UNIVERSITY OF TURKU

ABSTRACT

	Bachelor's thesis
X	Master's thesis
	Licentiate's thesis
	Doctoral dissertation

Subject	Accounting and Finance	Date	28.3.2022
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Title	The Fama-French Five-Factor model and Stressed Stock markets – Empirical evidence from European stock markets during the COVID-19		
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Abstract

This thesis is set to study the Fama-French Five-Factor model in stressed stock markets. In the stock markets, year 2020 was exceptional. Stock markets faced a major and sudden global crash due to COVID-19 pandemic. The STOXX Europe 600 index lost quickly over 20% of its value. Despite the major and sudden crash stock prices recovered rather quickly to pre-pandemic levels and even higher.

The Five-Factor model is an asset pricing model which was developed by Fama and French (2015) to explain the cross-section of asset returns through five factors. The original model contains five factors that are market, size, value, profitability, and investment factor.

First, we tested the original Five-Factor model. Our monthly data ranges from 2011 to 2020 and is from the European stock markets. After this we construct a COVID-19 dummy to see whether it explains the stock returns. We also did a multiple breakpoint test to see whether the pandemic caused a structural change in the Five-Factor model. The ECB continued and even accelerated the quantitative easing (QE) program that was started already before the pandemic. We wanted to test if a statistical relationship with the QE and stock markets could be found. To do this we added a self-constructed factor to the Five-Factor model. The factor was constructed from the balance sheet change of the ECB.

Based on our strong statistical results we can say that the Five-Factor model explains the sector returns in European stock markets. When testing the pandemic dummy, we could not find statistically significant relationship when considering the test assets jointly. However, we found one sector in which the dummy turned out to be statistically significant. The multiple breakpoint test also showed that there was only one sector where the pandemic could have caused a structural change to the model. The additional self-constructed factor showed statistical significance in two sectors and also when tested jointly. The statistical relationship was strong and we can say that the loose monetary policy of the ECB has affected the stock market returns in the European stock markets.

Key words	asset pricing, five-factor model, COVID-19, quantitative easing

TURUN YLIOPISTO

TIIVISTELMÄ

	Kandidaatintutkielma
X	Pro gradu -tutkielma
	Lisensiaatintutkielma
	Väitöskirja

Oppiaine	Laskentatoimi ja rahoitus	Päivämäärä	28.3.2022
Tekijä	Ville Hiltunen	Sivumäärä	72
Otsikko	Fama-French viisifaktori -malli epävakailla osakemarkkinoilla – Empiirinen tutkimus Euroopan osakemarkkinoilla COVID-19 pandemian aikana		
Ohjaaja	Prof. Mika Vaihekoski		

Tiivistelmä

Tämän opinnäytetyön tarkoituksena on tutkia Fama-French viisifaktori -mallia epävakailla osakemarkkinoilla. Vuosi 2020 oli osakemarkkinoilla poikkeuksellinen. Osakemarkkinat kohtasivat suuren ja äkillisen maailmanlaajuisen romahduksen COVID-19-pandemian vuoksi. STOXX Europe 600 -indeksi menetti nopeasti yli 20 % arvostaan. Suuresta ja äkillisestä romahduksesta huolimatta osakekurssit toipuivat melko nopeasti pandemiaa edeltävälle tasolle ja jopa korkeammalle.

Viisifaktori -malli on arvopapereiden hinnoittelumalli, jonka Fama ja French (2015) ovat kehittäneet selittämään arvopapereiden tuottoja viiden faktorin kautta. Alkuperäinen malli sisältää viisi faktoria, jotka ovat markkinafaktori, kokofaktori, arvofaktori, kannattavuusfaktori ja investointifaktori.

Ensin testasimme alkuperäistä viisifaktori-mallia. Kuukausittaiset aikasarjamme ovat vuosilta 2011–2020 ja ovat Euroopan osakemarkkinoilta. Tämän jälkeen rakensimme COVID-19 dummy-muuttujan nähdäksemme, selittääkö se osakkeiden tuottoja. Teimme myös usean rajapisteen testin nähdäksemme, aiheuttiko pandemia rakenteellisen muutoksen viisifaktori-mallissa. EKP jatkoi ja jopa vauhditti jo ennen pandemiaa aloitettua määrällistä elvytystä. Halusimme testata, löytyisikö tilastollinen yhteys määrällisen elvytyksen ja osakemarkkinoiden kanssa. Tätä varten lisäsimme itse rakennetun tekijän viisifaktori-malliin. Faktori muodostettiin EKP:n taseen muutoksesta.

Vahvojen tulostemme perusteella voidaan sanoa, että viisifaktori -malli selittää sektorien tuottoja Euroopan osakemarkkinoilla. Pandemia dummya testattaessa emme löytäneet tilastollisesti merkitsevää yhteyttä tarkasteltaessa sektoreita yhdessä. Löysimme kuitenkin yhden sektorin, jossa dummy osoittautui tilastollisesti merkitseväksi. Useiden rajapisteiden testi osoitti myös, että vain yhdellä sektorilla pandemia olisi voinut aiheuttaa rakenteellisen muutoksen malliin. Itse rakennettu lisätekijä osoitti tilastollista merkitsevyyttä kahdella sektorilla ja myös yhdessä testattuna. Tilastollinen suhde oli vahva ja voidaan sanoa, että EKP:n löysä rahapolitiikka on vaikuttanut osakemarkkinoiden tuottoon Euroopan osakemarkkinoilla.

Avainsanat	arvopapereiden hinnoittelu, viisifaktori -malli, COVID-19, määrällinen elvytys

UNIVERSITY OF TURKU
Turku School of Economics

THE FAMA-FRENCH FIVE-FACTOR MODEL AND STRESSED STOCK MARKET

Empirical evidence from European stock markets during the COVID-19

Master's Thesis
in Accounting & Finance

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28.3.2022
Turku

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1 INTRODUCTION

1.1 Background

Every now and then stock markets and capital markets, face crises that affects their functions significantly maybe even dramatically. Central issue in finance literature is how stocks behave during these crises. In the stock markets, year 2020 was exceptional. Stock markets faced a major and sudden global crash due to COVID-19 pandemic. The STOXX Europe 600 index lost quickly over 20% of its value. Despite the major and sudden crash stock prices recovered rather quickly to pre-pandemic levels and even higher. Till the end of the year 2020 the above-mentioned index had already surpassed the end of 2019 level. The global economy faced a sudden and vast crisis in 2020. Majority of global economies was forced to shut down to control the spread of the pandemic. The spread of the coronavirus undermined rapidly the growth prospects of economies in the euro area.

The European central bank (ECB) started extraordinary actions to mitigate the impact of COVID-19 pandemic on the euro area economy. ECB announced in its press release on 18 March 2020 that it is going to launch a €750 billion Pandemic Emergency Purchase Program (PEPP).[1] The initial purchase program envelope was increased by €600 billion on 4 June 2020 and by €500 billion on 10 December 2020. This way the new total was increased up to €1,850 billion.[2] The purchase program included all assets that were already eligible under the existing asset purchase program (APP) initiated in mid-2014.[3] This purchase program initiated by ECB made the already favorable financing environment even more favorable.

Research around finance and capital markets has produced many models that are trying to explain average stock returns. As a group these models are called asset pricing models. The capital asset pricing model was maybe the first widely acceptable asset pricing model developed. It was developed independently by Sharpe (1964) and Lintner (1965). According to The CAPM only factor explaining stock returns is its correlation between market returns. The CAPM offers a good way to measure risk and its relation between expected returns. Even though it is simple and widely used it does not explain average stock returns in necessary manner. The model has been tested extensively and its

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[1] https://www.ecb.europa.eu/press/pr/date/2020/html/ecb.pr200318_1~3949d6f266.fi.html, 16.4.2021
[2] https://www.ecb.europa.eu/mopo/implement/pepp/html/index.en.html, 16.4.2021
[3] For more informtation, see https://www.ecb.europa.eu/mopo/implement/app/html/index.en.html, 16.4.2021

empirical record is unfortunately quite poor. The model takes many simplifying assumptions, and some researchers say that it might be the reason for its empirical problems. For example, Fama and French (2004) say that these simplifying assumptions might be the reason for the poor empirical performance. They also say that the empirical problems might also be due to the difficulties in implementing valid tests of the model. For example, the idea behind the CAPM is that the risk of the stock should be measured relative to a market portfolio. The market portfolio could, in principle, include not just traded financial assets, but also consumer durables, real estate, human capital et cetera. This brings the question a light that is it legitimate to limit the market portfolio only to US common stocks. Even if the market portfolio was limited to financial assets, should it include for example bonds and other financial assets around the world. As we said that the CAPM has been tested extensively, we will go through studies that puts the empirical performance of the CAPM to bad light in the latter part of this thesis.

After the CAPM many researchers have studied factors affecting variance in stock returns. Later as a result of these studies many asset pricing models have formed. For example, the arbitrage pricing model of Ross (1976), the Three-Factor model of Fama and French (1993) and the Four-Factor model of Carhart (1997) The most recent and maybe the most developed model is Fama and French's (2015) five-factor model. The model is trying to explain average stock returns through five factors. These factors are market, size, value, profitability, and investment factor. We are going to discuss all the above-mentioned models in more detail in the theoretical background section of this thesis.

The performance of different asset pricing models has been tested quite extensively. The performance of Fama-French Five-Factor model have been tested internationally not only with U.S. data. (see Fama & French 2017) The standard practice in the asset pricing literature has been to evaluate asset pricing models based on their performance on explaining the average returns of portfolios that are formed based on size-B/M sorts. Testing how well the asset pricing models explain for example the average returns of sector portfolios has been done less. Lewellen et al. (2010) suggested that empirical tests of asset pricing models can be improved by including portfolios sorted by sectors in the tests. In this thesis we are going to follow this suggestion. Also, how the asset pricing models perform during exceptional market situations has been examined less. There are some papers that examine Fama-French Five-Factor model during the COVID-19 pandemic.

(See, Horváth – Wang 2020) During 2020 and 2021 many research papers about the impacts of COVID-19 to the stock markets and the economy have emerged.

Ramelli and Wagner (2020) conducted an event study to examine the impact of COVID-19 to US equity markets. They found evidence that US firms that had exposure to business related to China faced negative abnormal returns during the Incubation period (2.1.2020–17.1.2020) and during the outbreak period (20.1.2020–20.3.2020). According to their study investors became more concerned about high corporate debt and low cash holdings. They presented evidence that, while high cash holdings are expensive for companies because of the opportunity costs and agency problems, in this pandemic the importance of emergency cash holdings were vital for firm value.

1.2 Research questions

The goal in this thesis is to investigate how well the Five-Factor model explain the average returns of sector portfolios and what kind of impact the exceptional market situation caused by COVID-19 pandemic and further the liquidity provided by European Central Bank (ECB) has on the stock markets. The study will be conducted with European data. The research questions are stated as follows:

Does the Fama-French model work on the European stock markets?

Did the COVID-19 pandemic have an impact on stock market returns and did it cause a structural change on the Fama-French five factor model?

Does the liquidity provided by the European Central Bank have an impact on stock market returns?

The first question is examined with a simple regression model. We will run a regression model with original five-factor model factors and see how well it explains the stock returns of sector portfolios in European stock markets during the time period of 2011–2020. To answer the second question, we will construct a dummy variable of the period of the pandemic. The we add this dummy variable to the five-factor model and run the regression with it. The dummy variable will cover the period of 1.1.2020–31.12.2020. The second part of the second question will be answered with the multiple breakpoint test. For the third question we create sixth factor to the model in addition to the original five factors provided by Fama and French (2015). The sixth factor is the change in the balance sheet of the European Central bank. This sixth factor captures the exceptional actions taken by ECB to mitigate the impact of the pandemic to euro area economy.

1.3 The scope and limitations

The purpose of this thesis is to study the Fama-French Five-Factor model in stressed stock markets. The theoretical part of the thesis focuses on asset pricing models and factors that affect the stock returns. In the literature review we present the development path of asset pricing and provide comprehensive evidence that the Fama-French Five-Factor model offer a leading benchmark model for asset pricing. We also discuss the critique and opposite views around the asset pricing models.

There are several limitations in this thesis. First and maybe most impactful one is the observed time period. The time series on this thesis are from 2011 to 2020. It is important to notice that the COVID-19 pandemic did not end in 2020. The second one is that we focus only in one asset class, equities. Even though it would be interesting to study the impact of COVID-19 pandemic and the quantitative easing of European Central Bank to other asset classes as well, we narrow our focus solely on equities. The third one is that we limit our geographical scope only to the European stock markets. The fourth limitation is related to the first one. Since our time series' end 2020, we might miss some interesting results from the multiple breakpoint test. We use 10% trimming percentage when we conduct the multiple breakpoint test. This means that every break period must contain at least 10% of all the observations. Since we have 120 datapoints in our time series', every break period must contain at least 12 datapoints. In our study these datapoints presents months. This means that due to the settings of the breakpoint test it is not possible to come up with a break date that is for example dated in March 2020. We still find it interesting to see whether there is a structural change in the Five-Factor model in January 2020 or December 2019. Stock markets started to react to the COVID-19 pandemic already few months before the World Health Organization declared it as a pandemic.

1.4 Structure of the thesis

The rest of the thesis is organized as follows. Section two presents the relevant theoretical background of asset pricing. Section two starts with describing stock markets and relevant theories around the topic. First, we will discuss about efficient market hypothesis which can be seen as the groundwork for asset pricing models and their further development. After this we move on to asset pricing models. We shed a little light on the history of asset pricing and get acquainted with earlier studies around the topic.

In addition to the Fama-French Five-Factor model, we will discuss about other multifactor models and how these models are linked to the Five-Factor model. The other asset pricing models apart the Five-Factor model that we are going to cover is the capital asset pricing model, the arbitrage pricing model, the Fama-French Three-Factor model, and the Carhart Four-Factor model. We will discuss the differences of these models and their relative performance compared to one another.

The Section two will paint a general picture of the development of these asset pricing models and overall, the theory of asset pricing. After this we will take a closer look at the factors affecting stock prices. First, we will discuss about so called asset-based factors. The factors discussed are the original five factors proposed by Fama and French (2015), which are the market factor, the size factor, the value factor, the profitability factor, and the investment factor. After these asset-based factors we will discuss briefly about macroeconomic factors. We will discuss about monetary policy and its impacts on stock markets and after that we will discuss about financial crises and how stock markets have reacted to these severe events. The COVID-19 pandemic started as a health crisis, but it also caused a financial crisis. That is why it is justified to take a look on other financial crisis and their impacts on the stock markets.

Section 3 describes the data and the methodology behind the empirical part. The data includes the Fama-French factors for European stock markets, MSCI Sector indices and the ECB balance sheet change. All these time series are from 2011 to 2020. We are using monthly data. Seemingly unrelated regression builds the backbone of the methodology. In addition to the regression, we will run two tests, which are the Wald coefficient test and the multiple breakpoint test.

In Section 4 we present the empirical results. First, we will present the results for the first regression model, which was the original Five-Factor model of Fama and French. We will interpret the results and discuss how well the Five-Factor model explains the stock returns on European Stock markets. We will also do some sector comparison. and then move on to the second one dealing with the liquidity provided by ECB. To study the impact of the liquidity provided by ECB we will create a sixth factor that proxy the stimulus of the ECB. We will also test whether the COVID-19 caused a structural change on the Fama-French five factor model. Finally, Section 5 concludes and gives suggestions for further studies.

2 THEORETICAL BACKGROUND

2.1 Efficient market hypothesis

A few generations ago the efficient market hypothesis, hence EMH, was widely recognized hypothesis describing the anatomy of stock markets. The general belief was that the securities markets were efficient. The hypothesis assumed that when new information arises, it spreads quickly and widely, and it is immediately reflected in securities prices. (Malkiel 2003.) This means that the prices of securities always fully reflect all the information available. So according to this in efficient markets there should not be variation in prices of securities without appearing of new information.

The EMH was first presented by Fama (1970) and it is based on earlier conducted studies. In early studies of market efficiency, it was assumed that if the current price of the security fully reflects the information available it should imply that successive price changes are independent. In addition to this it was also assumed that the securities returns are identically distributed. Together these two statements formed the random walk model. This idea of random walk is widely associated with EMH. In the finance literature the term "random walk" is loosely used to characterize a price series where all the subsequent price changes are random and independent from recent or future price changes. The logic behind random walk is that, if all the information is available and the flow of new information is uninterrupted and the information is immediately reflected in stock prices, then tomorrow's news is only reflected in tomorrow's price changes. This means that the price changes today or price changes the day after tomorrow should be independent of the price changes today. The news is, in principle, random and from this we can draw a conclusion that the price changes, because the prices fully reflect all the known information, must be unpredictable and random. As a result of this, even an ignorant investor, investing in well diversified portfolio at prices given by the market, should obtain the same rate of returns as the professional investor who is studying the market extensively and trying to beat it. (Malkiel 2003.)

Fama stated that markets are efficient, and securities prices fully reflect all the available information if the following three assumptions hold true:

- There are no transaction costs when trading securities and the markets are frictionless.

- All available information is costless and available simultaneously for all market participants.

- All market participants agree on the interpretation of the available information and its implications for the current price and distributions of future prices of each security.

When we also assume that all the market participants are acting rationally and maximizing profits and that there is perfect competition in the market, it is easy to say that kind of market described should be efficient. However, as we know, these are not descriptions of markets met in practice.

Fama (1970) divided the concept of efficient market to three levels. These levels he described as weak efficiency, semi-strong efficiency and strong efficiency. These levels or categories are formed based on the nature of the information subset of interest. The definitions of these categories are as follows:

- The determinant of weak efficiency is that the current stock prices reflect all the historical stock price information. If the level of weak efficiency apply, investors cannot obtain excess returns using technical analysis, but they can recognize under- or overvalued stocks with fundamental analysis and obtain excess returns this way.

- The determinant of semi-strong efficiency is that the current stock prices reflect all the historical stock price information and in addition to weak efficiency, all publicly available information. This means that investors cannot obtain excess returns with technical nor fundamental analysis. The only way to obtain excess returns is to have and utilize information that is not publicly available.

