-free rate
σ_p = Standard deviation of the investment's excess return

If the same returns are reached with lower volatility, the risk-adjusted ratio is better. In the Sharpe ratio, the bigger value is the better. Criticism concerns the model's simplicity what comes to market cyclicality, thus the Sharpe ratio is usually calculated for many sub-periods instead of one long period. (Sharpe, 1966; Sharpe, 1994)

3.1.3 Treynor ratio

The Treynor ratio is a reward to the volatility model which is founded by Jack L. Treynor in 1965. The measure is similar to Sharpe's ratio, but the risk-adjusted return is calculated with the beta coefficient. Treynor ratio is a common meter in finance, it is used for evaluating a portfolio's performance. The higher Treynor ratio indicates better performance. Equation 4 is for Treynor Ratio.

$$\text{Treynor Ratio} = (R_i - R_f) / \beta_i \qquad (4)$$

R_i = Return of investment
R_f = Risk-free rate
β_i = Beta of the investment

In the Treynor ratio risk is measured by the beta of the portfolio, not the market beta, thus this ratio is good for evaluating sub-samples for the portfolio as well. (Treynor, 1965)

3.1.4 Jensen's alpha

Jensen's alpha is a measure of a risk ratio for a portfolio. The equation is presented below number 5. The ratio determines if the portfolio's returns are excess compared to the previously mentioned CAPM calculated returns. If the portfolio's returns are in the line with the market the Jensen's alpha is zero. Investors are trying to find positive alpha which means excess returns compared to carried risk. (Jensen, 1967)

$$\text{Jensen's alpha} = R_i - [R_f + \beta_i (R_m - R_f)] \qquad (5)$$

R_i = Return of investment
R_f = Risk-free rate
R_m = Return of the market
β_i = Beta of the investment

According to Fama's efficient market hypothesis, positive alpha should not exist, or gaining positive alpha is only possible by chance. However, investors all over the world are trying to achieve positive alpha by various means. Especially in smaller markets, it is easier to find inefficiencies because all stocks do not have even analyst tracking their performance.

3.2 Factor models

In finance is demand for finding the explaining factors for market behavior. There are several types of factor models that are trying to represent the best explanatory power for the equities. In addition to the previous chapter, these models have more than one explanatory factor. CAPM has only one factor and these models add other factors to support the explanation. Fama and French have been the initiators of the idea. Their three-factor model is the most well-known factor model. The economists have been building models based on their original model and but also with entirely new explanatory factors, the idea is to find which factors have the most effect on equity behavior. It has been discussed how many factors are needed and does the number of factors increases the explanatory power. Rehnby conducted a study in 2016 at the Swedish stock market and found out that the three-factor model improves explanatory power for portfolio returns in comparison to the CAPM but adding a fourth factor gives only a small improvement. He also found out that models suffer from low explanatory power when the market is volatile. (Rehnby, 2016)

3.2.1 Fama–French three-factor model

After empirical research, it has been found that CAPM explanatory level is limited, which is understandable as it can only make estimates for expected returns from the risk perspective. Fama–French three-factor model (FF-3) is based on CAPM adding two more factors on top of it. The factors are called small minus big (SMB) and high minus low (HML). SMB is a market capitalization-related factor that indicates how the size of the company affects the returns. SMB factor is based on estimating small-cap companies' excess returns companies over the big market capitalization returns. HML is a book value-related indicator that takes into account book to market (B/M) value. It refers to a company’s relationship between the company's book value and market capitalization. A high book to market value for a stock means that its book value is large compared to its market capitalization, these stocks are so-called value stocks. Low book-to-market stocks are more speculative, and their valuation relies on growth potential. (Fama & French, 1993) The equation for FF-3 is presented below as 6.

$$E(R_i)=R_f+\beta_1[E(R_m)-R_f] + ß_2(SMB) + ß_3(HML) + \varepsilon \qquad (6)$$

$E(R_i)$ = Expected return of investment
R_f = Risk-free rate
β_i = Factor’s beta coefficient
$E(R_m)$ = Expected return of the market
SMB = Historic excess returns of small-cap companies over large-cap companies
HML = Historic excess returns of high book to price ratio over the low book to price ratio
ε = Zero-mean residual

According to Fama & French study value firms have been overperforming the growth stocks during the period from 1975 to 1995. (Fama & French, 1998) Other studies have found similar results as conducted by Bauman, Conover, and Miller in 1998, and interestingly it concerns also total return basis, not only risk-adjusted returns. They also confirm the small-cap anomaly, returns are higher as well as volatility. (Bauman et al., 1998) These market activities explain well why Fama & French founded these specific SMB, and HML factors to explain size and value effects on the market precisely. IT sector is known for its low book-to-market ratios as usually there are not big inventories or other tangible assets. Many companies operate on rented offices with leasing hardware and services are purchased as subcontracting. Industries differ notably by capital intensively and IT sectors entry threshold is lower what comes to tangible assets.

3.2.2 Carhart four-factor model

Mark Carhart noticed that Fama–French three-factor model explanatory power is missing something, and he decided to add a factor in addition to FF-3 in 1997. The factor is called winners minus losers (WML), but also known as momentum factor. Carhart conducted his study on mutual funds instead of stocks, which corresponds with this thesis even better. Carhart's model is otherwise the same as FF-3, but Carhart has added a momentum factor to it for achieving better explanatory power. The functionality of this explanator depends on the material under study. (Carhart, 1997) The equation for the four-factor model is the number 7.

$$E(R_i)=R_f+\beta_1[E(R_m)-R_f] + \beta_2(SMB) + \beta_3(HML) + \beta_4(WML) + \varepsilon \qquad (7)$$

$E(R_i)$ = Expected return of investment
R_f = Risk-free rate
β_i = Factor's beta coefficient
$E(R_m)$ = Expected return of the market
SMB = Historic excess returns of small-cap companies over large-cap companies
HML = Historic excess returns of high book to price ratio over the low book to price ratio
WML = Historic excess returns highest-performing stocks minus the lowest-performing stocks
ε = Zero-mean residual

3.2.3 Fama–French five-factor model

In 2015 Eugene Fama and Kenneth French expanded their FF-3 model to capture more exact results from the stock market estimation. In addition to FF-3, there are two new factors for profitability and investments. Factors are robust minus weak (RMW) and conservative minus aggressive (CMA). Fama and French define the factors as follows, RMW is the difference between the returns on diversified portfolios of stocks with robust and weak profitability and CMA is the difference between the returns on diversified portfolios of the stocks of low and high investment firms, which we call conservative and aggressive. (Fama & French, 2015) Equation 8 is for the FF-5.

$$E(R_i)=R_f+\beta_1[E(R_m)-R_f] + ß_2(SMB) + ß_3(HML) + ß_4(RMW) + ß_5(CMA) + \varepsilon \quad (8)$$

$E(R_i)$ = Expected return of investment
R_f = Risk-free rate
β_i = Factor's beta coefficient
$E(R_m)$ = Expected return of the market
SMB = Historic excess returns of small-cap companies over large-cap companies
HML = Historic excess returns of high book to price ratio over the low book to price ratio
RMW = Historic excess returns of the most profitable firms minus the least profitable
CMA = Historic excess returns of firms that invest conservatively minus aggressively
ε = Zero-mean residual

Adding a CMA is effective in expanding the models' explanatory power. The purpose of the CMA factor is to extract different observations than the HML factor. Their long-term correlation in the U.S. market is -0,7. (Fama & French, 2015)