- The determinant of strong efficiency is that the current stock prices reflect all the historical stock price information, all publicly available information and all insider information. This means that all relevant information regarding the stock is reflected in the stock price. In other words, there are no ways to obtain excess returns.

As we can see the levels are not independent. In order for the level of semi-strong efficiency apply, the level of weak efficiency has to apply as well.

By the turn of the twenty-first century, the earlier widely recognized hypothesis of efficient market had become far less general. Many economists started to think that stock prices can be, at least partially, predicted. The new generation of economists stated that it is possible to certain extent predict stock market movements with past stock price patterns and fundamental elements. Many of these economists even claimed that it can be possible to obtain excess risk adjusted returns utilizing these predictable patterns. (Malkiel 2003.)

According to Malkiel (2003) efficient financial market is a such market where market participants cannot obtain excess returns without accepting above average risks. Efficient markets can be inefficient from time to time. Markets can be efficient and still make errors in valuation. This can be seen from the number of stock bubbles appeared. Even though efficient markets can make pricing errors, there is no way that investor can obtain excess risk adjusted returns by reliably exploiting any patterns or anomalies that might exist. Malkiel is skeptical that any of the predictable patterns that have been introduced by financial literature, were ever completely correct nor it was possible to make successful investment strategy to obtain excess returns based on these predictable patterns.

2.2 Introduction to asset pricing models

In this Section we will discuss about asset pricing models and how these models are linked to the Five-Factor model. The other asset pricing models apart the Five-Factor model that we are going to cover is the capital asset pricing model, the arbitrage pricing model, the Fama-French Three-Factor model, and the Carhart Four-Factor model. We will discuss the differences of these models and their relative performance compared to one another and so this Section will paint a broad picture about the development of asset pricing.

2.2.1 The Capital Asset Pricing model

The Capital Asset Pricing model (CAPM) is based on the work of Sharpe (1964) and Lintner (1965). It is trying to predict expected returns of stocks with the exposure to market risk. The market risk is measured by the coefficient beta. The model is based on the idea of EMH, that all the available information is perfectly reflected in the price of stock. This means that stocks are always perfectly priced and never mispriced. This leads to the conclusion that in efficient markets it is impossible to gain more returns without adding more risk. In other words, by growing the coefficient of the CAPM beta. The formula for the CAPM is as follows:

$$\boldsymbol{E(R_i) = R_f + \beta_i\big(E(r_m) - r_f\big)},$$

where $E(R_i)$ is the expected return of the stock, R_f is risk free rate, $E(R_m)$ is the expected market return and β_i is beta which represents the volatility or systematic risk of the stock compared to the market.

The CAPM has been empirically tested quite extensively during the past several decades. Roll (1977) presented critique for the early tests of the CAPM. Later many studies have shown evidence that the CAPM fails to explain the cross-section of asset returns in a robust manner. To name a few Fama and French (1992, 1996) showed that the relation between market β and average return disappeared during the period of 1941–1990 same goes for the earlier studies of Reinganum (1981) and Lakonishok and Shapiro (1986).

The explanation power of the CAPM is not the only problem with the model. Frazzini and Pedersen (2014) took leverage constraint into account when they studied the CAPM. The basic setting was that many investors face leverage constraint which leads to overweighting of risky assets instead of using leverage. This is against the basic premise of the CAPM which is that all investors invest in the portfolio with highest expected excess return per the given amount of risk and then leverage or de-leverage this portfolio to match their preferences of risk. They empirically found that high-beta portfolios have lower alphas and Sharpe ratios compared to low-beta portfolios. In their study this hold true not only in the US equity markets but also in 18 of 19 international equity markets. They also showed that this phenomenon can be captured using betting against beta (BAB) factor. These factors are simple portfolios that are long in low-beta securities and short in high-beta securities. The BAB factor return can challenge for example factors in newer and more developed models that are discussed later including value, momentum, and size factors in terms of economic magnitude, statistical significance, and robustness.

The basic idea behind the BAB factor was already presented by Black (1972) four decades earlier. However, Novy-Marx and Velikov (2022) challenge the robustness of BAB. They say that any empirical support for the underlaying theory of BAB and the interpretation is compromised because the factors constructed by Frazzini and Pedersen (2014) was done with biased beta estimates. The performance of the BAB strategies is driven by overweighting of low liquidity stocks and ignoring the transaction costs caused by this.

2.2.2 Arbitrage Pricing model

The arbitrage pricing model is based on the arbitrage pricing theory developed by Ross (1976). The arbitrage pricing model is the first multi-factor asset pricing model. It is based on an idea that asset's returns can be explained with linear relationship with the expected return of the asset and different factors that capture systematic risk. The difference between the basic idea of the CAPM and APT is that the CAPM assumes market to be efficient and stocks to be perfectly priced. APT differ from the CAPM in the assumption of the degree of market efficiency.

While the CAPM only identifies market risk as the only source of risk in risky assets, according to APT the total risk is formed from the combination of different kinds of factors. The formula for arbitrage pricing model is as follow:

$$\boldsymbol{E(R_i) = R_f + \beta_{i1}\left[E\left(r_1 - r_f\right)\right] + \beta_{i2}\left[E\left(r_2 - r_f\right)\right] + \cdots \beta_{in}\left[E\left(r_n - r_f\right)\right]},$$

where β_{i1}, β_{i2}, β_{in} are the stocks sensitivities to the given factors and $(r_1 - r_f)$, $(r_2 - r_f)$ $(r_n - r_f)$ are the risk premiums for the given factors. While Ross (1976) does not suggest any certain factors and he only provides the general idea of that total risk of the asset is formed from the combination of different factors, other studies have been made that suggest factors that can have an influence on stock prices.

We will discuss more about the asset-based factors in the following subsections, but we will comment here briefly on the macroeconomic factors since they are the group of factors that Ross (1976) in general terms means. Chen, Roll and Ross (1986) provided evidence that stock prices are exposed to different kinds of macroeconomic factors.

Systematic unanticipated economic events have an effect on stock prices according to their exposures to these events and some events have a greater effect on stock prices than do others. For example, they found a link between the oil price index and asset pricing. In later Sections of the thesis, we will discuss more about certain macroeconomic factors affecting stock prices and their behavior.

2.2.3 The Fama-French Three-Factor model

Fama and French (1993) developed an asset pricing model that explains 90% of the cross-section of average stock returns. This is significantly better result than the capital asset pricing model's explanatory power. The model is called Fama-French Three-Factor model. Fama and French added two factors that they discovered could explain stock returns. These factors are the size and the book-to-market equity referred as value factor. Fama and French (1996) studied the performance of the Three-Factor model. They found out that the model can explain all of the anomalies that occur with the CAPM except the momentum anomaly. The model says that the return on portfolio can be explained by its sensitivity to three factors: (i) the excess return on the market portfolio $(R_m - R_f)$, (ii) size premium (SMB, small minus big), (iii) value premium (HML, high minus low). The formula for Three-Factor model is as follows:

$$\boldsymbol{E(R_i) - R_f = \alpha_i + \beta_i(R_m - R_f) + s_i SMB + h_i HML,}$$

where β_i, s_i and h_i are the factor loadings.

The results in the study of Fama and French (1996) show that the CAPM misprices the low-book-to-market portfolio by -0.10 percent per month, small-stock portfolio by 0.28 percent per month and high-book-to-market portfolio by 0.46 percent per month. They used data from 1963 to 1993. These results are only a one point of view albeit a strong one. The interpretation of these results is more contentious.

Fama and French (1993) argue that the asset pricing is rational and that these three risk factors do indeed exist. Lakonishok, Shleifer, and Vishny (1994) argue that the value stocks are not riskier than other stocks. They say that value stocks have been underpriced relative to their risk and return characteristics and that this is due to irrational pricing which causes the high premium. This view is supported by Haugen (1995) and MacKinlay (1995). The third point of view that Fama and French (1996) pointed out was that the

CAPM holds, but it is falsely rejected. Kothari, Shanken and Sloan (1995) argue that returns used to test the CAPM suffer from survivor bias and especially the value factor of the three-factor model suffers from this bias. This is due to the tendency of stock prices to drift upwards when earnings increases are reported and that firms that report extreme earnings increases are more likely to be high value stocks. One other reason for the false rejection of the CAPM is data fishing. Black (1993) claims that Fama and French are misinterpreting their own results in the article Fama and French (1992) and blames them for data snooping. Data snooping is referred as an action where researcher tries many ways to conduct a study and then reports only the most successful ones. This makes the interpreting of the results very hard.

2.2.4 Carhart Four-Factor model

The Carhart Four-Factor model is a widely popular multifactor asset pricing model. It was founded by Carhart (1997). The model is based on the three-factor model developed by Fama and French (1993). The main improvement added by Carhart is the momentum factor.

The cross-sectional momentum factor was not discovered by Carhart. This factor was discovered few years before Carhart developed his model. The evidence for momentum factor was provided by Jegadeesh and Titman (1993). At the time there were a popular opinion among journalists, psychologists and economists that people have a habit of overreacting to information.[4] De Bondt and Thaler (1985) suggested that this view can be expanded directly to the stock markets and that stock markets tend to overreact to information. Jegadeesh and Titman showed that trading strategies that buy past winners and sell past losers can yield significant abnormal returns over the period of 1965 to 1989.

Carhart (1997) added the momentum factor, provided by Jegadeesh and Titman, to the Fama-French Three-Factor model. The model can be seen as consistent with the market equilibrium with four risk factors provided by Fama and French and Jegadeesh and Titman. On the other hand, it can also be seen as a performance attribution model where the coefficients indicate the proportion of mean return attributable to four factors. The Four-Factor model formula is as follows:

[4] For more information, see, Kahneman and Tversky (1982), De Bondt and Thaler (1985) and Shiller (1981).

$$\boldsymbol{E(R_i) - R_f = \alpha_i + \beta_i(R_m - R_f) + s_i SMB + h_i HML + p_i PR1YR},$$

where PR1YR is the momentum factor and p_i is the factor sensitivity.

Fama and French (2012) show that a local four-factor model does well in capturing average returns on local size-B/M portfolios, but not in capturing local size-momentum portfolios. They discovered that this momentum problem is concentrated heavily towards the extremes being the portfolios with heavy tilts toward winners or losers. These tilts towards the extremes are rare probably rare in their opinion. However, the results of Carhart (1997) and Fama and French (2010) show that there are extreme momentum tilts in mutual funds and the four-factor model may be in the extremes of momentum a serious problem in applications. Similarly, Avramov and Chordia (2006) show evidence that the four-factor model fails to explain all the momentum in the US stock markets. They argue that the source of the momentum profits is a systematic one rather than idiosyncratic one.

2.2.5 The Fama-French Five-Factor model

Novy-Marx (2013) discovered that profitability, which is measured by gross profit to assets, has around the same power predicting the cross-section of average returns as the book-to-market ratio has. Aharoni, Grundy and Zeng (2013) discovered a negative relation between expected investment and average stock returns. The Three-Factor model by Fama and French (1993) left unexplained considerably much of the variation in the average stock returns connected to profitability and investment factors. To tackle this Fama and French (2015) developed a five-factor model to better capture patterns in average stock returns. The formula for the Fama-French Five-Factor model is as follows:

$$\boldsymbol{E(R_i) - R_f = \alpha_i + \beta_i(R_m - R_f) + s_i SMB + h_i HML + r_i RMW + c_i CMA},$$

where RMW is the profitability factor, CMA is the investment factor and $\boldsymbol{r_i}$ as well as $\boldsymbol{c_i}$ are the factor sensitivities. Profitability factor is the difference between the returns of portfolios of stocks with strong and weak profitability. Investment factor is the difference between the returns of portfolios with stocks of low and high investment firms.

Fama and French (2015) tested the Five-Factor model in two steps. First, they applied the model to portfolios formed on size, B/M, profitability, and investment. Secondly, they moved on to testing whether the model can explain the average returns related to anomalies. They tested whether the Five-Factor model performs better than the Three-Factor model. They found that there are patterns in average returns related to size, B/M, profitability, and investment and that the GRS test rejects the Five-Factor model at capturing these patterns. However, they estimated that the model explains between 71% and 94% of the variance of expected returns for the Size, B/M, OP, and Inv portfolios. The main problem with the explanation power of the model is related to portfolios of small stocks with negative exposures to RMW and CMA factors. The firms in these portfolios invest a lot, but the negative exposures to RMW do not correspond to low profitability. They fail to explain the low average returns of small stocks that invest a lot despite the low profitability since the unexplained returns of big stocks that invest a lot despite the low profitability are positive. The biggest problem that asset pricing models face is the small stocks. This problem with small stocks is also pointed out in Fama and French (1993, 2012, 2014).

Fama and French (2016) extended their tests of the Five-Factor model to anomalies that are not targeted by the model and that are known to cause problems with the Three-factor model. They were inspired to extend their test of the Five-Factor model by the work of Lewellen et al. (2010) where they criticize the empirical methods used in the asset pricing literature. They argue that asset-pricing tests are often highly misleading and offer several suggestions for improving empirical asset pricing tests. One of their suggestions is to include other portfolios in the tests. They suggest for example portfolios sorted by industry or factor loadings. The anomaly portfolios that Fama and French (2016) include to their tests are formed on size and each of the anomaly variable. The anomaly variables included in the tests are brought up already by earlier studies.

First one is the market beta anomaly. Many studies find that the relation between beta and average stock returns is flatter than predicted by the CAPM (Black et al. 1972; Fama and MacBeth 1973; Frazzini and Pedersen 2014) The second anomaly variable is the net share issues. Ikenberry et al. (1995) find that after share repurchases average returns tend to be large and Loughran and Ritter (1995) that after share issues the average returns seem to be low. The third one is volatility. Ang et al. (2006) find that highly volatile stocks tend to have low average returns. This tends to hold true when volatility is measured as the variance of daily returns or as the variance of the residuals from the Three-Factor model. The fourth one is accruals. Sloan (1996) find that high accruals tend to be associated with low average returns. Accruals are the difference in cash earnings and book earnings caused by accounting decisions. The fifth one is momentum. Jegadeesh and Titman

(1993) showed evidence of momentum in U.S stock returns. Several studies have observed momentum also in international returns (Rouwenhorst 1998; Griffin et al. 2003; Chui et al. 2010; Asness et al. 2013).

Most of the anomalies observed by Fama and French cases to be anomalies with the Five-Factor model and that the returns associated with some of the anomalies shares factor exposures that suggest they are actually part of the same phenomenon. Typically, the Five-Factor model performs better than the Three-Factor model with one exception. Returns associated with accruals being this exception.

Fama and French (2012) discovered that the global version of the three-factor model does not explain the regional expected returns. Later when they tested the five-factor model internationally, the conclusion with the five-factor model was the same (Fama and French 2017).

Since earlier studies showed that the regional factors have done better job explaining the regional returns, in this thesis we are going to use the European factors instead of global factors. We obtain the factors from the Data Library of French (2021). Market risk factor is the difference of the return on a region's value-weight market portfolio and the U.S one month T-bill rate and the other factors are small minus big (SMB), high minus low (HML), robust minus weak (RMW), and conservative minus aggressive (CMA).

2.3 The asset-based factors affecting stock prices

2.3.1 Market factor

The basic rule of the traditional financial theory is that the investor is maximizing the discounted value of future returns. This implies that overall market development should not play any role in the pricing of the asset or stock. The pricing should be solely based on the future cash flows of the asset and the riskiness of these cash flows. As we can see from the previous subsections, many studies have shown that a number of factors have an impact on pricing of listed assets. One of these factors is the market factor.

According to traditional financial theory the investor should place all of his funds in the security with the greatest discounted value. Markovitz (1952) shoved that investor can achieve the desired expected return with lowest possible risk by diversification. The risk measure used in this context is the variance of the returns. Markovitz discovered that much of the variation in asset's returns is accounted by the variation of market returns.

This part of the total risk he termed as systematic risk and the remainder variation that is not correlated with the market return variation he termed as nonsystematic risk. This means that the attractiveness of the investment should not be viewed alone, but how the investment affects the expected return and risk of the overall portfolio. This leads to a situation where it might be beneficial to the investor to reject the investment opportunity that has a greater discounted value and accept the investment opportunity that has a better fit to the overall portfolio. When the investor acts upon this rule it is possible to optimize the overall portfolio in a manner that the overall risk is minimized, and the expected return maximized.

2.3.2 Size factor

While the CAPM assumes that there is a linear relationship between the expected return and the market risk of an asset, many studies have suggested that there are additional factors that have relevant impact on asset pricing as we have discussed on previous subsections. On this and coming subsection we will discuss in more detail these factors apart from the market factor already examined in the preceding subsection.

Banz (1981) presented evidence that on average small firms in New York Stock Exchange (NYSE) have had significantly larger risk adjusted returns than large NYSE firms. The evidence is from over a forty-year period between 1926 and 1975. Banz constructed arbitrage portfolios containing stocks with very large market capitalization and stocks with very small market capitalization. He formed the portfolios by combining long positions in very small firms and short positions in very large firms. Then he determined the difference in risk-adjusted returns between small and large firms by running a time series regression. Banz presented that holding a long position in very small firms and a short position in very large firms has yielded, on average, excess return of 1.52 percent on monthly basis and 19.8 percent as annualized return.

Basu (1983) presented similar evidence of the relation of firm size and the returns on the common stock of NYSE firms. Although the evidence Basu presented, suggest that the effect of size is far more complicated than documented in in the previous literature. He showed that the size effect tends to virtually disappear when accounted differences in risk and earnings-price ratio. He also suggests that risk-adjusted returns of common stocks might be indirectly affected by firm size.

2.3.3 Value factor

The basic idea behind value factor is the value anomaly where stocks that are inexpensive compared to some fundamental measure are going to outperform stocks that are expensive compared to the same measure. Many studies have shown evidence of the existence of this kind of anomaly. The measure of value differs between studies, but the basic idea remains the same.