3.3 Vector autoregression

Vector autoregression (VAR) is a statistical model used to describe the relationship between several quantities as they change over time. VAR belongs to the stochastic process models. VAR models generalize a single-variable autoregressive model by allowing multivariate time series. This model is very common in economic analyzes. It notices the strength of the interdependencies of the variables as well as allows the predicting the future values for the variable via the relation to other variables. When studying the interdependence of values, it is important to examine that the variables are not causal. The most commonly used test for testing causality is the Granger causality test which has already been discovered in 1969. The results of the test can be used to interpret whether a time series is useful in predicting another time series. (Luetkepohl, 2013)

3.4 Data validity tests

The estimation of time series data requires data to be stationary. This can be tested with the Augmented Dickey-Fuller (ADF) test. ADF tests that is a unit root present in a time series sample. ADF test gives a value and critical value for the result interpretation. Critical values are negative, the farther the negative value is from the critical value the stronger the rejection of the hypothesis that there is a unit root. (Elliott et al., 1996)

For a time-series analysis presence of autocorrelation should be tested. An efficient tool for that is the Durbin-Watson test. Autocorrelation is usually seen as a bad sign for regression analysis as the data has patterns if the autocorrelation exists. Autocorrelation means that there is a similarity between observations. Identifying this issue is developed the Durbin-Watson test which tests the presence of autocorrelation and the values are compared to the critical values. (Durbin & Watson, 1950)

4 DATA AND METHODOLOGY

4.1 Research methods

The research includes eight indices, seven of them are representing the IT sector and one is the market overall index. Indices are from the United States stock market and provided by Standard & Poor's Global Ratings. The stocks are divided into the indices according to The Global Industry Classification Standard which is presented in table 1. Stocks in the indices are from the big market cap since they are S&P 500 classified. Indices are float-adjusted market-cap-weighted and rebalanced quarterly. All the indices are taken as total return indexes, dividends are reinvested in shares.

The industries are strongly interconnected and support each other. Competition in the IT sector is high which leads to a situation where companies specialize in smaller areas of business and make it a strong core business. This strategy allows them to develop a competitive advantage in their areas. The information technology ecosystem is presented in figure 9. The industries within the IT sector are interdependent. As can be seen from the figure, the sector is built as industries build piece by piece on top of each other and generate added value.

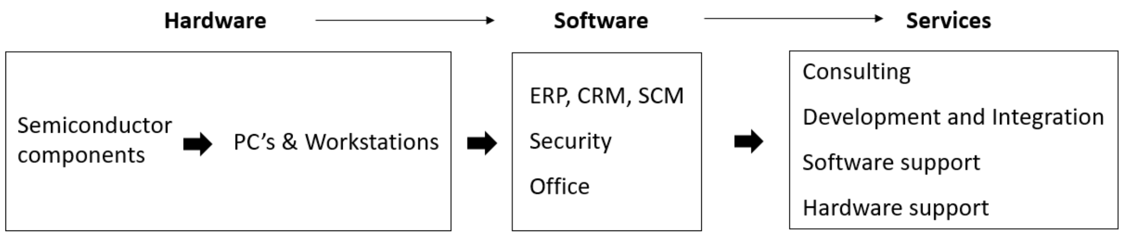

Figure 9 Information technology ecosystem based on (Iansiti & Richards, 2006)

The index data is analyzed according to chapter 3.1 performance evaluation methods. After performance evaluation research moves on to the factor models from chapter 3.2, three different factor models are added in addition to indices and analyzed on Stata 16 statistical software. The aim is to find the degree of explanation of factor models for the success of industries. This happens by conducting regression analysis for these factor variables against each industry. Then the interdependence of the industries has been studied using a vector autoregression model in section 5.3.

4.2 Data set

The stock market data is retrieved from Thomson Reuters Datastream. The period for this is from 01.05.2003 to 20.01.2021. All data has been collected daily series and as a total return index. Notable periods from the perspective of the IT sector during the period are the rise after the dot-com bubble, financial crisis, European debt crisis, and coronavirus pandemic. The data for factors are retrieved from Kenneth French's data library, which is a comprehensive free data library. As the study concerns the U.S. market the factors are also North American factors and daily series for the same period as indices. North American factors also include Canada, but it fits well because the market is similar to the U.S. and the S&P 500 companies' main markets are in North America, but global operations also have a strong presence in the IT sector. (French, 2021)

To mention from the IT services industry many of the companies are private for example Boston Consulting Group, McKinsey, Deloitte, E&Y, KPMG, and PwC. For some reason industry's major global companies are not listed on the stock market. Another interesting setting from the data is a confrontation of tangible sales versus intangible sales. IT services and software represent the intangible side and the rest are focused on tangible sales. Growth potential via scalability is on a different level if the company's product can be duplicated at a low cost.

Table 6 includes the indices that are part of the research. Each industry index comprises stocks from the S&P 500 that are classified as part of the industry under the GICS classification. The sector index includes in turn all six industries combined.

Table 6 Selected indices for research

Index	Code	Ticker
S&P 500 Communications Equipment (Industry)	SP5ICOM	SP500-452010
S&P 500 IT Services (Industry)	SP5IITC	SP500-451020
S&P 500 Software (Industry)	SP5ISWA	SP500-451030
S&P 500 Technology Hardware, Storage & Peripherals (Industry)	SP5ICPR	SP500-452020
S&P 500 Electronic Equipment, Instruments & Components (Industry)	SP5IEQI	SP500-452030
S&P 500 Semiconductors & Semiconductor Equipment (Industry)	SP5ISES	SP500-4530
S&P 500	S&PCOMP	SP500TR
S&P 500 Information Technology Sector	SP5EINT	SP500-45

4.2.1 Data description

Table 7 includes the descriptive statistics of the data set. All the variables include 4624 individual observations. In the table, the data is presented as daily relative changes of each index. The statistics follow a similar formula because they consist of indices and in that case, there are more stocks involved which greatly reduces the occurrence of extreme values. As a result, the indices are quite close to the market portfolio. For the clarity and readability of the table, the figures have been multiplied by a hundred before the table is formed.

Table 7 Descriptive statistics

Descriptive statistics	Communications	IT Services	Software	Hardware	Electronic Equipment	Semiconductors	S&P 500 TR	S&P 500 IT Sector
Mean	0,046	0,053	0,066	0,081	0,044	0,064	0,046	0,063
Standard Error	0,023	0,019	0,022	0,023	0,024	0,026	0,017	0,020
Median	0,023	0,059	0,028	0,062	0,024	0,047	0,053	0,076
Standard Deviation	1,593	1,304	1,488	1,554	1,662	1,745	1,187	1,378
Sample Variance	2,537	1,699	2,214	2,414	2,762	3,046	1,408	1,900
Kurtosis	7,131	12,849	10,476	6,659	6,313	5,874	14,839	10,147
Skewness	-0,010	0,068	0,178	-0,052	-0,052	-0,180	-0,271	-0,061
Range	24,214	26,993	29,856	24,497	24,965	29,419	23,561	26,058
Minimum	-10,388	-13,304	-13,980	-12,990	-12,267	-16,804	-11,980	-13,912
Maximum	13,826	13,689	15,876	11,508	12,698	12,615	11,581	12,146
Sum	212,380	242,871	304,075	373,977	205,001	295,380	212,285	290,824
Count	4624	4624	4624	4624	4624	4624	4624	4624
Confidence Level(95,0%)	0,046	0,038	0,043	0,045	0,048	0,050	0,034	0,040

In table 8 correlations between the industry returns are presented. For all industries, the correlation is the highest against the S&P 500 IT Sector which is reasonable. The highest industry cross-correlation is 0,8 which is between the IT services and software. The complexity of enterprise applications is reflected in the need for IT services. Software companies focus on program maintenance and development, while IT service companies are responsible for program implementation, connecting interfaces, and providing support to the end-user. The lowest correlation of 0,67 can be found between the electronic equipment and hardware. Although the correlation is high, it is still the lowest in the comparison group. There is a clear difference in the volume of these products, electronic equipment can be seen as supporting devices for hardware. The number of support devices is lower compared to the main devices.