Basu (1977) discovered relationship between price-earnings (P/E) ratio and the stock returns. The study showed evidence that during the period between 1957 and 1971 portfolios that was formed by combining stocks with low P/E ratio had, on average, higher absolute and risk-adjusted returns than the portfolios formed by combining stocks with high P/E ratio. In Basu's research the formed two low P/E portfolios yielded on average 13.5 percent and 16.3 percent per annum over the 14-year period while the two high P/E portfolios yielded 9.3–9.5 percent annually. The average annual returns declined as one moved from the low P/E ratio to high P/E ratio portfolios. Interestingly contrary to traditional financial theory the higher returns on the low P/E portfolios did not yield higher returns because of higher level of systematic risk. In fact, the systematic risks of the low P/E portfolios were lower than those for high P/E portfolios. Returns for the low P/E portfolios were 4.5 and 2.0 percent per annum more than the returns considering the levels of risks of the portfolios.

Fama and French (1992) discovered a strong positive relation between average stock returns and book-to-market equity (BE/ME). Average monthly return for the low BE/ME portfolio was 0.3 percent while the high BE/ME portfolio yielded 1.83 percent on monthly basis for the period of 1963 to 1990. They discovered also that BE/ME effect is even more powerful than the size effect in the analysis period. Fama and French suggest several explanations for the value effect. If the asset-pricing is rational they suggest, that BE/ME ratio should be direct indicator of the relative potential of the firm. On the other hand, if the rational asset-pricing is declined, they suggest that the effect of BE/ME ratio is due to market overreaction to the relative potential of the firm.

2.3.4 Profitability factor

Fama and French (2006) were able to extract the implications of the dividend discount model for the connection of expected return and expected profitability. They manipulated the model to the extent that the equation tells that higher expected earnings imply higher expected returns. It is clear that more profitable firms, ceteris paribus, should yield greater returns than less profitable ones. The empirical problem is that which kind of measure of profitability captures the average returns in the most robust way.

Novy-Marx (2013) discovered a linkage between profitability, measured by gross profits-to-assets, and average stock returns. Gross profits-to-assets has roughly the same predicting power of average returns than BE/ME ratio. If the profitability measure gross profits-to-assets is replaced with another profitability measure the results differ significantly. For example, variables like earnings-to-book equity and free cash flow-to-book equity have much less predicting power than gross profitability. Even though Novy-Marx remained agnostic about the profitability factors association with priced risks he finds that different profitability factors are useful in identifying underlaying commonalities of different anomalies. He argues that most of the earnings-based anomalies are just different expressions of three basic underlaying anomalies. These anomalies that he identifies are anomalies related to constructing the factors, earning-related anomalies and anomalies associated with strategies for example sorted on probability of failure which tend to yield anomalously low returns. These anomalously low returns were identified by Campbell et al. (2008).

2.3.5 Investment factor

In order to gain profits in the future, the firm needs to make investments in tangible or intangible assets. The need for investments differs significantly between individual firms. For example, a production company might need to invest heavily to machinery whereas a technology agnostic company’s investment requirement might be significantly lower.

Titman, Wei and Xie (2004) provided evidence of a negative relation between investments and future stock returns. Stocks of the firms that invest the most seem to have lower returns for five subsequent years. This relation cannot be explained by the risks nor the characteristics of the firms. The information provided by increased investments can in theory be both favorable and unfavorable. The favorable side of information is that the firms that invest more might have better investment opportunities and the unfavorable side is that the managements of the firms that invest more have more probably a tendency to overinvest. Fairfield et al. (2003) find that both growth in net operating assets and growth in long-term net operating assets are associated with negative returns in one-year ahead time. Sloan (1996) found that investors are failing to fully absorb the information contained in the accruals and cash flow components until the information is impacting the future earnings. Fairfield et al. (2003) argue that this accrual anomaly of Sloan (1996) is a special case of a more general growth anomaly.

In most of the studies where is shown that the expected investment is related to future stock returns this is attributed to mispricing. Xie (2001) tested whether the stock prices rationally reflect the one-year-ahead earnings of the abnormal accruals that are estimated with the Jones (1991) model. Xie find that market is overpricing portion of the abnormal accruals. Fama and French (2006) remained that the irrational pricing is not the only possibility. If the rational pricing holds true, the investment effects in expected returns are due to differences in risk. This would mean that ceteris paribus the firms that invest more are riskier and vice versa. They also argue that tests based on the valuation equations are not capable of determine whether this relation is due to rational or irrational pricing.

2.4 The macroeconomic factors

2.4.1 Monetary policy

Since the outbreak of COVID-19 pandemic the European Central Banks has expanded its balance sheet exceptionally. ECB started a purchase program called Pandemic Emergency Purchase Program, which envelope is totaling €1,850 billion. The program was started to support the euro area economy, which took a massive hit because the pandemic forced euro area economies to shut down. The program made the already favorable financing environment in euro area even more favorable. Liquidity in the capital markets increased substantially.

There are empirical studies that suggest the stock market returns to lag changes in monetary policy. Homa and Jaffee (1971) showed evidence that a significant and systematic relationship between money supply and stock market returns exists. They found that an investor who could have predicted the money supply and used that information would have succeeded in the stock market way better than the investor who was following the buy and hold strategy. Hamburger and Kochin (1972) also find evidence that changes in monetary growth have many effects on the stock market. However, they also state that it is unlikely that their results will help someone to gain alpha from the stock markets.

There are also opposite views on the relationship of stock markets and money supply. Cooper (1974) argues that the efficient markets hypothesis cannot be rejected because of the findings of earlier finance research about the relationship of monetary policy and the stock markets. Cooper shows evidence that stock markets lead the the change in monetary policy not the other way around. Cooper also points out that indeed change in money supply appears to influence stock market returns but the most plausible reason for this is a combination of efficient markets model and the quantity theory of money. In other words, the anticipation of future money supply changes is reflected to current stock prices. There are other researchers that are in line with Cooper's thoughts. Pesando (1974), Rozeff (1974) and Rogalski and Vinso (1977) all root in their study for the efficient markets and that the causality between stock markets and money supply goes from the stock markets to the money supply and maybe back to the stock markets. Rogalski and Vinso call this a bi-directional theory of causality between money supply and stock returns.

The money supply is not the only proxy for the changes in monetary policy and there are many studies that examine the effect of monetary policy in stock market returns not from the perspective of money supply but different monetary policy proxies. There are also studies that investigate the monetary policy shock effects rather than the continuous causality.

In Wall Street there is an expression that goes "don't fight the Fed". This is based on the idea that a loose monetary policy is good for the stock market. Maio (2014) presented evidence that change in Fed funds rate have significant predicting power over the stock returns. Fed funds rate (FFR) is the overnight interest rate at which institutions trade federal funds.[5] Maio constructed stock market timing investment strategy using FFR. The evidence shows that the market timing strategy that was formed using FFR significantly outperformed a buy-and hold strategy. Maio tested the strategy also with alternative asset classes. In most cases the evidence was similar to the evidence provided of the stock market behavior.

There is much evidence about the relationship of US stock markets and FED monetary policy. Conover et al. (1999) examined the relationship between monetary conditions and international stock returns. They find that local stock markets and local monetary policy have a significant relationship. They identified whether the monetary conditions were expansive or restrictive. This was done by looking at the local discount rate of the country. The monetary condition classification was kept the same until the discount rate was changed in the opposite direction. They created a dummy variable based on this monetary condition classification. In addition to the relationship with the local monetary conditions, they also found that foreign stock markets are significantly related to US

[5] https://fred.stlouisfed.org/series/FEDFUNDS, 18.4.2021

monetary conditions and several of the stock markets are more strongly related to US monetary conditions compared to the local one. Their results showed that higher returns associated with expansive monetary conditions are generally not obtained by increase in risk.

Fullana et al. (2020) provided evidence of the stock market returns responses to monetary policy shocks linked to the direction of monetary policy and the economic cycle. Their main finding is that when jointly consider the monetary policy shocks and the business cycle phase, the monetary policy does not play a significant role on the returns of the stock market when the shock is positive, and the business cycle is expansionary.

Chen (2007) discovered that monetary policy may have an effect on switching between bull and bear markets. This view is supported by many studies. Thorbecke (1997) showed evidence that positive monetary policy shock led to large effects on ex-ante and ex-post stock returns. Theoretically this would mean that positive shock in monetary policy should increase the future cash flows of the firm or lower the discount rate at which those cash flows are discounted. Bernanke and Kenneth (2005) find that on average an unanticipated 0.25% cut in the FFR is driving a 1% increase in stock indexes. They also argue that policy changes that are seen to be relatively more permanent are associated with larger market response.

Even though the relationship between stock markets and monetary policy is somewhat controversial, there seem to be a consensus that there is some level relationship between these two. These findings are interesting considering the topic of this thesis. Based on these studies it might be possible to explain the switch from the bear market caused by COVID-19 pandemic to the bull market with the action taken by ECB.

2.4.2 Financial crises

The global economy faced a financial crisis triggered by the collapse of the US sub-prime mortgage market in the summer of 2007 and the following Lehman failure in September 2008 and it was considered the most serious global crisis since the Great Depression. Governments in almost all advanced economies provided support to banks and financial institutions. They introduced both directed actions at individual troubled institutions and systemwide support packages. These actions were also complemented by several relatively novel credit market interventions and liquidity measures by central banks. (Claessens et al. 2010.) The crisis weakened the economic activity globally and declined economic growth and elevated considerably unemployment rates.

Figure 1 shows the price development of the STOXX Europe 600 price index. It is a stock index that covers 90% of the free-float market cap of the European stock market (Thomson Reuters Eikon 2021). From the figure we can see that during the financial crisis in 2007 and 2008 the index fell roughly 60% from its peak. The stock markets started to recover not until February 2009. Compared to the financial crisis caused by COVID-19 the stock market was in a downward trend for a much longer period. During the financial crisis it took stock markets over 1.5 years to hit the bottom. As we can see from the figure, during COVID-19 it took only three months to European stock market hit its bottom and start to recover.

Figure 1. STOXX Europe 600 Gross index development

By the end of 2020 the STOXX Europe 600 index had reached its pre-COVID-19 level and even climbed above that level.

Figure 2 presents the development of Euro STOXX 50 volatility index (VSTOXX). The VSTOXX index is designed to echo the market expectations of the market volatility. VSTOXX is based on EURO STOXX 50 index.[6] From the figure we can see that during the financial crisis the first jump in VSTOXX was on late 2007 followed by much larger jump on late 2008. It took two years VSTOXX to somewhat stabilize during the financial crisis. During the COVID-19 VSTOXX reached its peak value in March 2020. By the end of 2020 VSTOXX had not returned to the pre-pandemic levels. The COVID-19 pandemic was still somewhat ongoing in the end of 2020. This might explain, why the VSTOXX had not returned and stabilized to pre-pandemic levels.

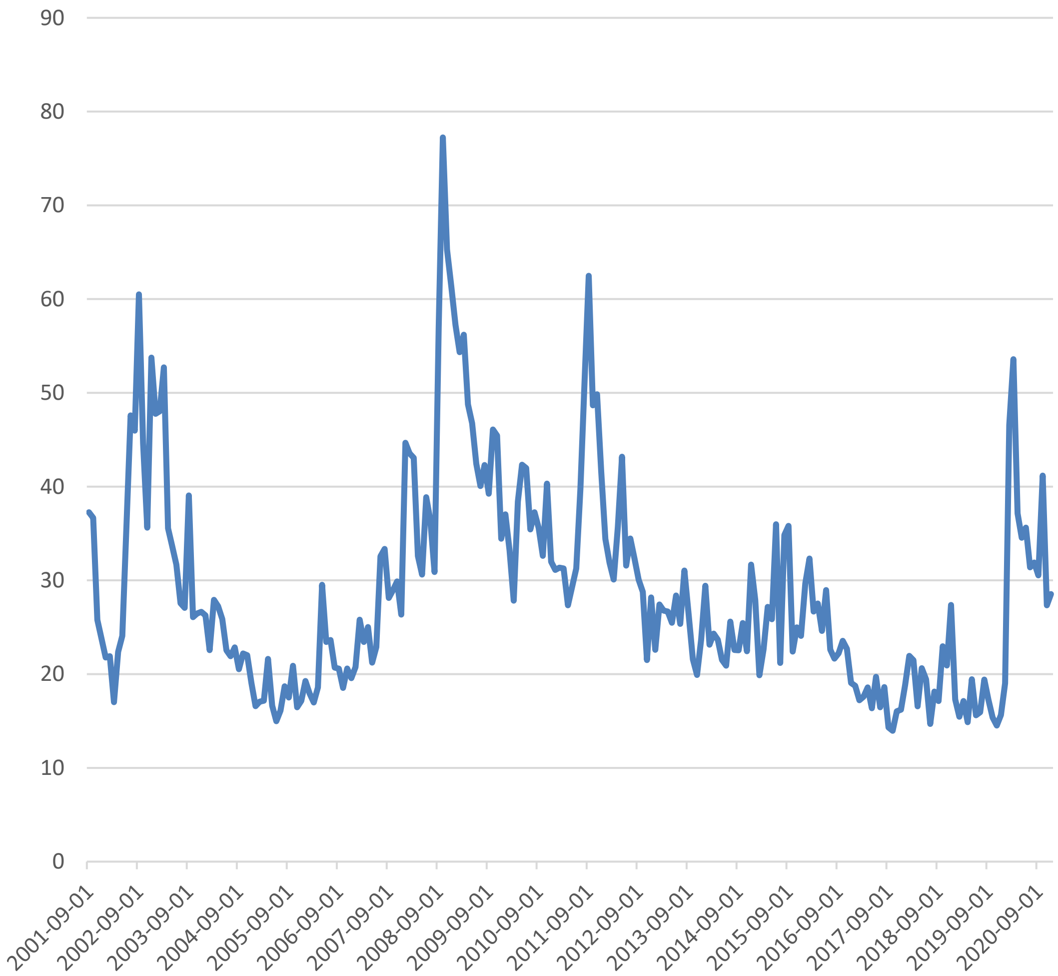


Figure 2. Euro STOXX 50 Volatility index development

[6] Web: https://bit.ly/3iaFfAv 26.9.2021

As we can see from the figure the VSTOXX level during COVID-19 was not in any way exceptional. During the period of 2000–2020 VSTOXX levels have risen above the level witnessed during 2020 three times. These times were during the year 2002, during the already mentioned financial crisis in 2008 and during the year 2011.

There are several other financial crises in addition to the financial crisis and the COVID-19 pandemic that have impacted the stock markets. In 1929 stock markets crashed and started the Great Depression. In 1987 the markets crashed, and the crash was called Black Monday. In the change of 20th century stock markets faced the Dot-com bubble. The difference between these crashes and the crash of 2020 was that all the above-mentioned crashes were caused by some sort of economic activity while the crash of 2020 was caused by a disease, which spread across the world and forced the economies to shut down. According to the EBA's (2020) note banks entered with stronger liquidity and capitalisation into the COVID-19 pandemic compared to previous crises. After the Financial Crisis in 2008–2009 the Common Equity Tier 1 (CET 1) ratio was 9% and in Q4 2019 the CET1 ratio was nearly 15%. This is well above the number required by regulation. CET1 is a component of Tier 1 capital and it consist of ordinary shares and retained earnings.[7] The banks' liquidity coverage ratios (LCR) before the outbreak were also above the regulatory limits. In Q1 2020 the overall LCR was almost 150%. LCR is the proportion of highly liquid assets of financial institutions, to ensure that they can meet their short-term liabilities. [8]

The bear market of 2020 was short compared to other crises. This might be due to the above-mentioned stronger capitalisation and liquidity of the banks and the nature of the crisis. Banks were stronger so the crisis did not escalate to systematic banking crisis. Huber (2018) presented evidence on the causal effect of bank lending on economic activity. Hubert analyzed the lending cut by Commerzbank, which is a large German bank. The lending cut was not due to domestic factors. It was caused by the financial crisis of 2008–2009. The lending cut lowered the output and employment of the firms dependent on Commerzbank. Firms that were fully dependent on Commerzbank faced and employment fall of 5.3 percent. Results suggests that lending cut did not only have direct effects but also indirect effects on firms' economic activity. The lending cut also affected the growth rates during the years of lending cut. The work shows findings of an indirect

[7] Web, https://bit.ly/3ohzxAm, 2.12.2021
[8] Web, https://bit.ly/3IajYm9, 2.12.2021

demand effect. This suggest that during a financial crisis, bank lending cuts can partially cause an aggregate demand shortfall. The make-up of productivity shortfalls of economies takes more than only a few years so the recoveries from banking crises are slow. As a one reason for a quick recovery from the financial crisis caused by the COVID-19 pandemic can be seen that the crisis did not escalate into a banking crisis. If this would have happened the consequences of the crisis might have been more severe, and the recovery might have been a lot slower.

Harjoto et al. (2021) conducted an event study of the stock market reactions to the shock caused by the COVID-19 pandemic and the stimulus from the government policy. They examined the cumulative abnormal returns (CAR) during the 10 days prior and 10 days after two event dates. These dates were 11.3.2020 and 9.4.2020. The former one presenting the shock date ante latter one the Fed stimulus. Thus, their event windows span from 26.2.2020 to 25.3.2020 for the first event and the second from 26.3.2020 to 23.4.2020. Their study showed that the adverse impact of the COVID-19 pandemic to the equity markets were greater on the emerging countries compared to developed countries. They also find that small cap firms had more negative impacts from the COVID-19 pandemic than the larger firms. They presented evidence that the Fed stimulus had a positive effect on the US equity markets. Interestingly their study shows that the Impact of Fed stimulus is positive for large cap firms but negative for small cap firms.

3 DATA AND METHODOLOGY

3.1 Data description

The data used in the empirical part of this thesis were obtained from Thomson Reuters Eikon and Kenneth R. French online data library. From Eikon we collected the European stock market data and from French online library the data for the Five-Factor model.

The European countries included in the data are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom as these are the countries included in the Fama's and French's international test of the Five-Factor model (Fama and French 2017). We take the perspective of a US investor and use USD returns. We have gathered data covering years 2011–2020 totaling of 10 years. This time frame will leave financial crisis outside the data. The time series data is monthly data. As test assets we will use sector indices from the European stock markets.