Table 8 Industry correlation matrix

Correlation	Communications	IT Services	Software	Hardware	Electronic Equipment	Semiconductors	S&P 500 TR	S&P 500 IT Sector
Communications	1							
IT Services	0,7430	1						
Software	0,7407	0,8001	1					
Hardware	0,6856	0,7071	0,7209	1				
Electronic Equipment	0,7634	0,7610	0,7153	0,6780	1			
Semiconductors	0,7617	0,7451	0,7604	0,7211	0,7761	1		
S&P 500 TR	0,8027	0,8921	0,8354	0,7662	0,8330	0,7981	1	
S&P 500 IT Sector	0,8530	0,8766	0,9095	0,8778	0,8261	0,8901	0,9130	1

4.2.2 Data validity

Table 9 shows the results of the Augmented Dickey-Fuller test. It confirms the stationarity of the data. The margin for 1,0 % is -2,6 and all the variables got the value of over -15.

Table 9 ADF Stationary Test

ADF Stationary Test	Score	P-Value	1,00 %
S&P 500 Communications Equipment	-16,33	0,1 %	-2,6
S&P 500 IT Services	-16,86	0,1 %	-2,6
S&P 500 Software	-19,71	0,1 %	-2,6
S&P 500 Technology Hardware, Storage & Peripherals	-15,65	0,1 %	-2,6
S&P 500 Electronic Equipment, Instruments & Components	-15,58	0,1 %	-2,6
S&P 500 Semiconductors & Semiconductor Equipment	-18,18	0,1 %	-2,6
S&P 500	-16,31	0,1 %	-2,6
S&P 500 Information Technology Sector	-15,57	0,1 %	-2,6

Table 10 provides the results of the Durbin-Watson test, the d-statistics statistic has a value between 0 and 4. A value of 2 indicates that there is no autocorrelation. When the value is below 2, it indicates a positive autocorrelation, and a value higher than 2 indicates a negative serial correlation. Durbin-Watson test results are slightly tilted to positive autocorrelation. As the sample size is big the critical value is close to 2. Time series data includes often serial dependence. The rule of thumb is that test statistic values in the range of 1,5 to 2,5 are relatively normal. The dataset is large, and autocorrelation is minor. Taking into account the above considerations the study is continued with this data.

Table 10 Durbin-Watson test

Name	Durbin-Watson d-statistic(K=1, N= 4624)	Critical value 5%	Critical value 1%
S&P 500 Communications Equipment	1,78	1,95	1,97
S&P 500 IT Services	1,82	1,95	1,97
S&P 500 Software	1,84	1,95	1,97
S&P 500 Technology Hardware, Storage & Peripherals	1,73	1,95	1,97
S&P 500 Electronic Equipment, Instruments & Components	1,69	1,95	1,97
S&P 500 Semiconductors & Semiconductor Equipment	1,83	1,95	1,97
S&P 500	1,86	1,95	1,97
S&P 500 Information Technology Sector	1,84	1,95	1,97

4.3 Fundamental analysis of the data

The information technology sector is known for its growth potential. A study conducted in India by Sehgal & Pandey, 2009 found out that stocks from the IT sector are valuated with higher pricing multiples than other sectors. On the other hand, high pricing multiples exhibit greater volatility. This is the result of a very weak relationship between price multiples and their fundamental determinants which was found in the same study. As an exception were price to book value (P/B) and price to sales (P/S) ratios. Earnings multiples are more driven by sentiments, there are different kinds of phenomena behind this as noise trading, social media activity, and strong momentums. In the long run, earnings do matter but in the short term, they do not have a connection to price behaviour. There is a lack of respect regarding earnings as it is a bottom-line number and thus is severely affected by accounting biases and judgments. (Sehgal & Pandey, 2009)

In table 11 are presented price-to-earnings (P/E) multiples for the selected indices. The period for this review is 01.05.2003 – 20.01.2021. It is noticeable that the IT sector is trading with a higher P/E than the average. From the average perspective, all the industries are the over S&P 500. But from the latest numbers of communications equipment have significantly lower P/E than others. All the pricing multiples are calculated by Refinitiv Eikon Datastream, derived by dividing the total market value of an index by the total earnings.

Table 11 Price to earnings ratio

Index	P/E Average	P/E Min	P/E Max	P/E Latest
S&P 500 Communications Equipment	20,41	8,92	53,75	20,94
S&P 500 IT Services	21,65	10,39	41,10	39,94
S&P 500 Software	24,57	10,00	51,33	39,42
S&P 500 Technology Hardware, Storage & Peripherals	18,36	9,44	39,63	38,33
S&P 500 Electronic Equipment, Instruments & Components	26,34	8,48	102,30	37,17
S&P 500 Semiconductors & Semiconductor Equipment	20,84	9,26	63,55	33,50
S&P 500	18,98	9,60	32,90	32,90
S&P 500 Information Technology Sector	21,70	10,06	38,88	37,02

Figure 10 presents the graphs for P/E ratios at S&P 500 and S&P 500 IT sector, before the financial crisis IT sector was trading with higher multiple but then it levelled to even until 2018. Last three years IT sector has been valued with higher multiple again.

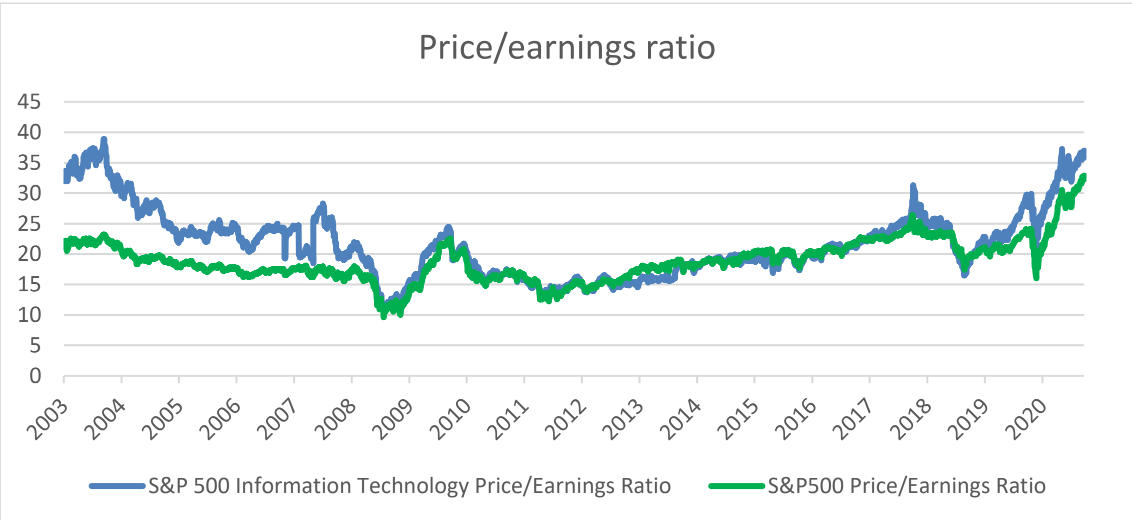

Figure 10 Price to earnings ratio

In table 12 Price to book ratios (P/B) is presented for the indices. All the industries have a higher P/B ratio than the market average. Reasonably software industry has the highest multiple as the nature of the industry does not require as many tangible assets as manufacturing production. Even though a study conducted by (Sehgal & Pandey, 2009) found out that P/B has a relationship between multiple and the fundamental determinant, this does not apply to the IT sectors as strongly. IT sector stocks are thus closer to the definition of growth stocks, which the FF-3 HML factor seeks to measure. However, sectoral differences need to be taken into account, as the said IT sector is not as capital-intensive as the other sectors, thus the balance sheet balances are smaller. From the GICS sectors, IT is priced with the highest P/B ratio of all on 31.12.2020. (Siblis research, 2020)

Accounting policies for intangible assets have just begun to develop in recent years, for example, International Financial Reporting Standards (IFRS) have begun to take better account of intangible assets in the balance sheet.

Table 12 Price to book ratio

Index	P/B Average	P/B Min	P/B Max	P/B Latest
S&P 500 Communications Equipment	3,42	1,83	5,79	4,74
S&P 500 IT Services	5,58	2,32	12,41	7,48
S&P 500 Software	5,76	2,79	14,34	13,59
S&P 500 Technology Hardware, Storage & Peripherals	5,04	2,47	25,28	24,27
S&P 500 Electronic Equipment, Instruments & Components	3,45	1,79	7,40	7,02
S&P 500 Semiconductors & Semiconductor Equipment	3,55	1,49	8,10	8,10
S&P 500	2,71	1,78	4,08	4,04
S&P 500 Information Technology Sector	4,59	2,14	10,74	10,74

5 RESULTS AND ANALYSIS

In this paragraph results from the data set are presented and analysed via methods that are introduced in the theory section. All the presented values are from the period from 01.05.2003 to 20.01.2021 and the changes are calculated as relative changes.

5.1 Portfolio performance evaluation

Performance measurements for selected data are presented in table 13, the hardware industry has been performing distinctly better than any other. The performance of the sector is conspicuous, over double than the market portfolio. As the portfolios are S&P 500 listed the beta coefficients for all portfolios are close to one. Industry indices have behaved similarly despite differences in returns, otherwise, the consistent results are explained by the interdependence of the industries and the long length of the period which equalize the variation. Sharpe ratios are close to each other since the standard deviations are similar. After the hardware index, the best risk-adjusted has been provided by the IT sector index. The semiconductor index has yielded over 300% more than the S&P500, but due to greater volatility, the Sharpe ratio in the S&P 500 is higher which signals better return relative to carried risk. The lowest Sharpe's are found in the least performed indices communications and electronic equipment. Treynor's ratio follows the same formula where well-performing indices get better values, but in this case, after hardware, the second-best value can be found from the software index. Besides, IT services have better value than semiconductor manufacturers.

Table 13 Portfolio performance

Portfolio	Communications	IT Services	Software	Hardware	Electronic Equipment	Semiconductors	S&P 500 TR	S&P 500 IT Sector
Average daily return	0,046 %	0,053 %	0,066 %	0,081 %	0,044 %	0,064 %	0,046 %	0,063 %
Holding period return	364,85 %	665,57 %	1153,75 %	2305,05 %	309,82 %	846,23 %	502,62 %	1079,89 %
Standard deviation	0,0159	0,0130	0,0149	0,0155	0,0166	0,0175	0,0119	0,0138
Beta	1,078	0,980	1,048	1,003	1,167	1,174	1,000	1,061
Annalized return	9,05 %	12,16 %	15,32 %	19,64 %	8,28 %	13,51 %	10,66 %	14,93 %
Sharpe ratio	0,31	0,52	0,59	0,74	0,26	0,44	0,49	0,62
Treynor's ratio	0,073	0,112	0,135	0,184	0,061	0,105	0,095	0,130
CAPM expectation	11,39 %	10,47 %	11,11 %	10,69 %	12,24 %	12,30 %	10,66 %	11,23 %

The annual return is calculated according to the investigation period, the length of the study period is 6474 days which is 17,74 years. Due to the stock market development-oriented meters, the values were close to their performance order. Semiconductor manufacturers had the highest standard deviation, which reduced the points it received from the meters, although the return has been good. From the example of semiconductor manufacturers can be detected that a higher return is not always better, if the review period shortens, the risks increases as the effect of volatility intensifies.

Explanatory factors for two the worst performed industries are possible to notice from table 3 presented in the 2. chapter. Electronic equipment returned only 309,82 % during the reference period, the industry includes for example scanner/barcode products, lasers, display screens, point-of-sale machines, and security system equipment. These kinds of products are tangible assets without a competitive edge, high volume products whose production is done in large factories. A barrier to competition is low as electronic solutions are simple and copyable. These factors drive the margins down and manufacturing is moving more and more to lower-cost countries. Communications suffer from similar circumstances as it includes communication equipment and products, including LANs, WANs, routers, telephones, switchboards, and exchanges, excluding cellular phone manufacturers which are classified in the technology hardware, storage & peripherals sub-industry. These are low-price tangible products which are founded already decades ago. Generating profits and thereby performing at the stock market is challenging taking into account the above facts.

In the following Figures 11, 12, 13, and 14 are the daily return histograms for each portfolio. In the beginning, volatility is higher since the industries are reviving from the IT bubble. A few calmer years before the global financial crisis (GFC) 2007–2008, when volatility hit highs and lows for the longest time during the period. After that, it is smoother until the European debt crisis has affected the overall market, but the volatility is more restrained. The highest fluctuations are in almost all industries at the beginning of 2020 when the coronavirus pandemic hit the market, the effect was strong but short. The effects of the corona pandemic have been discussed previously in connection with figure 7. As the industries have performed well, their volatility has been higher than the S&P 500 level. In all portfolios, peaks are about the same point, but the intensity is industry specific.