3.2 Fama-French factors

We collected the Fama-French factors from the Data Library of French (2021). Fama and French (2017) used this data when they tested the Five-Factor model internationally and that is why we chose to use this data as well. Returns are in US dollars and they include dividends and capital gains. Stocks are sorted into groups by market cap and book-to-market equity. The size breakpoints are the 3^{rd}, 7^{th} , 13^{th} , and 25^{th} percentiles of the aggregate market capitalization of Europe. The countries included in the data are Austria, Belgium, Switzerland, Germany, Denmark, Spain, Finland, France, Great Britain, Greece, Ireland, Italy, Netherlands, Norway, Portugal, and Sweden. The sample period is from beginning of 2011 to the end of 2020. Which should be sufficient to study the impact of COVID-19. The data for 25 portfolios originates from Bloomberg database.

The Fama-French five factors are constructed using the portfolios formed on size and book-to-market, size and operating profitability, and size and investment. All the portfolios are value-weight portfolios. The factors include excess market return (Rm-Rf), small minus big (SMB), high minus low (HML), robust minus weak (RMW), conservative minus aggressive (CMA). The SMB factor is so called size factor and it is defined as:

$$SMB = \frac{1}{3}(SMB_{BM} + SMB_{OP} + SMB_{INV}),$$

where SMB is the average return difference on the nine small stock portfolios and the nine big stock portfolios. SMB_{BM}, SMB_{OP}, and SMB_{INV} portfolios consist of the average return difference in three small stock portfolios and three big stock portfolios. The HML is so called value factor and it is defined as:

$$HML = \frac{1}{2}(Small\ Value + Big\ Value) - \frac{1}{2}(Small\ Growth + Big\ Growth),$$

where HML is the return difference on the two value portfolios and the two growth portfolios. The RMW is so called profitability factor and it is the return difference on the two robust operating profitability portfolios and on the two weak operating profitability portfolios,

$$RMW = \frac{1}{2}(Small\ Robust + Big\ Robust) - \frac{1}{2}(Small\ Weak - Big\ Weak).$$

The profitability is defined as operating income before depreciation and amortization. The CMA is the investment factor and it is defined as the return difference on the two conservative investment portfolios and the two aggressive investment portfolios,

$$CMA = \frac{1}{2}(Small\ Conservative + Big\ Conservative) - \frac{1}{2}(Small\ Aggressive + Big\ Aggressive).$$

The investment ratio used to sort the stocks to portfolios is the change in total assets during the fiscal year. (French 2021.)

3.3 MSCI Sector indices

As dependent variables we use MSCI sector index returns. The original Global Industry Classification Standard (GICS) consist of 11 sectors. We included 9 of the original 11 sectors. Sectors included in the data are energy, materials, industrials, consumer staples, heath care, financials, information technology, communication services and utilities. In addition to these sector indices, we have two industry group indices from the consumer discretionary sector which we left out of the data. Given the nature of the crisis we wanted to include consumer services and retailing indices to the data. The definitions of GICS Sectors that are included in this study are presented in the table 1.

Table 1. GICS Sector definitions [9]

This table presents the Global Industry Classification Standard (GICS) sector definitions. In this study we use sector indices based on this GICS classification.

Sector	Definiton
Energy	Exploration, production, refining, marketing, storage and transportation of oil, gas, coal, and consumable fuels. Oil and gas equipment and services
Materials	Manufacturing chemicals, construction materials, glass, paper, forest products and related packaging products, metals, minerals and mining and steel production.
Industrials	Manufaturing and distributing of capital goods such as aerospace, defense, building products, electrical equipment, and companies that offer construction and engineering services. Companies that provide commercial and professional services.
Consumer Staples	Maufacturing and distributing food, beverages and tobacco. Producers of non-durable household goods and personal products. Food and drug retailing. Hypermarkets and consumer super centers.
Health Care	Health care providers and services, manufacturing and distribution of health care equipment and supplies. Health care technology companies. Research, development, production and marketing of pharmaceuticals and biotechnology products.
Financials	Banking, thrifts and mortgage finance, specialiced finance, consumer finance, asset management and custody banks, investment banking and brokerage and insurance.
Information Technology	Software and information technology services, manufacturers and distributors of technology hardware and equipment.
Communication Services	Telecom and media & entertainment companies, producers of interactive gaming products, content and information creation or distribution through proprietary platforms.
Utilities	Electric, gas and water utilities. Independent power producers and energy traders. Generation and distribution of electricity using renewable sources
Consumer Discretionary	
Consumer Services	Hotels, restaurants and other leisure facilities, media production and services
Retailing	Distributors, multiline retail, speciality retail, internet and direct marketing retail.

[9] Web: https://bit.ly/3df45fI, 6.9.2021

3.4 Constructing the ECB liquidity factor

As we can see from the figure 3 there is a sharp increase in the monthly change of M3 during March 2020. The ECB launched its Pandemic Emergency Purchasing Program on 18 March 2020. We can see that the program had a quick effect on money supply in the Euro area. During the last ten years the monthly change in M3 money supply in the Euro area has not been over 2% before the March 2020. Closest to these levels it was in December 2014 when the monthly change was almost 1.5%. This would suggest that the money supply expanded extensively during the first few months of the pandemic.

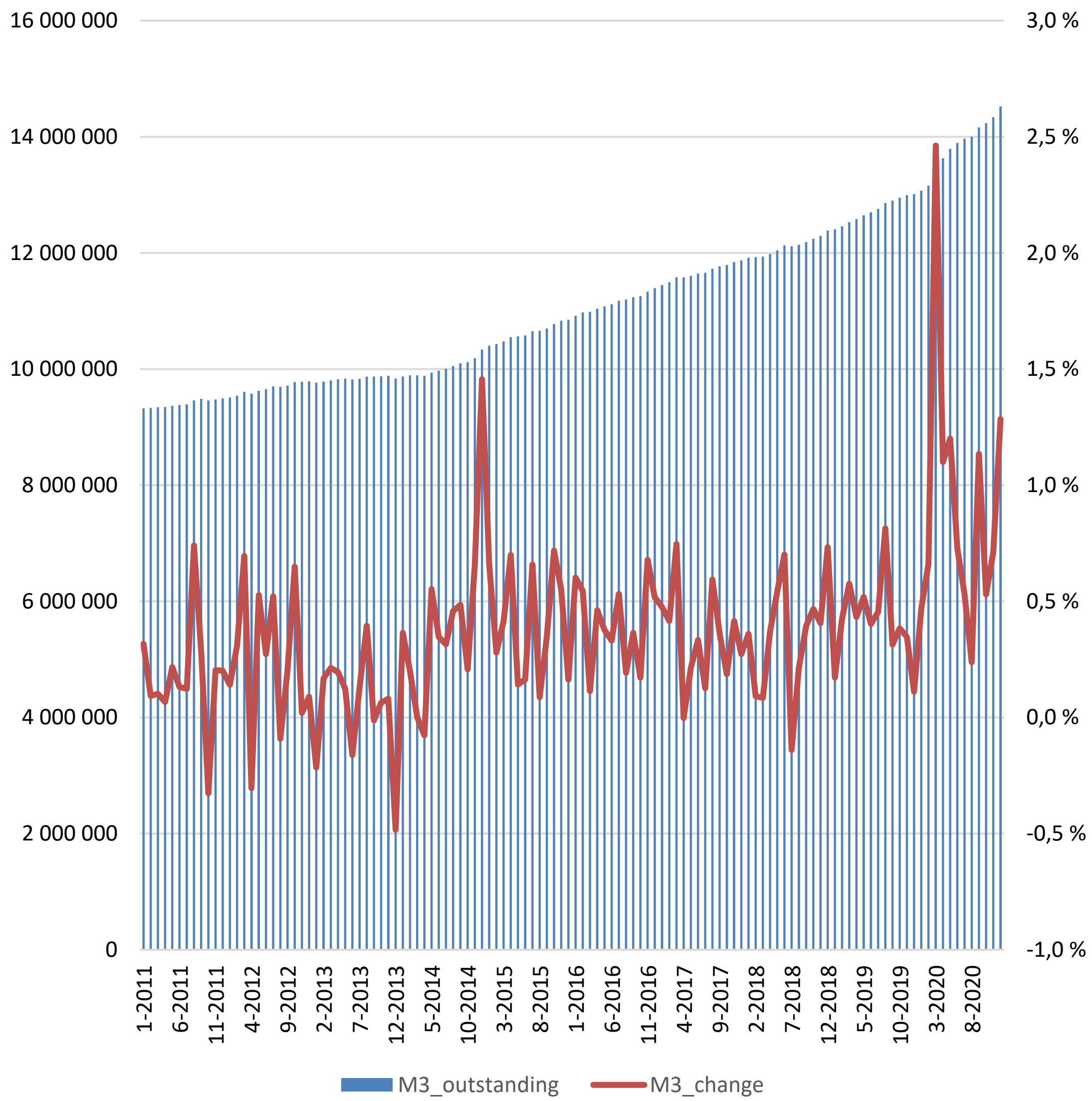


Figure 3. M3 Monetary policy aggregate

On the left in the graph is the M3 outstanding amount and on the right is the monthly percentage change of the M3 amount.

The definitions of monetary aggregates M1, M2 and M3 three are presented in the table 2. Monetary aggregates are categories that measure the supply of money in an economy. These monetary aggregates are used by the European central bank.

Table 2. Monetary aggregate definitions[10]

Monetary aggregate	Definition
M1	The sum of currency in circulation and overnight deposits
M2	The sum of M1, deposits with an agreed maturity of up to two years and deposits redeemable at notice of up to three months
M3	The sum of M2, repurchase agreements, money market fund shares/units and debt securities with maturity of up to two years

As we cans see from the Table 2 the M3 is the broadest monetary aggregate. It includes for example repurchase agreements, money market fund shares, and debt securities with maturity of up to two years.

To answer the research question provided earlier, we need to construct a factor that proxies the liquidity provided by European Central Bank. The first proxy we considered was the money supply in the Euro area, but to the best of our knowledge the balance sheet change gives better proxy for the monetary policy, and we decided to construct the ECB factor form the balance sheet change of the ECB. To do this we have collected outstanding amounts at the end of the period of the balance sheet of the European Central Bank. To construct the factor that we can use to answer the research question we have calculated the monthly change of the balance sheet of ECB. Figure 3 presents the outstanding value and the monthly change in the balance sheet. From the figure we can see sharp increase in balance sheet of the ECB during March 2020. The balance sheet expanded by 16.4 percent. ECB launched its Pandemic Emergency Purchasing Program on 18 March 2020 and accelerated the quantitative easing in Europe.

[10] Web: https://bit.ly/3JaDT3T, 1.10.2021

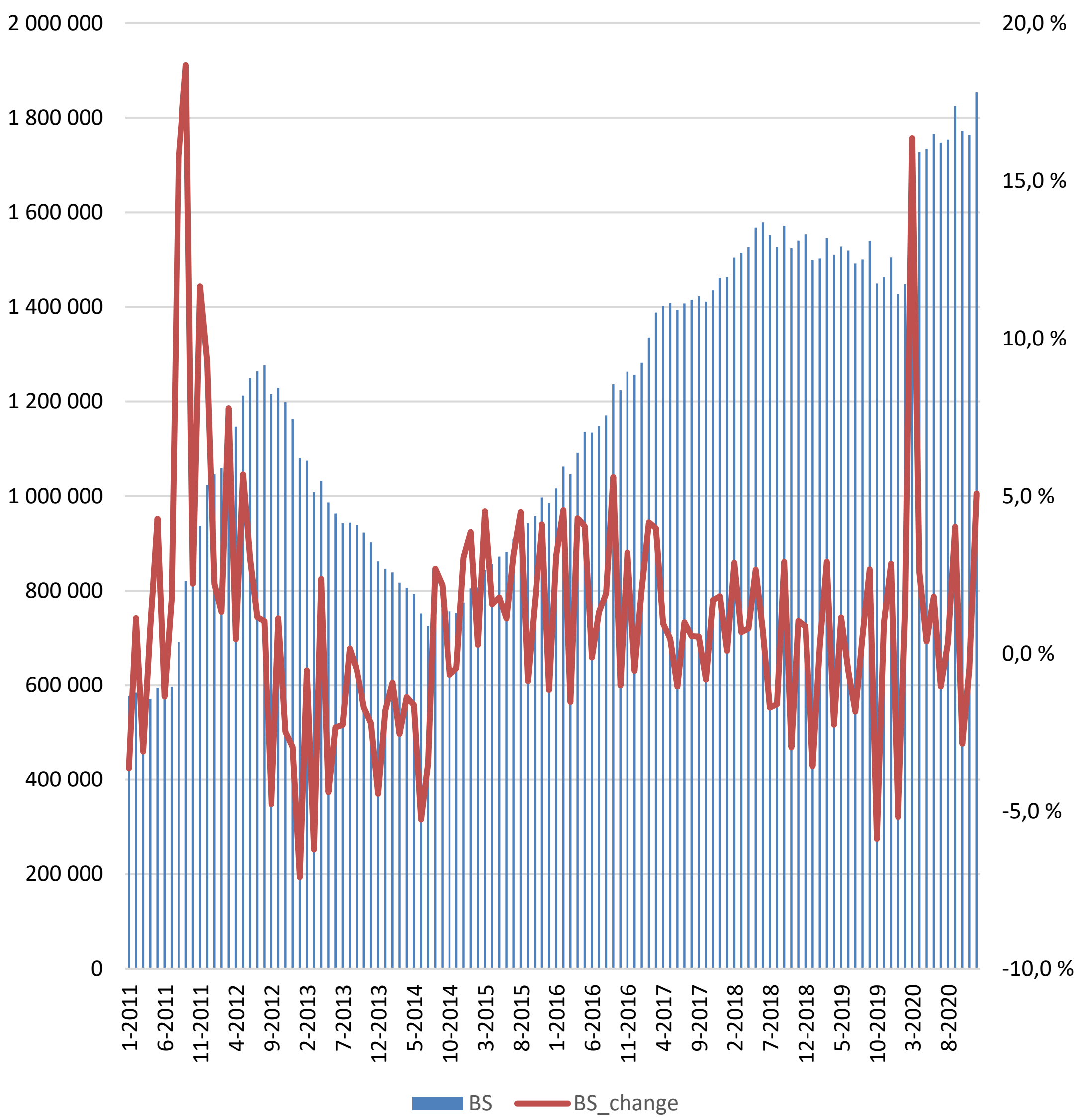


Figure 4. ECB Balance sheet and monthly change

On the left in the graph is the outstanding balance sheet and on the right is the monthly percentage change of the balance sheet.

We call the new factor BS Change (BSC) factor. It proxies the loose monetary policy and the liquidity provided by the European Central Bank. We will add this new factor to the Five-Factor model and examine whether it has explanatory power over the stock market returns. Our approach won’t take a stand on the question, whether the actions taken by ECB caused the shift between bear and bull market during the pandemic.

3.5 Methodology

3.5.1 Seemingly Unrelated Regression

The statistical analyzes of the data is conducted with regression analysis. We will apply systems of equations, which means that the model includes multiple equations instead of one equation. The regression method is Seemingly Unrelated Regression (SUR). In previous studies by Zellner (1962), Zellner (1963), Felmlee and Hargens (1988) and Kim and Cho (2019) the SUR simultaneous equation systems have been specified as follows:

$$Y1 = \beta_{11} + \beta_{12}X_{12} + \beta_{13}X_{13} + \cdots \beta_{1K}X_{1K} + \varepsilon_1$$
$$Y2 = \beta_{21} + \beta_{22}X_{22} + \beta_{23}X_{23} + \cdots \beta_{2K}X_{2K} + \varepsilon_2$$
$$.$$
$$.$$
$$.$$
$$YM = \beta_{M1} + \beta_{M2}X_{M2} + \beta_{M3}X_{M3} + \cdots \beta_{MK}X_{MK} + \varepsilon_M$$

OR

$$Y_i = X_i\beta_i + u_i, i = 1,2,3, \dots, m,$$

where Y_M is an $n\ x\ 1$ vector observations on the dependent variable, X_M is an $n\ x\ K$ matrix containing the observations of K independent variables in the regression equation i. A SUR model was originally introduced by Zellner (1962). SUR model allows to test multiple assets at the same time. The SUR model estimators are more efficient compared to standard OLS estimators since as a result of estimating SUR model, a combination of information from different equations is formed. The first regression model is the original five-factor model from Fama & French (2015)

$$\boldsymbol{R_{i,t} - R_{f,t} = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2}SMB_t + \beta_{it3}HML_t}$$
$$\boldsymbol{+\beta_{i4}RMW_t + \beta_{i5}CMA_t + \varepsilon_{i,t},}$$

where LHS variables are excess returns for sector indices and RHS variables are the five-factor model factors.

The second model is the first extension of the five-factor model created for the purposes of this thesis. The element we add to the model is a dummy variable that represents the COVID-19 period inside the analyzing period. The dummy variable covers the period of 1.1.2020–31.12.2020. The model equation is written as follows:

$$\boldsymbol{R_{i,t} - R_{f,t} = \alpha_i + \beta D_{i,t} + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2} SMB_t + \beta_{i3} HML_t}$$
$$\boldsymbol{+\beta_{i4} RMW_t + \beta_{i5} CMA_t + \varepsilon_{i,t}},$$

where again LHS variables are the excess returns for sector indices and RHS variables are the five-factor model variables with the D_i COVID-19 dummy.

The third regression model is the second extension of the five-factor model. Again, we keep the LHS variables the same as we did with the earlier models. For this model we created a macroeconomic factor that represents the liquidity provided by European Central Bank. The factor was constructed as presented in the chapter 3.4. The model equation is written as follows:

$$\boldsymbol{R_{i,t} - R_{f,t} = \alpha_i + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2} SMB_t + \beta_{i3} HML_t}$$
$$\boldsymbol{+\beta_{i4} RMW_t + \beta_{i5} CMA_t + \beta_{i6} ECB_t + \varepsilon_{i,t}},$$

where ECB is the factor representing the liquidity provided by European Central Bank and β_{i6} is the factor loading of the ECB factor.

The fourth and final regression model is a combination of the earlier models. The model is original five-factor model with both the COVID-19 dummy and the ECB factor. The model equation is written as follows

$$\boldsymbol{R_{i,t} - R_{f,t} = \alpha_i + \beta D_{i,t} + \beta_{i1}(R_{mt} - R_{ft}) + \beta_{i2} SMB_t + \beta_{i3} HML_t}$$
$$\boldsymbol{+\beta_{i4} RMW_t + \beta_{i5} CMA_t + \beta_{i6} ECB_t + \varepsilon_{i,t}}.$$

For all models the intercept α_i represents the abnormal returns that are left explained by the model.

3.5.2 Wald Coefficient test

Wald Coefficient test will be used to evaluate the joint significance of the betas. As said before, the regressions will be estimated as a system of regressions, where dependent variables are different sector indices. In these regressions the independent variables are the same for all the regressions. Wald test will be used to test the joint significance of these independent variable among all the regressions. The Wald test is about testing the null hypothesis that the set of betas is equal to specified value, in our case this value is zero. We test whether the set of betas of interest are simultaneously equal to zero. If the test fails to reject the null hypothesis, this indicates that the beta does not have a statistically significant relationship towards the dependent variable. Wald test tests how far the estimated parameters are from zero in standard errors. The null hypothesis is

$$H_0 : \beta 1j = \beta 2j \dots \beta nj = 0$$
$$H_1 : \beta 1j = \beta 2j \dots \beta nj \neq 0$$

where j is the factor in question and N is the number of test assets, which here is 11. For example, $\beta 1$j is the factor loading for the Communications Services sector, $\beta 2j$ factor loading for the Consumer Staples sector et cetera. This will be done separately for every beta in every regression equation used in this thesis to see whether there are statistically significant relationships between independent and dependent variables. [11]

3.5.3 Multiple breakpoint tests

A time series data may include a structural break due to a surprising event. The event can be for example a shock in the economy or a change in policy. For the purpose of this thesis, we are concentrating on the COVID-19 pandemic and its effect on the European stock market. We will identify whether there are structural break dates in the factor time series of the Fama-French five factor model. The purpose of this test is to study whether the COVID-19 pandemic caused a structural change in the Fama-French five factor model. The analysis will be conducted sector by sector.

[11] Web: https://bit.ly/3Ej3S7l, 2.12.2021

Multiple breakpoint tests can be divided into three categories.[12] These test categories are: tests that employ global maximizers for the breakpoints, tests that employ sequentially determined breakpoints and hybrid tests which combine the two approaches. We will use a test that fits in to a sequentially determined breakpoints test category. The approach we use is developed by Bai (1997) and Bai and Perron (1998). The approach allows to detect unknown break dates and whether there is more than one break. The test is a sequential application of breakpoint tests. First a test of parameter constancy with unknown break is conducted with the full sample. The null hypothesis is that parameters are constant. If the test rejects the null hypothesis the break date is determined, and the sample is divided into two samples. After this single unknown breakpoint tests are performed in both subsamples and if the subsample null hypothesis is rejected, a breakpoint will be added. This procedure is repeated until none of the subsamples rejects the null hypothesis or maximum number of breakpoints allowed is reached.

We will allow a maximum number of 5 breaks, use trimming percentage of 10% and use the 5% significance level when conducting the sequential testing. Since there are 120 observations in the sample and we use the trimming percentage of 10%, the regimes are restricted to have at least 10 observations. For the test we will report F-statistic, scaled F-statistic, critical value, and the possible break dates. We are interested whether the test brings up break dates for the early 2020 or late 2019. This would imply that the COVID-19 pandemic caused a structural change in the Fama-French five factor model.

3.6 Hypotheses

The first research question of this thesis is whether the Fama-French Five-Factor model works in the European stock markets. This problem is investigated by testing if the Five-Factor model can explain the average excess returns of different European sector indices. We will investigate the adjusted R squared and the intercept of the model. If the model can completely explain the excess returns of these sector indices the intercept should not differ significantly from zero. We will first examine these sector by sector. Hence, the first hypothesis is:

$$H_0 = The\ regression\ intercept\ does\ not\ significantly\ differ\ from\ zero$$

[12] Web: http://www.eviews.com/help/helpintro.html#page/content%2Ftesting-Stability_Diagnostics.html%23ww186159, 22.12.2021

$$H_1 = The\ regression\ intercept\ significantly\ differs\ from\ zero$$

To get more indisputable answer to the research question, we will conduct a Wald coefficient test. The Wald test is used to test whether the intercept from the sector indices regressions jointly differ significantly from zero. The second hypothesis for the first research question is:

$$H_0 = The\ intercepts\ do\ not\ jointly\ differ\ significantly\ from\ zero$$
$$H_1 = The\ intercepts\ jointly\ differs\ significantly\ from\ zero$$

These hypotheses should provide answer to the first research question.

The second research question of this thesis is whether the COVID-19 pandemic had an impact on stock market returns and did it cause a structural change in the Fama-French Five-Factor model. To answer the first part of the question we will form a COVID-19 Dummy variable and test whether its coefficient differ significantly from zero. First, we will observe the dummy variable sector by sector and after that jointly. Again, to answer the question we will form two sets of hypotheses. The first hypothesis is:

$$H_0 = The\ dummy\ coefficient\ does\ not\ significantly\ differ\ from\ zero$$
$$H_1 = The\ dummy\ coefficient\ sginificantly\ differs\ from\ zero$$

This hypothesis is investigated sector by sector. The second one is investigated jointly, and the hypothesis is:

$$H_0 = The\ coefficients\ do\ not\ jointly\ differ\ significantly\ from\ zero$$
$$H_1 = The\ coefficients\ jointly\ differs\ significantly\ from\ zero$$

The answer to the second hypothesis is obtain from the Wald coefficient test. The second part of the research question, about the structural change in Five-Factor model is investigated with multiple breakpoint test. We will basically observe whether there is a structural change in the model and if yes when it is dated. This will be done sector by sector.

The third research question is whether the loose monetary policy of the European Central Bank during the COVID-19 pandemic had an effect on stock market returns. The ECB accelerated its purchase program, which was initiated already before the pandemic, to fight the economic consequences of the pandemic. To answer this question, we will form a new factor that captures the action taken by the ECB. We call this factor as BS Change-factor (BSC) and test whether its regression coefficient significantly differs from zero. The problem will be examined first sector by sector and after that jointly. The hypothesis for the third question is:

$$H_0 = \ The\ BSC\ factor\ does\ not\ significantly\ differ\ from\ zero$$
$$H_1 = The\ BSC\ factor\ significantly\ differs\ from\ zero$$

This factor will also be investigated jointly as we did with other factors and the hypothesis is formed similarly. The hypothesis is:

$$H_0 = The\ BSC\ factors\ do\ not\ jointly\ differ\ significantly\ from\ zero$$
$$H_1 = The\ BSC\ factors\ jointly\ differs\ significantly\ from\ zero$$

Testing these hypotheses should provide answers to all research questions of this thesis. In addition to testing these hypotheses we will examine and discuss the regression result more in depth.

4 EMPIRICAL RESULTS

4.1 Descriptive statistics

Figure 5 shows the monthly and cumulative market returns in percentage. The cumulative returns have been calculated as follows:

$$CR_T = (1 + r_1) \times (1 + r_2) \times \dots (1 + r_T) - 1,$$

where r is monthly percentage return. The figure represents the total European stock market. We calculated the market return by adding the risk-free rate to the Rm-Rf factor obtained from Data Library of Kenneth French (2021).

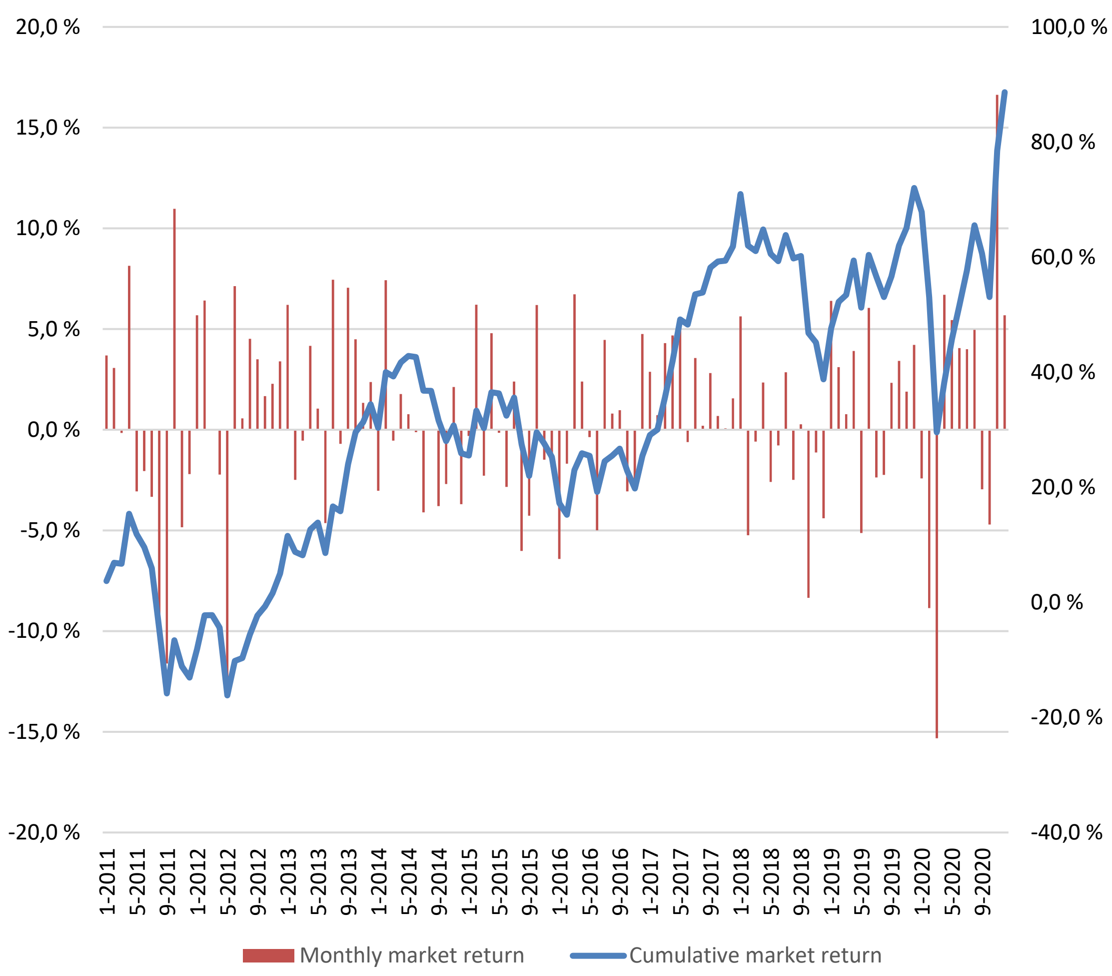


Figure 5. Monthly and cumulative market return

In the graph on the left is the monthly market return and on the right is the cumulative market return.

From the figure we can see that in the early 2020 the European stock market started to react to the news about COVID-19. In February 2020 the market return was -8.9% and in March 2020 when the WHO declared COVID-19 as a pandemic the market yielded a negative return of -15.3%. We can also see a sharp decline on the cumulative market return starting from the beginning of the 2020. We can also see that the markets recovered rather quickly. By the end of the year 2020 the cumulative market return had already surpassed the levels in the end of the 2019.

Table 3 presents the descriptive statistics for the monthly Fama-French factor returns during the time of 2011–2020.

Table 3. Descriptive statistics FF 2011–2020

	Mean	Median	Maxi-mum	Mini-mum	Std. Dev.	Ske-wness	Kurto-sis
MKT_RF	0.006	0.006	0.166	-0.154	0.048	-0.308	4.216
SMB	0.002	0.002	0.047	-0.051	0.017	-0.071	3.433
RMW	0.004	0.005	0.035	-0.039	0.016	-0.358	2.818
HML	-0.004	-0.005	0.108	-0.113	0.027	0.246	6.476
CMA	-0.002	-0.001	0.030	-0.044	0.013	-0.327	3.613
RF	0.000	0.000	0.002	0.000	0.001	1.245	3.020

Each time series consists of 120 data points. The data is from the period of 2011–2020. We can see that the market, SMB and RMW factors have yielded a positive average return during the analysis period. The HML and CMA factors have a negative average return. The market factor has the highest standard deviation while the CMA factor has the lowest. The equity premium (MKT_RF factor) during the period of 2011–2020 was 0.06% per month. The size premium (SMB factor) was 0.02% per month. The profitability premium (RMW factor) was 0.04% per month. The value premium (HML factor) was -0.04% per month. The investment premium (CMA factor) was -0.02% per month. Fama and French (2017) tested the Five-Factor model internationally. In their sample they recorded the equity premium to be in Europe 0.47% per month, the size premium to be 0.05% per month, the profitability premium to be 0.41% per month, the value premium to be 0.32% per month and the investment premium to be 0.20% per month. As we can see these factor premiums have been much lower in our data sample and the value premium and investment premium have turned negative.

The skewness of all the factors is between -0.5 and 0.5 which means that the data of these factors are nearly symmetrical. If the skewness were less than -0.5 the data would be skewed to the left and if the skewness were more than 0.5 the data would be skewed to the right.

The correlation matrix for the Fama French factors is presented in the Table 4.

Table 4. Correlation matrix FF 2011–2020

	MKT_RF	SMB	RMW	HML	CMA	RF
MKT_RF	1.000					
SMB	0.085	1.000				
RMW	-0.361	-0.078	1.000			
HML	0.476	0.053	-0.814	1.000		
CMA	-0.010	-0.164	-0.478	0.642	1.000	
RF	-0.111	-0.183	-0.047	-0.063	-0.079	1.000

The SMB and HML factors are positively correlated with the excess market return. The RMW and CMA factors that Fama and French added to their five-factor model are negatively correlated with the excess market return.

Cumulative returns of FF factors during 2011–2020 are presented in the Figure 6. We calculated cumulative returns starting from January 2011. During this 10-year period the market factor has yielded the highest cumulative return. As Table 3 presented the market factor had also the highest standard deviation this can be seen also from the Figure 6. Other factors remain rather stable compared to the market factor.

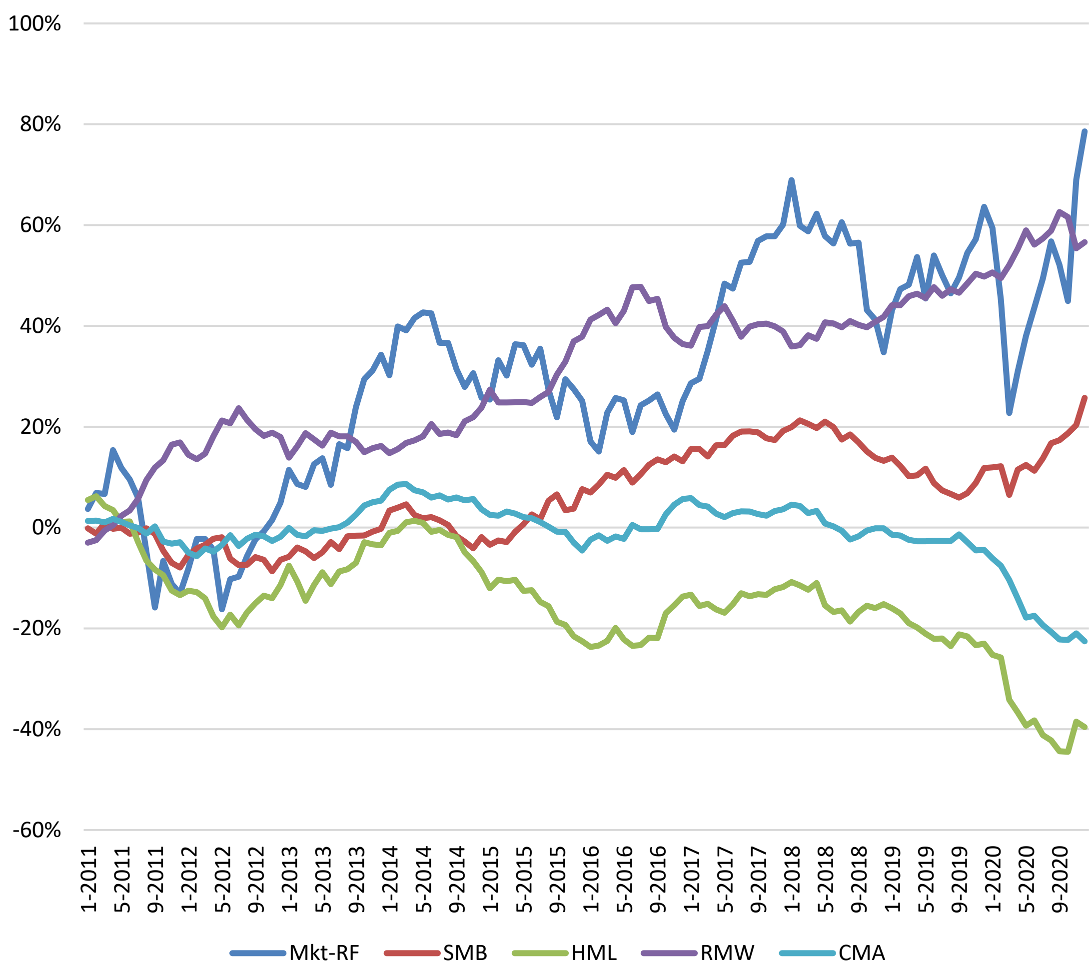


Figure 6. Cumulative FF factor returns 2011–2020

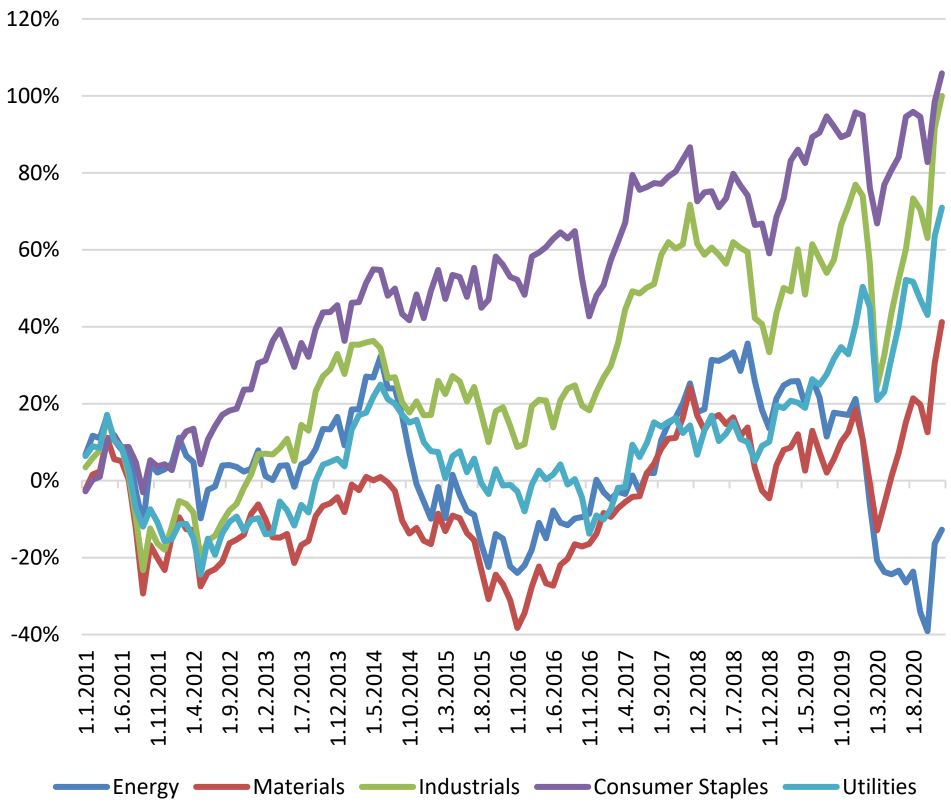
While market, SMB and RMW factors yielded positive cumulative returns during the analysis period HML and CMA returns were negative. The market factor has yielded almost an 80% cumulative return by the end of the year 2020 while RMW yielded almost an 60% cumulative return and SMB over 20% cumulative return.