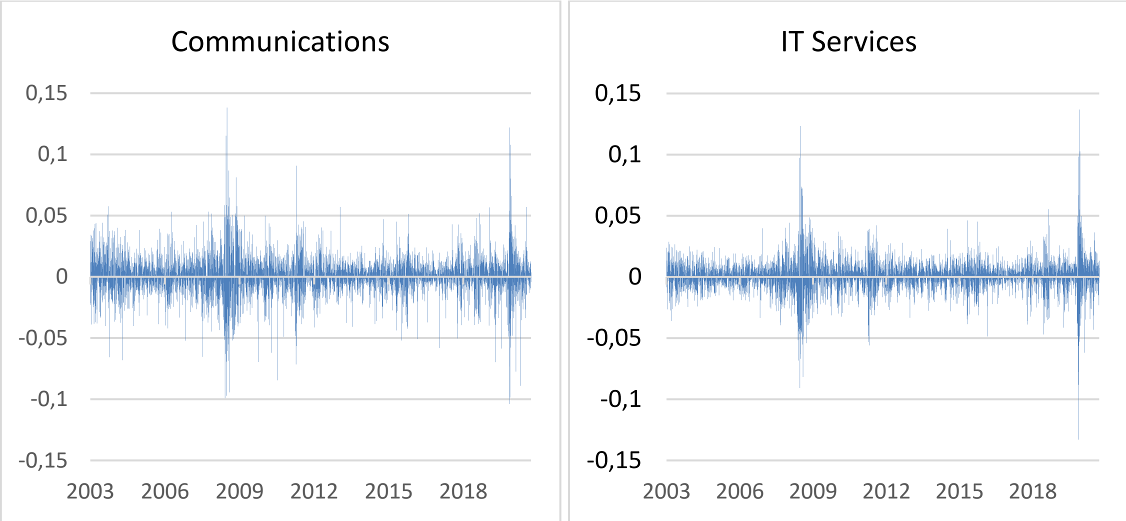

Figure 11 Communications and IT Services

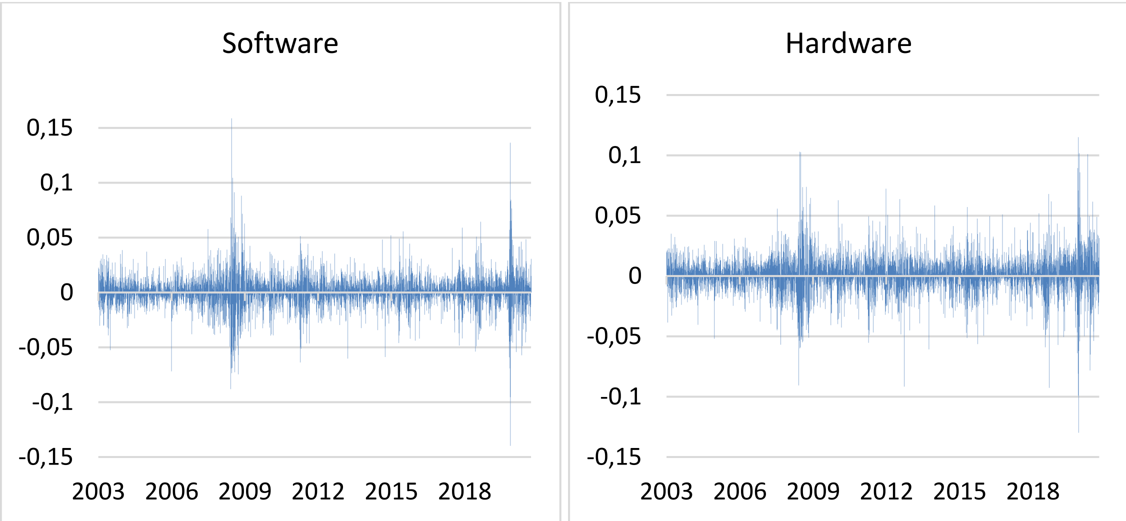

Figure 12 Software and Hardware

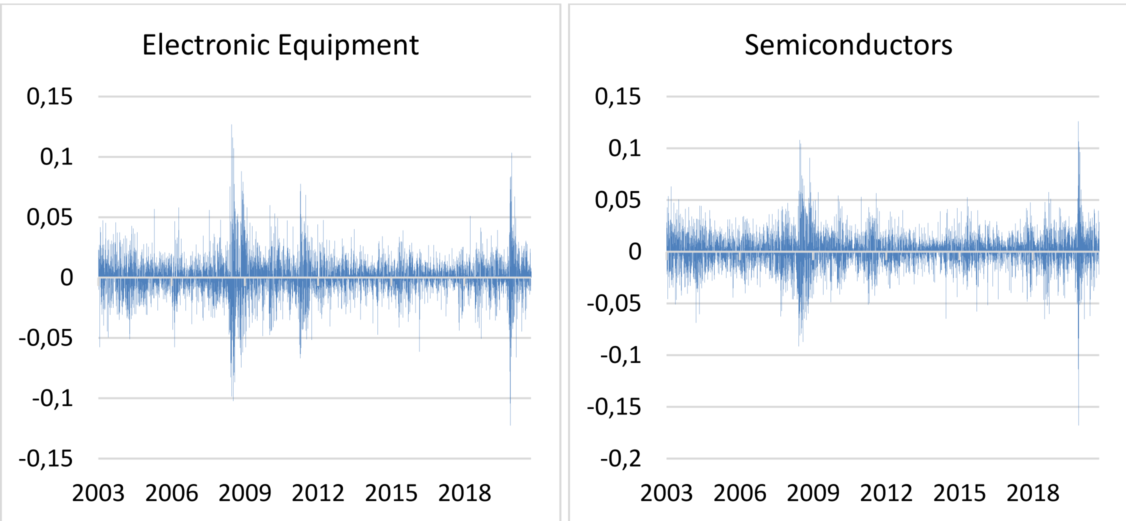

Figure 13 Electronic equipment and Semiconductors

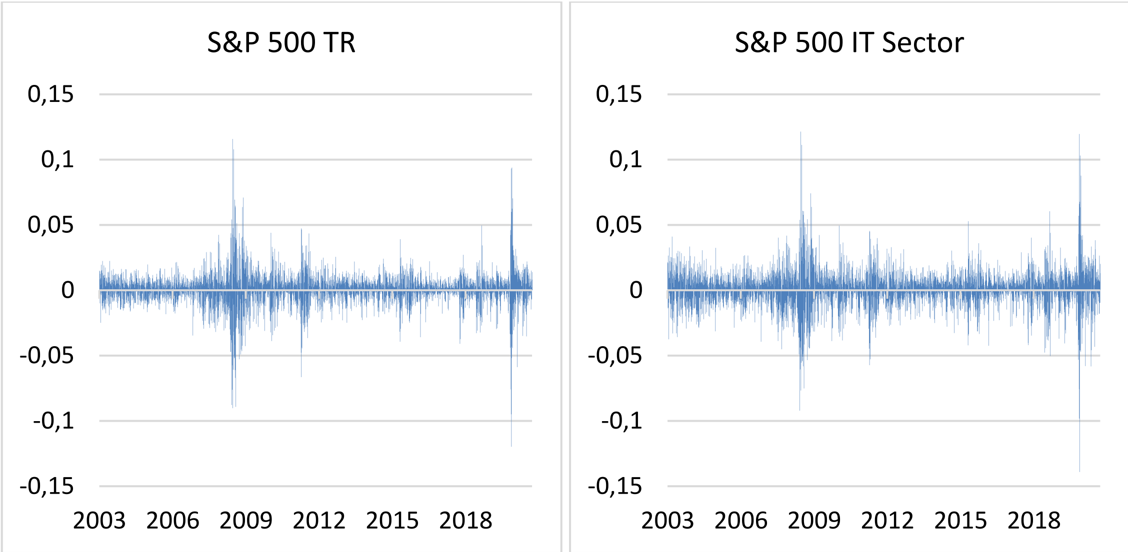

Figure 14 S&P 500 and IT Sector

5.2 Regression analysis

Results of the regression analysis are presented in table 14, coefficients for factors are presented first and the t-values are shown in parentheses. The critical value of t (two-tailed) is ± 2,58 at a probability level of 0,01 and ± 1.96 (two-tailed) at a probability level of 0,05. The result for Fama–French three-factor model is presented in the first section of the table. The first line has a value of constant which is known also as alpha, positive values indicate that it is possible to get excess returns by utilizing the FF-3 model. R-squared values are telling the explanatory power of the Fama–French three-factor model for each industry. FF-3 gets the highest r-squared value against the IT services industry. Can be interpreted that FF-3 explains 79,7 % of the IT service industry index market movements when the r-squared value is 0,797. At the other end is the hardware industry which has the lowest r-squared value of 0,631 but the communication industry is close, at 0,649. These industries have more inexplicable movements from the perspective of FF-3. When interpreting explanatory factors separately, SMB is not a significant explanatory factor for the communication industry and the HML factor does not explain S&P 500. Constant's results are positive and negative, however, none of them are significant. As a whole, we can interpret that the FF-3 model is explaining different indices well but there are differences between industries.