Table 5 presents the descriptive statistics for the sector indices used as a LHS variables in the regression models. Mean returns for every sector are surprisingly low but all the sectors recorded a positive mean return. Information technology sector has the highest mean return while energy sector has the lowest. Health care sector has the lowest standard deviation while energy sector has the highest.

Table 5. Sector returns and characteristics 2011–2020

Industry	Mean	SD	Min	Max
Consumer services	0.0003	0.014	-0.146	0.127
Consumer staples	0.0003	0.010	-0.097	0.050
Energy	0.0001	0.017	-0.173	0.198
Financials	0.0002	0.016	-0.159	0.125
Health care	0.0004	0.010	-0.105	0.051
Industrials	0.0004	0.014	-0.138	0.103
Information technology	0.0005	0.014	-0.123	0.107
Materials	0.0002	0.015	-0.133	0.103
Retailing	0.0003	0.014	-0.121	0.097
Utilities	0.0003	0.013	-0.159	0.064

Figure 7 shows the cumulative returns for the sectors during 2011–2020. Figure is divided into two to clarify the content. The sectors are roughly divided so that the first figure includes for example commodities and materials and the second one technology and services. Information technology sector yielded the highest cumulative returns with the return of 202.1%. Energy sector had the lowest cumulative return, and it was the only sector that yielded negative return during the analysis period. We can see that in the early 2020 cumulative returns of every sector started to decline. We can also see that almost all the sectors started to recover quite rapidly. The only exception is the Energy sector which started to recover not until late 2020.



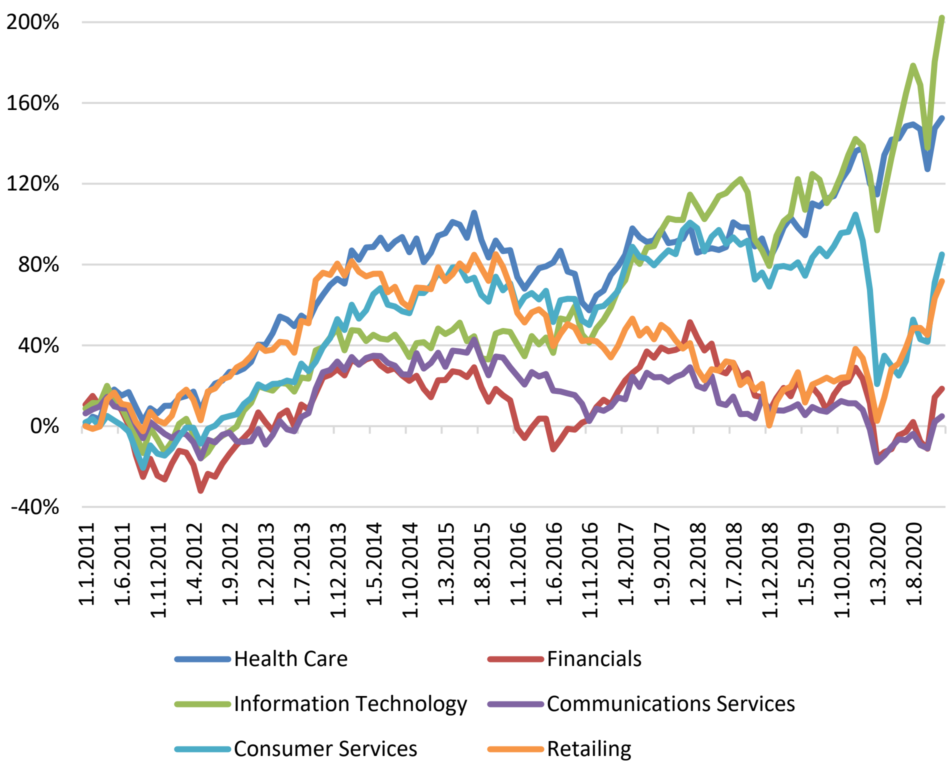


Figure 7. Cumulative sector returns 2011–2020

From the Figure 7 we can see that the Consumer Services took the biggest hit starting in the beginning of the year 2020. Consumer Services had yielded a cumulative return of 104.72% by the end of 2019. After that the cumulative return of the Consumer Services sector fell as low as 20.82% during the first quarter of 2020.

4.2 Regression results

4.2.1 Regression coefficients and Wald coefficient tests

Table 6 presents the regression coefficients and p-values for the first regression model. None of the sector indices show statistically significant abnormal returns during 2011–2020. Utilities have the lowest adjusted R squared while Financials sector have the highest. The market factor is positive and significant at 5% level in every sector. Wald coefficient test shows that when we tested alphas jointly, the result remains the same and no abnormal returns during the sample period was found. Jointly the alphas do not differ statistically from zero. When observing high adjusted R squared numbers and that there are no abnormal returns during the 2011–2020, the results show that five factor model explain the returns of sector indices rather well.

Table 6. Regression coefficients and p-values 2011–2020

Table shows the results for the first regression. P-values for regression coefficients are presented under each coefficient. Adjusted R squared is presented for each test asset. Wald coefficient test results are presented for alphas and factor loadings. The regression equation is presented in Section 3.5. P-values are reported for Wald Coefficient test.

Sector	Alpha	Mkt-Rf	SMB	HML	RMW	CMA	Adj. R^2
Communications Servi-ces	-0.003	0.880	-0.427	0.092	0.453	0.756	0.707
	0.226	0.000	0.004	0.663	0.090	0.008	
Consumer Staples	-0.001	0.882	-0.401	-0.675	0.388	0.687	0.825
	0.600	0.000	0.000	0.000	0.017	0.000	
Consumer Services	-0.003	1.045	0.508	0.186	0.823	0.353	0.732
	0.346	0.000	0.002	0.430	0.006	0.263	
Energy	-0.003	0.957	-0.637	1.172	1.173	0.234	0.704
	0.342	0.000	0.002	0.000	0.002	0.551	
Financials	0.002	1.099	-0.120	0.551	-0.824	-0.287	0.945
	0.257	0.000	0.176	0.000	0.000	0.095	
Health Care	0.002	0.851	-0.419	-0.727	0.008	0.678	0.727
	0.222	0.000	0.000	0.000	0.968	0.002	
Industrials	-0.001	1.129	0.062	0.106	0.282	-0.258	0.943
	0.338	0.000	0.390	0.314	0.033	0.066	
Materials	-0.002	1.147	-0.021	-0.052	-0.288	-0.407	0.813
	0.346	0.000	0.885	0.805	0.279	0.150	
Retailing	-0.002	1.140	-0.031	-0.664	-0.154	0.472	0.690
	0.495	0.000	0.861	0.009	0.628	0.161	
Utilities	0.000	0.830	-0.326	0.343	0.683	0.290	0.644
	0.930	0.000	0.048	0.149	0.023	0.362	
IT	0.002	1.119	-0.039	-0.295	-0.103	-0.367	0.807
	0.335	0.000	0.774	0.135	0.679	0.164	
Wald Coefficient test p-value	0.462	0.000	0.000	0.000	0.000	0.001	

In the Communications Services sector, the SMB factor is negative and significant at 5% level. This suggests that the exposure to the size premium has negative affect on investors returns in the Communications Services sector. The same phenomenon can be seen in the Consumer Staples sector, the Energy sector, the Health Care sector, and the Utilities sector. In the Consumer Services sector the SMB factor is positive and significant at 5% level. The exposure to size premium benefits the investor on average in the Consumer Services sector. In the Financial sector, the Industrials sector, the Materials sector, the Retailing sector, and the Information Technology sector the SMB factor is statistically insignificant. However according to Wald test SMB factor is significant at 5% level, which means that on average the SMB factor explains the cross-section of stock returns.

In the Energy sector and the Financials sector the HML factor is positive and significant at 5% level. In these two sectors the exposure to value premium benefits the investor on average. In the Consumer Staples sector, the Health Care sector, and the Retailing sector the HML factor is negative and significant at 5% level. On average the exposure to value premium in these sectors has negative affect on investors returns. In the Communications Services sector, the Consumer Services sector, the Industrials sector, the Materials sector, the Utilities sector, and the Information technology sector the HML factor is statistically insignificant. Overall, according to Wald coefficient test the HML factor is significant at 5% level, suggesting that the HML factor explains the cross-section of stock returns.

In the Consumer staples sector, the Consumer Services sector, the Energy sector, the Industrials sector, and the Utilities sector the RMW factor is positive and significant at 5% level. In these sectors the exposure to profitability premium benefits the investor on average. The RMW factor also showed a bit weaker statistical significance in the Communications Services sector with a significance level of 10%. The only sector where RMW factor is negative and significant at 5% level is the Financial sector. So, the only sector where exposure to the profitability premium appears to have a negative effect on investors returns is the Financial sector. In the Communications Services sector, the Health Care sector, the Materials sector, the Retailing sector, and the Information Technology sector the RMW factor is statistically insignificant. Again, the RMW factor is, according to Wald test, overall significant at 5% level.

In the Communications Services sector, the Consumer Staples sector, and the Health Care sector the CMA factor is positive and significant at 5% level. In these three sectors the investor benefits from the exposure to the investment premium. The CMA factor is not negative and significant at 5% level in any of the sectors. However, it is negative and significant at 0.10 level in the Financial sector and the Industrials sector and statistically insignificant in the Consumer Services sector, the Energy sector, the Materials sector, the Retailing sector, the Utilities sector, and the Information Technology Sector. Overall, the CMA factor is significant at 5% level.

We have now presented and discussed the results to answer the first research question. Based on these results we can accept the null hypotheses that the regression intercept does not significantly differ from zero in any sector. We can also accept the null hypotheses that jointly the intercepts do not differ significantly from zero. Mirroring to this we can say that the Fama-French Five-Factor model does explain the returns of European stock markets and that it works in this market. The adjusted R squared is over 0.70 in almost every sector and the lowest one is 0.644. The alpha was not statistically significant in any sector, which means that there were no returns left unexplained.

Next, we estimated the regression model with COVID-19 dummy variable. Table 7 presents the regression coefficients and p-values for the regression model. After we added the dummy variable, still none of the sector indices showed statistically significant abnormal returns. However, we found that in the Utilities sector the COVID-19 dummy coefficient is statistically significant. The coefficient value is 0.032, which means that during the COVID-19 period we recorded statistically significant positive returns. The Utilities sector had also the lowest adjusted R-Squared. This was also the case with the first regression model that we estimated. This could indicate that in the Utilities sector, compared to other sectors, there are more factors apart from the Fama-French factors that explain the returns of the Utilities index. Results also suggest that the investor have benefitted from COVID-19 in the Utilities sector.

Table 7. Regression coefficients and p-values with COVID-Dummy 2011–2020

Table shows the results for the second regression. P-values for regression coefficients are presented under each coefficient. Adjusted R squared is presented for each test asset. Wald coefficient test results are presented for alphas and factor loadings. The regression equation is presented in Section 3.5. P-values are reported for Wald Coefficient test.

Sector	Alpha	COVID-Dummy	Mkt-Rf	SMB	HML	RMW	CMA	Adj. R^2
Communications Servi-ces	-0.004	0.012	0.880	-0.443	0.127	0.546	0.871	0.709
	0.109	0.166	0.000	0.002	0.547	0.046	0.003	
Consumer Services	-0.002	-0.010	1.045	0.522	0.156	0.744	0.255	0.732
	0.578	0.293	0.000	0.001	0.509	0.015	0.435	
Consumer Staples	-0.001	-0.002	0.882	-0.398	-0.681	0.371	0.666	0.823
	0.718	0.673	0.000	0.000	0.000	0.027	0.000	
Energy	-0.004	0.003	0.957	-0.641	1.181	1.195	0.261	0.702
	0.330	0.818	0.000	0.002	0.000	0.002	0.524	
Financials	0.002	-0.005	1.099	-0.113	0.536	-0.864	-0.336	0.945
	0.166	0.338	0.000	0.202	0.000	0.000	0.060	
Health Care	0.003	-0.004	0.851	-0.414	-0.738	-0.020	0.643	0.726
	0.183	0.584	0.000	0.000	0.000	0.924	0.005	
Industrials	-0.001	-0.001	1.129	0.063	0.104	0.278	-0.263	0.943
	0.386	0.902	0.000	0.386	0.324	0.041	0.072	
IT	0.003	-0.005	1.119	-0.033	-0.308	-0.137	-0.409	0.806
	0.277	0.591	0.000	0.808	0.121	0.594	0.137	
Materials	-0.003	0.002	1.147	-0.024	-0.046	-0.272	-0.387	0.811
	0.332	0.809	0.000	0.870	0.829	0.322	0.189	
Retailing	-0.003	0.011	1.140	-0.046	-0.632	-0.069	0.577	0.690
	0.322	0.291	0.000	0.794	0.013	0.831	0.099	
Utilities	-0.003	0.032	0.830	-0.368	0.432	0.919	0.583	0.670
	0.336	**0.001**	0.000	0.020	0.060	0.002	0.067	
Wald Coefficient test p-value	0.174	0.081	0.000	0.000	0.000	0.000	0.001	

According to the Wald test, when tested the COVID-Dummy jointly with all the LHS assets we could not find statistical significance with the 5% significance level. However, we could find statistical significance with 10% significance level. It is quite clear that COVID-19 had strong impact on stock markets in Europe although the results above states that statistically the impact was not that strong.

After we included the COVID-19 dummy the SMB factors statistical significance remained the same. The SMB factor is negative and significant at 5% level in same sectors as without the COVID-19 dummy. The same applies for the positive SMB factor. The

HML factor is positive and statistically significant at 5% level in the Energy and Financial sectors as they were also before we added the COVID-19 dummy. In the Utilities sector the HML factor is positive and significant at 10% level. Without the COVID-19 dummy the HML factor in the Utilities sector was insignificant. The RMW factor was positive and significant at 10% level before we added the COVID-19 dummy and after the statistical significance was stronger being at 5% level. In the Retailing and Utilities sector the CMA factor is positive and turned statistically significant at 10% level after we added the COVID-19 dummy.

We have now presented and discussed the results to answer the first part of the second research question. Based on these results we can accept the null hypotheses that the COVID-19 dummy coefficient does not significantly differ from zero in all the sectors except one. In Utilities sector we can reject the null hypothesis. According to this the COVID-19 had a statistically significant effect on stock returns in Utilities sector. Jointly we can accept the null hypothesis that dummy coefficients do not differ significantly from zero at the 5% significance level. However, at the 10% significance level we can reject the null hypothesis.

The third regression model we estimated, was the five-factor model with additional factor of ECB balance sheet change (BS Change). Table 8 presents the regression coefficients and p-values for this regression. Again, we found none of the alphas to be statistically significant. The additional factor that we included in the model turned out to be statistically significant in Energy and Industrials sectors with a significance level of 5% as well as in Financials, Retailing and Utilities sector with a significance level of 1%. In the Energy sector the BS Change factor was positive. This means that in the Energy sector the investor has benefitted from the expansive monetary policy. In the Industrials sector the situation is opposite. The BS Change factor is negative in the Industrials sector which could indicate that the expansive monetary policy has had a negative effect on the investors returns.

When we compare the SMB factor in this regression model and in the first original five factor model, we see no changes in the statistical significance of the factors. Same is true with the HML factor, the RMW factor and the CMA factor.

Table 8. Regression coefficients and p-values with ECB BS change 2011–2020

Table shows the results for the third regression. P-values for regression coefficients are presented under each coefficient. Adjusted R squared is presented for each test asset. Wald coefficient test results are presented for alphas and factor loadings. The regression equation is presented in Section 3.5. P-values are reported for Wald Coefficient test.

Sector	Alpha	Mkt-Rf	SMB	HML	RMW	CMA	BS Change	Adj. R^2
Communications Services	-0.002	0.867	-0.443	0.074	0.461	0.765	-0.061	0.707
	0.357	0.000	0.003	0.727	0.083	0.007	0.368	
Consumer Services	-0.002	1.038	0.500	0.176	0.827	0.357	-0.032	0.730
	0.429	0.000	0.002	0.456	0.005	0.257	0.672	
Consumer Staples	-0.001	0.883	-0.400	-0.674	0.387	0.687	0.004	0.823
	0.596	0.000	0.000	0.000	0.017	0.000	0.928	
Energy	-0.005	1.000	-0.586	1.231	1.147	0.206	0.195	0.712
	0.131	0.000	0.004	0.000	0.002	0.593	0.035	
Financials	0.001	1.114	-0.102	0.571	-0.834	-0.297	0.069	0.946
	0.521	0.000	0.249	0.000	0.000	0.081	0.093	
Health Care	0.002	0.851	-0.419	-0.727	0.008	0.678	0.000	0.725
	0.240	0.000	0.000	0.000	0.968	0.002	0.995	
Industrials	-0.001	1.114	0.045	0.086	0.291	-0.249	-0.066	0.944
	0.698	0.000	0.534	0.407	0.025	0.072	0.046	
IT	0.002	1.128	-0.029	-0.283	-0.108	-0.373	0.039	0.806
	0.448	0.000	0.834	0.153	0.664	0.158	0.536	
Materials	-0.003	1.160	-0.006	-0.035	-0.296	-0.416	0.058	0.812
	0.253	0.000	0.968	0.869	0.265	0.141	0.395	
Retailing	-0.003	1.170	0.005	-0.624	-0.172	0.453	0.134	0.694
	0.262	0.000	0.977	0.013	0.583	0.175	0.095	
Utilities	0.002	0.801	-0.361	0.304	0.701	0.309	-0.130	0.650
	0.576	0.000	0.028	0.197	0.018	0.326	0.085	
Wald Coefficient test p-value	0.546	0.000	0.000	0.000	0.000	0.002	0.001	

Wald coefficient test shows a strong statistical relation with sector returns and ECB balance sheet change. The ECB factor is statistically significant with the significance level of 1%. According to this result it appears to be true that expansive monetary policy has a strong impact on the stock market, at least from the statistical point of view.

We have now presented and discussed the results to answer the third research question. Based on these results we can accept the null hypotheses that the BSC factor coefficients do not differ significantly from zero at the 5% significance level in all the sectors except two. In the Industrials sector and the Energy sector we can reject the null hypothesis. We can also reject the null hypothesis at the 10% significance level in the Utilities sector and the Retailing sector. Jointly we can reject the null hypothesis that BSC factor coefficient does not differ significantly from zero at the 1% significance level.

Fourth regression model is a combination of all the previous models. We have included the COVID-19 dummy and the ECB balance sheet change in the five-factor model regression equation. This regression model and discussion of its results will give more in depth and insights to the research problems. Table 9 presents the results for the estimation of the fourth regression model. The alpha coefficient is statistically insignificant as it was in all the previous regression models. All the factors in the model are according to the Wald test statistically significant with the significance level of 0.05. After we included the ECB balance sheet change into the model with COVID-Dummy both coefficients were statistically significant with the significance level of 5%. When estimated separately, only ECB balance sheet change showed statistical significance with the respective significance level.

When looking at the additional factors sector by sector we find sectors where they are statistically significant. The COVID-19 dummy is statistically significant in the Utilities sector at the 1% level. This is a strong statistical significance. The COVID-19 dummy coefficient is 0.034 which indicates that the investor in the Utilities sector has done better during COVID-19 compared to pre-COVID performance. The COVID-19 dummy was statistically significant and positive in the Utilities sector also in the previous model which included the five Fama French factors and the COVID-19 dummy.

The BS Change factor is statistically significant in the Energy sector, the Industrials sector, and the Utilities sector at the 5% level. It is also significant at 10% level in the Financial sector. The factor is positive in the Energy sector and negative in the Industrials sector and the Utilities sector. This indicates that the investor has benefitted from the expansive monetary policy in the Energy sector and suffered from it in the Industrials and the Utilities sector.

Table 9. Regression coefficients and p-values with COVID-dummy and ECB BS change 2011–2020

Table shows the results for the fourth regression. P-values for regression coefficients are presented under each coefficient. Adjusted R squared is presented for each test asset. Wald coefficient test results are presented for alphas and factor loadings. The regression equation is presented in Section 3.5. P-values are reported for Wald Coefficient test.

Sector	Alpha	COVID-Dummy	Mkt-Rf	SMB	HML	RMW	CMA	BS Change	Adj. R^2
Communications Services	-0.004	0.013	0.865	-0.464	0.109	0.562	0.890	-0.071	0.709
	0.186	0.136	0.000	0.002	0.606	0.039	0.002	0.292	
Consumer Services	-0.001	-0.010	1.040	0.515	0.150	0.750	0.262	-0.024	0.730
	0.641	0.311	0.000	0.002	0.527	0.014	0.424	0.749	
Consumer Staples	-0.001	-0.002	0.883	-0.397	-0.680	0.369	0.664	0.006	0.822
	0.702	0.665	0.000	0.000	0.000	0.028	0.000	0.893	
Energy	-0.005	0.000	1.000	-0.586	1.231	1.149	0.209	0.195	0.710
	0.147	0.982	0.000	0.004	0.000	0.002	0.604	0.036	
Financials	0.002	-0.006	1.115	-0.093	0.555	-0.881	-0.356	0.073	0.946
	0.343	0.251	0.000	0.295	0.000	0.000	0.044	0.073	
Health Care	0.003	-0.004	0.851	-0.413	-0.737	-0.021	0.642	0.003	0.723
	0.199	0.582	0.000	0.000	0.000	0.921	0.005	0.961	
Industrials	-0.001	0.000	1.114	0.044	0.087	0.294	-0.245	-0.066	0.944
	0.694	0.939	0.000	0.540	0.405	0.029	0.089	0.046	
IT	0.002	-0.005	1.129	-0.021	-0.297	-0.147	-0.421	0.043	0.805
	0.367	0.545	0.000	0.879	0.136	0.567	0.126	0.498	
Materials	-0.003	0.001	1.159	-0.008	-0.031	-0.285	-0.402	0.057	0.811
	0.255	0.875	0.000	0.956	0.883	0.299	0.172	0.406	
Retailing	-0.004	0.010	1.168	-0.010	-0.599	-0.099	0.543	0.126	0.693
	0.181	0.366	0.000	0.955	0.017	0.759	0.118	0.115	
Utilities	-0.001	0.034	0.796	-0.412	0.392	0.956	0.625	-0.156	0.679
	0.651	0.001	0.000	0.009	0.083	0.001	0.046	0.031	
Wald Coefficient test p-value	0.318	0.036	0.000	0.000	0.000	0.000	0.001	0.000	

4.2.2 Results for multiple breakpoint tests

Table 10 presents the results for multiple breakpoint tests. From the figure we can see that in several sectors there appears to be at least one sequential F-statistic determined break. Sectors that present break dates are the Consumer Services sector, the Energy sector, the Financial sector, the Materials sector, and the Utilities sector.

Most of the break dates are irrelevant for the purposes of this thesis. We are interested in break dates that takes place in late 2019 and early 2020. Only sector that presents such break date is the Consumer Services sector. In this sector the break date is in the first month of 2020. This means that there is a structural change in the regression model in the Consumer Services sector in the beginning of 2020. This can be interpreted in a way that COVID-19 had an impact on the structural change in the Consumer Services sector. This would make sense, because the Consumer Services sector was one of the sectors that were more negatively affected by the COVID-19 pandemic than the other sectors and did not recover as quickly as the other sectors. When we observed the cumulative returns of Consumer Services sector, we discovered a substantial drop in returns. In the late 2019 the cumulative return during the analysis period was over 100% and during the first quarter of 2020 the cumulative return fell as low as to 20%. This might be due the social distancing and restriction imposed by governments around the Europe. It is hard to run a service business if social distancing is a must and gatherings are limited to a certain number. This might have put the Consumer Services sector investors on their toes. The firms in the Consumer Services sector are also relatively small compared to other sectors. As Harjoto, Rossi and Paglia (2021) found out, small cap firms suffered more from the COVID-19 pandemic than the larger ones. They also found out that small cap firms in the equity markets reacted negatively to the stimulus package while large cap firms reacted positively.

Table 10. Results for multiple breakpoint tests

	Sequential F-statistic determined breaks:	Break Test	F-Statistic	Scaled F-Statistic	Critical Va-lue**	Break Dates
Communications Services	0	0 vs. 1	2.267094	13.60256	20.76	-
Consumer Services	1	0 vs. 1 *	6.578718	39.47231	20.76	2020M01
		1 vs. 2	1.565477	9.39286	23.01	
Consumer Staples	0	0 vs. 1	2.552861	15.31717	20.76	-
Energy	2	0 vs. 1 *	3.792203	22.75322	20.76	2015M09
		1 vs. 2 *	5.846078	35.07647	23.01	2014M04
		2 vs. 3	3.327592	19.96555	24.14	
Financials	3	0 vs. 1 *	7.704764	46.22858	20.76	2016M06
		1 vs. 2 *	9.012014	54.07209	23.01	2015M06
		2 vs. 3 *	4.170387	25.02232	24.14	2012M12
		3 vs. 4	2.313877	13.88326	24.77	
Health Care	0	0 vs. 1	2.376197	14.25718	20.76	-
Industrials	0	0 vs. 1	1.491488	8.948926	20.76	-
Information Technology	0	0 vs. 1	2.037043	12.22226	20.76	-
Materials	1	0 vs. 1 *	4.064195	24.38517	20.76	2016M02
		1 vs. 2	3.693707	22.16224	23.01	
Retailing	0	0 vs. 1	2.830107	16.98064	20.76	-
Utilities	3	0 vs. 1 *	3.483648	20.90189	20.76	2018M03
		1 vs. 2 *	3.969999	23.81999	23.01	2016M02
		2 vs. 3 *	6.963118	41.77871	24.14	2014M12
		3 vs. 4	3.534503	21.20702	24.77	

* Significant at the 5% level.

Based on these results we can answer the second part of the second research question. There is little evidence that the COVID-19 pandemic caused a structural change in the Fama-French Five-Factor model. However, this evidence is not a strong one. Only one sector out of 11 showed evidence of structural change in the model. Even though the results of the multiple breakpoint test are interesting the results are so weak that we cannot generalize them.

We used 10% trimming percentage when we conducted the multiple breakpoint test. Our data ends in the end of 2020. This means that only two interesting breakpoints are possible. These are 2019M12 and 2020M1. This might be one reason for the weak results of the test. For example, if we had the sample period of 2012–2021 the results might have been lot more significant. This would make it possible to attain breakpoints such as 2020M2 or 2020M3. For further study purposes it would be interesting to extent the sample period to cover the year 2021.

5 CONCLUSIONS

In this thesis we have studied the Fama-French Five-Factor model in stressed stock markets. In the late 2019 and early 2020 stock markets faced a massive shock globally. The COVID-19 pandemic forced governments around the world to set up restrictions and shut down the economies. This put globally the stock markets in a stressed state. In Europe the stock markets fell over 20% during the first few months of 2020. Also, the market volatility spiked into new highs not seen since 2011. The pandemic forced the European Central Bank to further accelerate the quantitative easing, which has been ongoing already since mid-2014.

This thesis consisted of theoretical background and empirical study. In the theoretical part we went through the theory behind asset pricing and the development path of the theory. In the empirical part of the thesis a central method was seemingly unrelated regression. This method allowed us to regress the model simultaneously in different sectors. In addition to running the regression we also conducted a Wald coefficient test to test the statistical significance of the model coefficients and multiple breakpoint test to test the stability of the model.

We set off to answer three research questions. The first one was a simple question about the functionality of the Fama-French Five-Factor model in the European stock markets. The null hypothesis associated with this question was that the regression intercepts do not differ significantly from zero sector by sector. To get more general answer we also tested the null hypothesis jointly. Based on our results we could accept the null hypothesis in the sector-by-sector approach and jointly. This gives strong support for the functionality of Fama-French Five-Factor model in the European stock markets. These results are not surprising since the Five-Factor model has been tested quite intensively and not only in US but also internationally and according to earlier research it is the leading-practice benchmark for asset pricing. As expected, we also found the adjusted R squared to be high in every sector. In the light of these results, it appears to hold true that the appearance of this stressed period caused by the COVID-19 pandemic in the stock markets did not influence on the Five-Factor model functionality.

The second research question dived deeper into the causality between the COVID-19 pandemic and the stock markets. The question included two parts. To answer the first one, we constructed a dummy variable for the pandemic period from 1.1.2020 to 31.12.2020. The null hypothesis associated with the question was that the dummy variable coefficients do not differ significantly from zero. Again, as we did with the first problem, we tested these coefficients sector by sector and jointly. Based on our results we could reject the null hypothesis in the Utilities sector. This suggests that the pandemic had statistically significant effect on the stock returns in the Utilities sector. Jointly we could not reject the null hypothesis at 5% level of significance. Although we could reject the null hypothesis at 10% level of significance. This suggests that the pandemic had statistically significant effect on the stock returns in Europe, but not as strongly significant as one could imagine. The second part of the question was that did the start of the COVID-19 pandemic cause a structural change on the Fama-French Five-Factor model. To answer this question, we conducted a multiple breakpoint test. We found that the pandemic caused a structural change on the model in the Consumer Services sector in January 2020. The date of this break would suggest that the pandemic caused it. This is interesting since the Consumer Services sector is one of the sectors that suffered the most from the lock-downs and restrictions that shut down the economy.

The final research question took the generous monetary policy of the European Central Bank under review. We studied that does the balance sheet expansion of the ECB have an effect on the stock market returns. To answer this question, we created a factor that proxies the loose monetary policy in Europe. We calculated the monthly change of the ECB balance sheet and created a time series out of these monthly changes. The null hypothesis associated with the third research question was that the BS Change factor does not significantly differ from zero. As we did with both earlier questions, we confronted the problem one sector at a time and jointly. We could reject the null hypothesis in the Energy and the Industrials sector. This would suggest that in these sectors loose monetary policy would have influenced stock returns. Interestingly we could also reject the null hypothesis when we tested these coefficients jointly. The null hypothesis was rejected at the 1% significance level. This is a strong statistical relationship. In the light of these results, we can say that the monetary policy has influenced the returns of European stock markets.

Based on our results we can argue that the pandemic had an effect on the stock market returns. However, the statistical significance was a bit lower than expected. The COVID-19 pandemic is still somewhat ongoing and that is why it is quite a topical issue. When writing this thesis, the number of research papers studying the effects of the pandemic on stock markets was quite limited.

There are three main contributions to prior literature. Firstly, this thesis contributed to prior literature by giving first-hand information about the effects of the pandemic on stock markets. Secondly, in many studies of the asset pricing models, the models are tested by evaluating them based on how well they explain returns on size-B/M portfolios. This thesis contributed to prior literature by evaluating how well the Five-Factor model explains the average returns on sector portfolios. Thirdly, the research around the effects of the monetary policy on stock markets is more extent and it is more or less controversial. However, we managed to produce evidence to support literature that argues in favor of the effects of monetary policy in the stock markets. This thesis did not directly answer whether the purchase program initiated by the ECB to fight the effects of the pandemic influenced the stock market returns, but whether have the long-lasting loose monetary policy influenced the stock returns. To further extent this study it would be interesting to examine whether the actions taken by ECB caused a regime shift from bear market to bull market. The effects of the pandemic on stock market returns should also be re-examined when we have left the pandemic behind us.

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APPENDICES

Appendix 1. Five-Factor model output

System: SUR1
Estimation Method: Seemingly Unrelated Regression
Date: 02/16/22 Time: 20:23
Sample: 2011M01 2020M12
Included observations: 120
Total system (balanced) observations 1320
Linear estimation after one-step weighting matrix

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.003083	0.002544	-1.211700	0.2259
C(2)	0.880220	0.064912	13.56025	0.0000
C(3)	-0.426863	0.146626	-2.911236	0.0037
C(4)	0.092291	0.211788	0.435768	0.6631
C(5)	0.452657	0.266604	1.697859	0.0898
C(6)	0.756186	0.283265	2.669535	0.0077
C(7)	-0.002667	0.002831	-0.942179	0.3463
C(8)	1.045376	0.072226	14.47358	0.0000
C(9)	0.508097	0.163149	3.114317	0.0019
C(10)	0.185895	0.235654	0.788847	0.4304
C(11)	0.822618	0.296647	2.773052	0.0056
C(12)	0.352799	0.315185	1.119339	0.2632
C(13)	-0.000812	0.001547	-0.524905	0.5997
C(14)	0.881721	0.039466	22.34121	0.0000
C(15)	-0.401392	0.089148	-4.502532	0.0000
C(16)	-0.674772	0.128766	-5.240280	0.0000
C(17)	0.387820	0.162094	2.392555	0.0169
C(18)	0.687366	0.172224	3.991114	0.0001
C(19)	-0.003350	0.003524	-0.950773	0.3419
C(20)	0.957319	0.089894	10.64942	0.0000
C(21)	-0.637494	0.203057	-3.139479	0.0017
C(22)	1.172482	0.293298	3.997582	0.0001
C(23)	1.173180	0.369211	3.177534	0.0015
C(24)	0.234211	0.392284	0.597046	0.5506
C(25)	0.001751	0.001544	1.134383	0.2569
C(26)	1.098629	0.039387	27.89298	0.0000
C(27)	-0.120435	0.088970	-1.353655	0.1761
C(28)	0.550561	0.128509	4.284213	0.0000
C(29)	-0.824405	0.161771	-5.096131	0.0000
C(30)	-0.287338	0.171880	-1.671736	0.0948
C(31)	0.002405	0.001970	1.220820	0.2224
C(32)	0.850620	0.050262	16.92372	0.0000
C(33)	-0.419185	0.113534	-3.692142	0.0002
C(34)	-0.726839	0.163990	-4.432206	0.0000
C(35)	0.008209	0.206435	0.039764	0.9683
C(36)	0.678411	0.219336	3.093027	0.0020
C(37)	-0.001207	0.001259	-0.958250	0.3381
C(38)	1.128838	0.032124	35.14046	0.0000
C(39)	0.062340	0.072562	0.859125	0.3904
C(40)	0.105631	0.104810	1.007831	0.3137
C(41)	0.282483	0.131937	2.141038	0.0325
C(42)	-0.258149	0.140182	-1.841521	0.0658
C(43)	0.002289	0.002372	0.965053	0.3347
C(44)	1.119259	0.060514	18.49595	0.0000
C(45)	-0.039280	0.136692	-0.287362	0.7739