Results of the regression analysis for the Carhart four-factor model are presented in the second section of table 14, in addition to the FF-3 model now the momentum factor (WML) is included. R-squared values are telling the explanatory power of the Carhart four-factor model for each industry. Carhart's model gets the highest r-squared value against the IT services industry which is the same as the FF-3 model. Can be interpreted that the four-factor model explains 79,8% of the IT service industry index market movements. The lowest r-squared values are for the hardware industry 0,631 and the communication industry 0,653. As a difference to the FF-3 model added factor adds a little more explanatory power, but not significantly. Hardware, software, and S&P 500 were with the same explanation rate, no better results were obtained with the momentum factor. However, the momentum factor is significant for S&P 500, but its level of explanation is already so high that in this case, it will not rise. In other indices, a slightly better degree of explanation was achieved. SMB factor's weakness for communications is at a similar level as in the FF-3 model. The hardware industry was the only one that WML does not have a significant t-value. For the software industry, WML significance is at a 10% level, the critical value of two-tailed t is ± 1.65 at a probability level of 0,10. In the 4-factor model, constant gets significant values for the hardware, the value is positive, and the t-value is 1,87 which is at the 10% level. For other constants, t-values are low.

Results of the regression analysis for the Fama–French five-factor model are in the last section of table 14, in addition to the FF-3 model and as a difference to the four-factor model, there are two new factors RMW and CMA. Can be interpreted of the r-squared values of the 5-factor model that the best explanation rate is found in IT services at 79,9%, as in previous models. In the 5-factor model, the explanation rate is the highest of all. Although, RMW is not a significant explanatory factor only in the IT services industry. The lowest r-squared values are at the hardware industry 0,631 followed by the communication industry by 0,668. Unlike previous models, the SMB factor also emerges as a significant explanatory factor in the communications industry in the 5-factor model. CMA's regression is not significant regarding hardware. As a difference to the previous models added factors adds a little more explanatory power, but not significantly. Hardware's r-squared value is on the same level at the all factor models although the different amount of explanatory factors. The negative correlation between HML and CMA is noticeable from the results, because HML values are on the minus, while in turn, CMA receives positive values. The only exception is the best performing hardware industry, it gets a negative value for CMA. Constant has significant results in hardware at the 10% level. The only statistically significant alpha coefficient was in the hardware industry, it was positive, and the coefficient is 0,0003. This means that factor models cannot be used widely for gaining excess returns from the industries of the IT sector. Significance can be found only from one industry and it is weak.

Table 14 Regression results of the factor models

Fama–French three-factor model

Industry	Communications	IT Services	Software	Hardware	Electronic Equipment	Semiconductors	S&P 500 TR	S&P 500 IT Sector
Constant	-0,0001	0,00004	0,0001	0,0003	-0,0001	0,00002	-0,00001	0,0001
	(-0,62)	(0,42)	(0,82)	(1,87)	(-0,95)	(0,14)	(-0,84)	(0,89)
Mkt-RF	1,10	1,01	1,12	1,07	1,16	1,21	1,01	1,11
	(90,54)	(132,87)	(116,33)	(87,82)	(102,03)	(92,92)	(797,98)	(173,85)
SMB	-0,01	-0,15	-0,28	-0,19	0,28	0,14	-0,17	-0,11
	(-0,20)	(-8,69)	(-12,90)	(-6,99)	(10,86)	(4,80)	(-57,91)	(-7,76)
HML	-0,27	-0,20	-0,61	-0,58	-0,05	-0,47	0,00	-0,49
	(-11,35)	(-13,02)	(-31,82)	(-23,99)	(-2,14)	(-18,39)	(0,83)	(-38,95)
R-squared	0,649	0,797	0,749	0,631	0,717	0,665	0,993	0,870

Carhart four-factor model

Industry	Communications	IT Services	Software	Hardware	Electronic Equipment	Semiconductors	S&P 500 TR	S&P 500 IT Sector
Constant	-0,0001	0,00004	0,0001	0,0003	-0,0001	0,00003	-0,00001	0,0001
	(-0,55)	(0,48)	(0,84)	(1,87)	(-0,88)	(0,18)	(-0,76)	(0,91)
Mkt-RF	1,09	1,00	1,12	1,07	1,15	1,20	1,01	1,11
	(89,71)	(131,90)	(115,48)	(87,28)	(101,23)	(92,08)	(798,97)	(172,64)
SMB	-0,01	-0,15	-0,28	-0,19	0,28	0,14	-0,17	-0,11
	(-0,22)	(-8,74)	(-12,91)	(-6,99)	(10,91)	(4,79)	(-58,42)	(-7,78)
HML	-0,39	-0,25	-0,63	-0,58	-0,17	-0,54	-0,01	-0,51
	(-13,47)	(-13,88)	(-27,33)	(-19,99)	(-6,21)	(-17,52)	(-4,29)	(-33,70)
WML	-0,14	-0,07	-0,03	0,00	-0,14	-0,08	-0,02	-0,03
	(-7,16)	(-5,45)	(-1,65)	(-0,15)	(-7,92)	(-4,01)	(-8,92)	(-2,43)
R-squared	0,653	0,798	0,749	0,631	0,721	0,667	0,993	0,871

Fama–French five-factor model

Industry	Communications	IT Services	Software	Hardware	Electronic Equipment	Semiconductors	S&P 500 TR	S&P 500 IT Sector
Constant	-0,0001	0,00003	0,0001	0,0003	-0,0001	0,00004	-0,00002	0,0001
	(-0,48)	(0,30)	(0,91)	(1,80)	(-0,93)	(0,28)	(-1,08)	(1,11)
Mkt-RF	1,13	1,02	1,13	1,07	1,19	1,23	1,02	1,12
	(89,55)	(127,18)	(110,35)	(82,26)	(99,44)	(89,94)	(787,53)	(165,81)
SMB	-0,08	-0,14	-0,30	-0,16	0,24	0,08	-0,17	-0,14
	(-2,69)	(-7,68)	(-13,36)	(-5,55)	(9,10)	(2,51)	(-58,30)	(-9,46)
HML	-0,53	-0,24	-0,65	-0,52	-0,29	-0,70	-0,01	-0,57
	(-18,17)	(-13,13)	(-27,46)	(-17,51)	(-10,36)	(-22,20)	(-3,07)	(-36,41)
RMW	-0,40	0,03	-0,11	0,12	-0,25	-0,36	0,01	-0,19
	(-9,69)	(1,15)	(-3,39)	(2,73)	(-6,42)	(-8,12)	(1,68)	(-8,47)
CMA	0,62	0,22	0,21	-0,04	0,49	0,48	0,11	0,19
	(12,71)	(7,23)	(5,22)	(-0,76)	(10,68)	(9,03)	(22,94)	(7,32)
R-squared	0,668	0,799	0,751	0,631	0,727	0,676	0,994	0,874

From a factor perspective, the regression of all industries is strong relative to the market portfolio and the coefficient is over 1. SMB has a negative impact on others except for electronic equipment and semiconductors. SMB refers to smaller companies outperform larger ones. This means that when industries behave negatively compared to that, they hold high market value stocks. All companies are S&P 500 listed, thus these are just big companies, but the difference is still noticeable. Can be concluded that the electronic equipment and semiconductor industries behave more like small stock portfolios than other industries from the regression relative to the SMB factor. For the communications industry, this is not reflected in the 3-factor model, but the 5-factor model. The reason for regression with the SMB can be seen from table 4, considering the market value of the indices and the number of firms, electronic equipment, and semiconductors include the smallest companies. Their average market capitalization for each stock is less than 30 billion while averages are more than 30 billion in other industries. This explains why the SMB factor has a greater impact on these industries, even though they include large companies relative to the general level.

The HML factor gets negative coefficients with significant t-values relative to industries. HML refers to the outperformance of value stocks over growth stocks. This is to be expected, as seen in table 12, IT sector stocks are not at a general level so-called value stocks. As the sector grows strongly, equities behave like growth stocks which leads to a negative regression with the HML factor. Industries regression is also negative with the WML momentum factor. WML factor includes the weighted average of the returns for the two winner portfolios minus the returns of the two loser portfolios. It is noted that the IT sector industries have performed worse than the stocks taken into account by the WML factor. Profitability factor RMW factor gets mainly negative coefficients, but the exception is the hardware industry where is a significant positive coefficient. Since the RMW is positive only for the best performing industry, can be interpreted that the operating profitability ratio of the RMW factor is high. It holds more strong profitability stocks than weak as the factor is an average return of robust minus weak portfolios, only the best performing industry was able to overcome this. For the investment factor CMA, the coefficients are significant except hardware. All the significant industries receive a positive coefficient. From the CMA factor figures, can be seen that aggressive investment portfolios have a slightly higher weight because the mean and median of the CMA factor are slightly negative. This indicates that the industries in the IT sector are behaving in the same way as companies investing aggressively, which is understandable given the nature of the sector.

Table 15 shows the regression against market returns. First, Jensen’s alphas are presented annually, and then in constant on a daily basis. Coefficients are presented first, and the t-values are shown in parentheses. The regression is strong and significant for all industries against the market minus risk-free factor, but there are only little noticeable excess returns. Jensen’s alphas are calculated relative to the market return taken from Kenneth French's data library. Only the hardware index has a significant positive factor, but the t-value is 1,93 which indicates a 5,3% level of certainty. The most significant result is for the S&P 500 index, it is a negative coefficient of -3,25 with a 0,1% confidence level. Other constants are not statistically significant. From Jensen's alpha, communications, electronic equipment and S&P 500 get a negative value. Can be interpreted that they are returning less than the market portfolio, and as can be seen from table 13, communications, electronic equipment and the S&P 500 are the three weakest performing indices.

Table 15 Regression results of the market return

Industry	Communications	IT Services	Software	Hardware	Electronic Equipment	Semiconductors	S&P 500 TR	S&P 500 IT Sector
Jensen's alpha	-2,50 %	0,34 %	3,08 %	7,47 %	-4,11 %	1,03 %	-1,61 %	2,13 %
Constant	-0,000096	0,000013	0,000118	0,000286	-0,000158	0,000039	-0,000062	0,000082
	(-0,68)	(0,15)	(0,96)	(1,93)	(-1,20)	(0,25)	(-3,25)	(0,96)
Mkt-RF	1,07	0,97	1,04	1,00	1,18	1,18	1,00	1,06
	(90,55)	(130,18)	(99,92)	(79,93)	(106,35)	(90,55)	(620,35)	(147,94)
R-squared	0,640	0,786	0,684	0,580	0,710	0,640	0,988	0,826

The factor's market portfolio differs from the S&P 500 index in its scope. French's market portfolio comes from the Center for Research in Security Prices (CRSP). This market portfolio is significantly wider than the S&P 500 index, representing nearly 100% of the entire U.S. stock market, thus containing nearly 4000 stocks including small and micro market capitalization stocks. It can be interpreted that the overall market portfolio has outperformed the S&P 500 index by 1,61 % annually and the result is significant. The difference seems to arise from small and micro stocks, which is the reason for the SMB factor of the FF-3 model. In addition to this, the hardware industry's excess return is substantial, but its significance is affected slightly by the low t-value. Further to this, the return on the entire index has been borne by the development of the Apple stock, which has already been mentioned in connection with figure 6.

5.3 Vector autoregression

The purpose of vector autoregression is to interpret the interdependencies of industry indices. The coefficient shows the relation to how variables have behaved historically to each other. Thus, the results can be used to interpret historical dependence as well as to predict future values with the help of historical dependence. A long period can provide a clear picture of how indices behave concerning each other, but on the other hand, the use of historical performance in forecasting is controversial. According to the efficient market hypothesis, which is mentioned in chapter 3, historical data does not affect future behaviour.

From the selection-order criteria for industries, it is considered how many lags produce the best evaluation result. For industries, the Akaike Information Criterion (AIC) result is best in a single lag thus it has been used in vector autoregression. Table 16 shows the results of vector autoregression, where the interdependencies of the industries can be interpreted. The first line shows the coefficient, and the second line shows its Z-value. Critical values for Z-value are ±2,65 at 1 % level, ±1,96 at 5 % level and ±1,65 at 10 % level. A one-period lag refers to future price behaviour. The industry-specific coefficient can be used to predict what will happen in the future. Half of the values in the table are negative and half are positive, this suggests that the price behaviour of the sector is not always parallel. Another factor contributing to this is that the data is on a daily basis, daily fluctuations can be due to irrational factors, thus the effect of volatility is greater. It can be interpreted from the table that the same industries have parallel coefficients with other industries. For example, the coefficients for IT services, software, and hardware are negative for all industries. The coefficients in the communications and electronic equipment industry are not significant explanatory factors for any other industry.

To predict future price behaviour for communications is possible to interpret from IT services, software, hardware, and semiconductors. These industries provide significant levels of explanation. The coefficients to the first three industries are negative which means that if they have risen in the previous period communications should fall in the next period. The semiconductor industry in turn has a positive coefficient, suggesting parallel price behaviour. The highest explanation rate by one industry is noticeable for the semiconductor industry where the software has a negative factor. It is the strongest explanation thus the previous price behaviour of the software industry has the opposite relationship to the future change in the semiconductors industry. The strongest positive factor is the impact of the semiconductor industry on the communications industry. In figure 9, the interdependence of the industries is shown, but at least daily, price behaviour does not correspond to the relationship shown in the figure. However, this is understandable, as this is a behaviour of stock prices that is not directly related to the cooperation of companies and their support of each other's business activities. But significant values in the explanatory industries tell an effect that other industries have on industries operating within the sector. For all industries, the constant is significant and positive, indicating that the price behaviour of any industry cannot be fully explained by other industries. When looking at the constant, the software industry has the highest Z-value for the coefficient and IT services come to the second, which is different from the degree of explanation offered by factor models. In turn, the lowest value can be found in the communications industry. The highest Z-value in the software industry for constant suggests that its interpretation is the most challenging of the industries. The result was as expected as the nature of the software industry differs from other industries. If the potential of the software is realized, the shares may grow sharply, but success is challenging.

Table 16 Vector autoregression for industries

	Explanatory variable						
Explained variable	**Communications**	**IT Services**	**Software**	**Hardware**	**Electronic Equipment**	**Semiconductors**	**Constant**
Communications	0,03	-0,12	-0,06	-0,10	-0,01	0,09	0,001
	0,93	-3,00	-1,83	-3,63	-0,35	3,18	2,09
IT Services	0,0003	-0,09	-0,07	-0,05	-0,002	0,06	0,001
	0,01	-3,05	-2,41	-2,43	-0,08	2,77	3,32
Software	0,01	-0,11	-0,06	-0,08	-0,02	0,04	0,001
	0,40	-3,17	-1,72	-3,07	-0,74	1,56	3,54
Hardware	0,01	-0,08	-0,10	-0,04	0,001	0,08	0,001
	0,24	-2,17	-2,90	-1,63	0,02	2,88	2,19
Electronic Equipment	0,04	-0,08	-0,09	-0,07	0,02	0,07	0,001
	1,46	-2,02	-2,54	-2,42	0,64	2,42	2,16
Semiconductors	0,01	-0,07	-0,14	-0,06	0,001	0,04	0,001
	0,36	-1,66	-3,75	-1,92	0,03	1,15	2,70

From the explanatory variables, it can be interpreted that the market values of the industries affect the degree of explanation. The second part of table 4 shows the market values of the industries. The software and hardware industries have averages during the period in the 700 billion category which is reflected in the impact on the other industries. IT services and semiconductors are also significant with an average market value of approximately 500 million. The communications industry is below 300 and the electronic equipment market value is significantly lower at 65 billion. The weights of the market values are noticeable from the VAR results. IT Services, software, and hardware are strong explanatory factors with negative coefficients for other industries and semiconductors with a positive coefficient. Due to small market value communications and the electronic equipment industry are not significant explanatory factors for any other industry.

6 SUMMARY AND CONCLUSIONS

In this master's thesis, the focus was on the IT sectors' different industries, to find out differences from their indexed stock market performance and explainability of market behaviour through factor models. It was found that portfolios performed in a different way compared to each other even though they are highly correlated to each other and benefit from each other's success directly or indirectly. In addition, the interrelationships between the industries were examined. From the perspective of the results, the most interesting industry was technology hardware, storage & peripherals. As an industry index, it offered the best returns on a nominal and risk-adjusted basis by returning 2305,05 % during the 18 years reference period. It is noteworthy that the index of the IT sector yielded more than two times the S&P 500 index and reached the second-best Sharpe ratio.

Results from the regression analysis that explanatory power does not increase in proportion to the number of factors, actually the degree of explanation is mainly based on Fama–French three-factor model. By adding WML, RMW or CMA can achieve only a minor advantage in some cases. This result is in line with the results found by Rehnby in his 2016 study of the Swedish stock market. (Rehnby, 2016) When interpreting degrees of explanation can be noted that Mkt-RF is the strongest explaining factor in all cases, but HML also provides great support for capturing regression. All in all, the hardware index was the least explained by all factor models which confirms the explanatory power of Mkt-RF as the hardware index furthest from market returns. On the other hand, in terms of industry return compared to market return communications was the closest but the regression was second least. All the factor models had the closest regression with the IT services, with a nearly 80% degree of explanation. For the IT services, the explanatory rate of the models for it increased by 0,1% while the number of explanatory factors increased by one. From the perspective of vector autoregression, the best degree of explanation with the help of variables was achieved for the communications industry. This means that the communications industry can be predicted the best based on the history of other industries. The least explained industry was software. From the VAR results can be interpreted that the market values of the industries affected their degree of explanation. The largest market value industries, software, hardware, and IT Services have negative coefficients for other industries. In the smaller market value industries electronic equipment and communications, the coefficients are not significant explanatory factors for the other industries.

The information technology sector has been doing well in the 21st century and will continue to grow with the megatrend. (Hagberg et al., 2016) There is something to be learned about the growth of the sector and utilized in other contexts. As an interesting topic and for further research suggest the comparison of tangible and intangible assets. Software index performed the second-best and its scalability and cost-effectiveness are superior compared to other industries or sectors. For the study, the use of monthly data could have provided better results because their changes are more consistent. Also examining shorter periods within the era could have yielded interesting results, such as the recovery of industries from the corona crisis.

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APPENDIX 1

Original descriptive statistics

Descriptive statistics	Communications	IT Services	Software	Hardware	Electronic Equipment	Semiconductors	S&P 500 TR	S&P 500 IT Sector
Mean	0,00046	0,00053	0,00066	0,00081	0,00044	0,00064	0,00046	0,00063
Standard Error	0,00023	0,00019	0,00022	0,00023	0,00024	0,00026	0,00017	0,00020
Median	0,00023	0,00059	0,00028	0,00062	0,00024	0,00047	0,00053	0,00076
Standard Deviation	0,01593	0,01304	0,01488	0,01554	0,01662	0,01745	0,01187	0,01378
Sample Variance	0,00025	0,00017	0,00022	0,00024	0,00028	0,00030	0,00014	0,00019
Kurtosis	7,131	12,849	10,476	6,659	6,313	5,874	14,839	10,147
Skewness	-0,010	0,068	0,178	-0,052	-0,052	-0,180	-0,271	-0,061
Range	0,242	0,270	0,299	0,245	0,250	0,294	0,236	0,261
Minimum	-0,104	-0,133	-0,140	-0,130	-0,123	-0,168	-0,120	-0,139
Maximum	0,138	0,137	0,159	0,115	0,127	0,126	0,116	0,121
Sum	2,124	2,429	3,041	3,740	2,050	2,954	2,123	2,908
Count	4624	4624	4624	4624	4624	4624	4624	4624
Confidence Level(95,0%)	0,00046	0,00038	0,00043	0,00045	0,00048	0,00050	0,00034	0,00040

Selection-order criteria

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	17837,8				0,000	-38,60	-38,59*	-38,57*
1	17894,7	113,75	36	0,00	0,00*	-38,64*	-38,56	-38,42
2	17918,6	47,90	36	0,09	0,00	-38,62	-38,46	-38,21
3	17961,3	85,40	36	0,00	0,00	-38,63	-38,40	-38,03
4	17998,6	74,488*	36	0,00	0,00	-38,63	-38,33	-37,85

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
Communications	ITServices	8,97	1	0,003
Communications	Software	3,35	1	0,067
Communications	Hardware	13,20	1	0,000
Communications	ElectronicEquipment	0,12	1	0,725
Communications	Semiconductors	10,14	1	0,001
Communications	ALL	55,46	5	0,000
ITServices	Communications	0,00	1	0,990
ITServices	Software	5,80	1	0,016
ITServices	Hardware	5,88	1	0,015
ITServices	ElectronicEquipment	0,01	1	0,936

ITServices	Semiconductors	7,69	1	0,006
ITServices	ALL	17,44	5	0,004
Software	Communications	0,16	1	0,692
Software	ITServices	10,40	1	0,002
Software	Hardware	9,41	1	0,002
Software	ElectronicEquipment	0,55	1	0,458
Software	Semiconductors	2,45	1	0,118
Software	ALL	28,01	5	0,000
Hardware	Communications	0,06	1	0,811
Hardware	ITServices	4,73	1	0,030
Hardware	Software	8,44	1	0,004
Hardware	ElectronicEquipment	0,00	1	0,982
Hardware	Semiconductors	8,27	1	0,004
Hardware	ALL	26,20	5	0,000
ElectronicEquipment	Communications	2,13	1	0,144
ElectronicEquipment	ITServices	4,09	1	0,043
ElectronicEquipment	Software	6,45	1	0,011
ElectronicEquipment	Hardware	5,85	1	0,016
ElectronicEquipment	Semiconductors	5,83	1	0,016
ElectronicEquipment	ALL	33,73	5	0,000
Semiconductors	Communications	0,13	1	0,718
Semiconductors	ITServices	2,74	1	0,098
Semiconductors	Software	14,03	1	0,000
Semiconductors	Hardware	3,70	1	0,054
Semiconductors	ElectronicEquipment	0,00	1	0,972
Semiconductors	ALL	51,56	5	0,000