C(46)	-0.295146	0.197439	-1.494875	0.1352
C(47)	-0.102726	0.248541	-0.413317	0.6794
C(48)	-0.367459	0.264073	-1.391507	0.1643
C(49)	-0.002394	0.002540	-0.942382	0.3462
C(50)	1.146844	0.064794	17.69990	0.0000
C(52)	-0.021201	0.146360	-0.144856	0.8848
C(53)	-0.052170	0.211403	-0.246778	0.8051
C(54)	-0.287976	0.266120	-1.082129	0.2794
C(55)	-0.407298	0.282750	-1.440488	0.1500
C(56)	-0.002066	0.003028	-0.682319	0.4952
C(57)	1.140258	0.077248	14.76107	0.0000
C(58)	-0.030500	0.174491	-0.174796	0.8613
C(59)	-0.663603	0.252037	-2.632964	0.0086
C(60)	-0.154000	0.317270	-0.485391	0.6275
C(61)	0.472380	0.337097	1.401317	0.1614
C(62)	0.000252	0.002854	0.088444	0.9295
C(63)	0.830026	0.072809	11.40002	0.0000
C(64)	-0.326139	0.164465	-1.983032	0.0476
C(65)	0.343022	0.237555	1.443971	0.1490
C(66)	0.683082	0.299040	2.284248	0.0225
C(67)	0.289903	0.317728	0.912426	0.3617

Determinant residual covariance 1.34E-37

Equation: COMMUNICATIONS_SERVICES = C(1) + C(2)*MKT_RF + C(3)
*SMB + C(4)*HML + C(5)*RMW + C(6)*CMA
Observations: 120

R-squared	0.719538	Mean dependent var	0.001166
Adjusted R-squared	0.707237	S.D. dependent var	0.049677
S.E. of regression	0.026879	Sum squared resid	0.082364
Durbin-Watson stat	1.989646		

Equation: CONSUMER_SERVICES = C(7) + C(8)*MKT_RF + C(9)*SMB +
C(10)*HML + C(11)*RMW + C(12)*CMA
Observations: 120

R-squared	0.743297	Mean dependent var	0.006387
Adjusted R-squared	0.732038	S.D. dependent var	0.057777
S.E. of regression	0.029908	Sum squared resid	0.101972
Durbin-Watson stat	2.078503		

Equation: CONSUMER_STAPLES = C(13) + C(14)*MKT_RF + C(15)*SMB +
C(16)*HML + C(17)*RMW + C(18)*CMA
Observations: 120

R-squared	0.832049	Mean dependent var	0.006333
Adjusted R-squared	0.824682	S.D. dependent var	0.039031
S.E. of regression	0.016342	Sum squared resid	0.030447
Durbin-Watson stat	2.263003		

Equation: ENERGY = C(19) + C(20)*MKT_RF + C(21)*SMB + C(22)*HML +
C(23)*RMW + C(24)*CMA
Observations: 120

R-squared	0.716535	Mean dependent var	0.000636
Adjusted R-squared	0.704102	S.D. dependent var	0.068431
S.E. of regression	0.037224	Sum squared resid	0.157962
Durbin-Watson stat	2.099043		

Equation: FINANCIALS = C(25) + C(26)*MKT_RF + C(27)*SMB + C(28)*HML
+ C(29)*RMW + C(30)*CMA
Observations: 120

R-squared	0.947192	Mean dependent var	0.003375

Adjusted R-squared	0.944876	S.D. dependent var	0.069467
S.E. of regression	0.016310	Sum squared resid	0.030325
Durbin-Watson stat	2.108326		

Equation: HEALTH_CARE = C(31) + C(32)*MKT_RF + C(33)*SMB + C(34)
*HML + C(35)*RMW + C(36)*CMA
Observations: 120

R-squared	0.738887	Mean dependent var	0.008078
Adjusted R-squared	0.727435	S.D. dependent var	0.039865
S.E. of regression	0.020813	Sum squared resid	0.049382
Durbin-Watson stat	1.972803		

Equation: INDUSTRIALS = C(37) + C(38)*MKT_RF + C(39)*SMB + C(40)
*HML + C(41)*RMW + C(42)*CMA
Observations: 120

R-squared	0.945454	Mean dependent var	0.006901
Adjusted R-squared	0.943062	S.D. dependent var	0.055746
S.E. of regression	0.013302	Sum squared resid	0.020172
Durbin-Watson stat	2.107020		

Equation: INFORMATION_TECHNOLOGY = C(43) + C(44)*MKT_RF + C(45)
*SMB + C(46)*HML + C(47)*RMW + C(48)*CMA
Observations: 120

R-squared	0.814912	Mean dependent var	0.010403
Adjusted R-squared	0.806794	S.D. dependent var	0.057008
S.E. of regression	0.025058	Sum squared resid	0.071581
Durbin-Watson stat	2.306370		

Equation: MATERIALS = C(49) + C(50)*MKT_RF + C(52)*SMB + C(53)*HML
+ C(54)*RMW + C(55)*CMA
Observations: 120

R-squared	0.820858	Mean dependent var	0.004356
Adjusted R-squared	0.813001	S.D. dependent var	0.062045
S.E. of regression	0.026830	Sum squared resid	0.082065
Durbin-Watson stat	1.962968		

Equation: RETAILING = C(56) + C(57)*MKT_RF + C(58)*SMB + C(59)*HML
+ C(60)*RMW + C(61)*CMA
Observations: 120

R-squared	0.702767	Mean dependent var	0.005691
Adjusted R-squared	0.689731	S.D. dependent var	0.057426
S.E. of regression	0.031987	Sum squared resid	0.116644
Durbin-Watson stat	1.882514		

Equation: UTILITIES = C(62) + C(63)*MKT_RF + C(64)*SMB + C(65)*HML +
C(66)*RMW + C(67)*CMA
Observations: 120

R-squared	0.658932	Mean dependent var	0.005290
Adjusted R-squared	0.643973	S.D. dependent var	0.050529
S.E. of regression	0.030149	Sum squared resid	0.103624
Durbin-Watson stat	2.009449		

Appendix 2. Five-Factor model with COVID-19 dummy output

System: SUR_DUMMY
Estimation Method: Seemingly Unrelated Regression
Date: 09/09/21 Time: 10:00
Sample: 2011M01 2020M12

Included observations: 120
Total system (balanced) observations 1320
Linear estimation after one-step weighting matrix

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.004277	0.002667	-1.603657	0.1090
C(2)	0.012390	0.008932	1.387144	0.1656
C(3)	0.880199	0.064398	13.66821	0.0000
C(4)	-0.443457	0.145955	-3.038304	0.0024
C(5)	0.127458	0.211634	0.602256	0.5471
C(6)	0.545597	0.272847	1.999648	0.0458
C(7)	0.871357	0.293030	2.973615	0.0030
C(8)	-0.001657	0.002978	-0.556433	0.5780
C(9)	-0.010490	0.009972	-1.051919	0.2930
C(10)	1.045393	0.071896	14.54041	0.0000
C(11)	0.522146	0.162950	3.204334	0.0014
C(12)	0.156121	0.236276	0.660756	0.5089
C(13)	0.743931	0.304616	2.442193	0.0147
C(14)	0.255291	0.327149	0.780352	0.4353
C(15)	-0.000590	0.001633	-0.361132	0.7181
C(16)	-0.002306	0.005470	-0.421643	0.6734
C(17)	0.881725	0.039437	22.35785	0.0000
C(18)	-0.398303	0.089383	-4.456147	0.0000
C(19)	-0.681318	0.129604	-5.256906	0.0000
C(20)	0.370519	0.167091	2.217472	0.0268
C(21)	0.665927	0.179451	3.710918	0.0002
C(22)	-0.003627	0.003722	-0.974554	0.3300
C(23)	0.002876	0.012466	0.230695	0.8176
C(24)	0.957314	0.089874	10.65173	0.0000
C(25)	-0.641345	0.203697	-3.148519	0.0017
C(26)	1.180645	0.295360	3.997310	0.0001
C(27)	1.194752	0.380789	3.137572	0.0017
C(28)	0.260943	0.408956	0.638071	0.5235
C(29)	0.002254	0.001625	1.387112	0.1657
C(30)	-0.005217	0.005442	-0.958537	0.3380
C(31)	1.098638	0.039237	27.99978	0.0000
C(32)	-0.113448	0.088931	-1.275691	0.2023
C(33)	0.535754	0.128949	4.154787	0.0000
C(34)	-0.863536	0.166245	-5.194348	0.0000
C(35)	-0.335830	0.178543	-1.880947	0.0602
C(36)	0.002773	0.002079	1.333936	0.1825
C(37)	-0.003819	0.006963	-0.548443	0.5835
C(38)	0.850627	0.050199	16.94505	0.0000
C(39)	-0.414071	0.113775	-3.639377	0.0003
C(40)	-0.737677	0.164973	-4.471500	0.0000
C(41)	-0.020436	0.212689	-0.096084	0.9235
C(42)	0.642915	0.228422	2.814589	0.0050
C(43)	-0.001154	0.001330	-0.867191	0.3860
C(44)	-0.000550	0.004455	-0.123504	0.9017
C(45)	1.128839	0.032122	35.14273	0.0000
C(46)	0.063077	0.072803	0.866411	0.3864
C(47)	0.104069	0.105563	0.985842	0.3244
C(48)	0.278355	0.136096	2.045283	0.0410
C(49)	-0.263264	0.146164	-1.801159	0.0719
C(50)	0.002724	0.002503	1.088195	0.2767
C(51)	-0.004512	0.008383	-0.538181	0.5905
C(52)	1.119267	0.060441	18.51839	0.0000
C(53)	-0.033237	0.136988	-0.242630	0.8083
C(54)	-0.307952	0.198631	-1.550371	0.1213
C(55)	-0.136570	0.256083	-0.533302	0.5939
C(56)	-0.409398	0.275025	-1.488581	0.1369

C(57)	-0.002603	0.002683	-0.970151	0.3322
C(58)	0.002171	0.008985	0.241611	0.8091
C(59)	1.146840	0.064778	17.70415	0.0000
C(60)	-0.024108	0.146818	-0.164207	0.8696
C(61)	-0.046008	0.212885	-0.216117	0.8289
C(62)	-0.271692	0.274459	-0.989919	0.3224
C(63)	-0.387119	0.294761	-1.313333	0.1893
C(64)	-0.003153	0.003184	-0.990071	0.3223
C(65)	0.011278	0.010665	1.057516	0.2905
C(66)	1.140239	0.076890	14.82944	0.0000
C(67)	-0.045605	0.174270	-0.261694	0.7936
C(68)	-0.631591	0.252690	-2.499472	0.0126
C(69)	-0.069399	0.325777	-0.213027	0.8313
C(70)	0.577216	0.349875	1.649776	0.0992
C(71)	-0.002783	0.002891	-0.962667	0.3359
C(72)	0.031500	0.009681	3.253862	0.0012
C(73)	0.829972	0.069795	11.89155	0.0000
C(74)	-0.368328	0.158189	-2.328400	0.0201
C(75)	0.432430	0.229373	1.885270	0.0596
C(76)	0.919369	0.295716	3.108959	0.0019
C(77)	0.582708	0.317591	1.834778	0.0668

Determinant residual covariance	1.17E-37

Equation: COMMUNICATIONS_SERVICES = C(1) + C(2)*COVID_DUMMY + C(3)*MKT_RF + C(4)*SMB + C(5)*HML + C(6)*RMW + C(7)*CMA
Observations: 120

R-squared	0.723964	Mean dependent var	0.001166
Adjusted R-squared	0.709307	S.D. dependent var	0.049677
S.E. of regression	0.026784	Sum squared resid	0.081064
Durbin-Watson stat	2.014235		

Equation: CONSUMER_SERVICES = C(8) + C(9)*COVID_DUMMY + C(10) *MKT_RF + C(11)*SMB + C(12)*HML + C(13)*RMW + C(14)*CMA
Observations: 120

R-squared	0.745643	Mean dependent var	0.006387
Adjusted R-squared	0.732137	S.D. dependent var	0.057777
S.E. of regression	0.029903	Sum squared resid	0.101041
Durbin-Watson stat	2.069761		

Equation: CONSUMER_STAPLES = C(15) + C(16)*COVID_DUMMY + C(17) *MKT_RF + C(18)*SMB + C(19)*HML + C(20)*RMW + C(21)*CMA
Observations: 120

R-squared	0.832297	Mean dependent var	0.006333
Adjusted R-squared	0.823393	S.D. dependent var	0.039031
S.E. of regression	0.016402	Sum squared resid	0.030402
Durbin-Watson stat	2.266848		

Equation: ENERGY = C(22) + C(23)*COVID_DUMMY + C(24)*MKT_RF + C(25)*SMB + C(26)*HML + C(27)*RMW + C(28)*CMA
Observations: 120

R-squared	0.716661	Mean dependent var	0.000636
Adjusted R-squared	0.701616	S.D. dependent var	0.068431
S.E. of regression	0.037380	Sum squared resid	0.157891
Durbin-Watson stat	2.100097		

Equation: FINANCIALS = C(29) + C(30)*COVID_DUMMY + C(31)*MKT_RF + C(32)*SMB + C(33)*HML + C(34)*RMW + C(35)*CMA
Observations: 120

R-squared	0.947594	Mean dependent var	0.003375

Adjusted R-squared	0.944811	S.D. dependent var	0.069467
S.E. of regression	0.016319	Sum squared resid	0.030095
Durbin-Watson stat	2.124205		

Equation: HEALTH_CARE = C(36) + C(37)*COVID_DUMMY + C(38)
*MKT_RF + C(39)*SMB + C(40)*HML + C(41)*RMW + C(42)*CMA
Observations: 120

R-squared	0.739540	Mean dependent var	0.008078
Adjusted R-squared	0.725710	S.D. dependent var	0.039865
S.E. of regression	0.020879	Sum squared resid	0.049259
Durbin-Watson stat	1.979567		

Equation: INDUSTRIALS = C(43) + C(44)*COVID_DUMMY + C(45)*MKT_RF
+ C(46)*SMB + C(47)*HML + C(48)*RMW + C(49)*CMA
Observations: 120

R-squared	0.945461	Mean dependent var	0.006901
Adjusted R-squared	0.942565	S.D. dependent var	0.055746
S.E. of regression	0.013360	Sum squared resid	0.020169
Durbin-Watson stat	2.107481		

Equation: INFORMATION_TECHNOLOGY = C(50) + C(51)*COVID_DUMMY
+ C(52)*MKT_RF + C(53)*SMB + C(54)*HML + C(55)*RMW + C(56)
*CMA
Observations: 120

R-squared	0.815358	Mean dependent var	0.010403
Adjusted R-squared	0.805554	S.D. dependent var	0.057008
S.E. of regression	0.025138	Sum squared resid	0.071409
Durbin-Watson stat	2.313790		

Equation: MATERIALS = C(57) + C(58)*COVID_DUMMY + C(59)*MKT_RF +
C(60)*SMB + C(61)*HML + C(62)*RMW + C(63)*CMA
Observations: 120

R-squared	0.820945	Mean dependent var	0.004356
Adjusted R-squared	0.811438	S.D. dependent var	0.062045
S.E. of regression	0.026942	Sum squared resid	0.082025
Durbin-Watson stat	1.968243		

Equation: RETAILING = C(64) + C(65)*COVID_DUMMY + C(66)*MKT_RF +
C(67)*SMB + C(68)*HML + C(69)*RMW + C(70)*CMA
Observations: 120

R-squared	0.705512	Mean dependent var	0.005691
Adjusted R-squared	0.689875	S.D. dependent var	0.057426
S.E. of regression	0.031980	Sum squared resid	0.115567
Durbin-Watson stat	1.909850		

Equation: UTILITIES = C(71) + C(72)*COVID_DUMMY + C(73)*MKT_RF +
C(74)*SMB + C(75)*HML + C(76)*RMW + C(77)*CMA
Observations: 120

R-squared	0.686585	Mean dependent var	0.005290
Adjusted R-squared	0.669943	S.D. dependent var	0.050529
S.E. of regression	0.029029	Sum squared resid	0.095223
Durbin-Watson stat	2.077583		

Appendix 3. Five-Factor model with BS change factor output

System: SUR_BS_CHANGE
Estimation Method: Seemingly Unrelated Regression
Date: 09/06/21 Time: 15:55

Sample: 2011M01 2020M12
Included observations: 120
Total system (balanced) observations 1320
Linear estimation after one-step weighting matrix

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.002431	0.002637	-0.921939	0.3567
C(2)	0.866776	0.066395	13.05478	0.0000
C(3)	-0.443067	0.147238	-3.009186	0.0027
C(4)	0.074105	0.212042	0.349481	0.7268
C(5)	0.460962	0.265869	1.733795	0.0832
C(6)	0.764995	0.282483	2.708108	0.0069
C(7)	-0.060969	0.067735	-0.900115	0.3682
C(8)	-0.002326	0.002942	-0.790464	0.4294
C(9)	1.038325	0.074071	14.01798	0.0000
C(10)	0.499598	0.164260	3.041513	0.0024
C(11)	0.176356	0.236554	0.745521	0.4561
C(12)	0.826974	0.296605	2.788137	0.0054
C(13)	0.357420	0.315139	1.134163	0.2569
C(14)	-0.031978	0.075565	-0.423190	0.6722
C(15)	-0.000852	0.001609	-0.529730	0.5964
C(16)	0.882550	0.040503	21.78986	0.0000
C(17)	-0.400393	0.089819	-4.457781	0.0000
C(18)	-0.673651	0.129351	-5.207949	0.0000
C(19)	0.387308	0.162187	2.388038	0.0171
C(20)	0.686823	0.172322	3.985703	0.0001
C(21)	0.003759	0.041320	0.090978	0.9275
C(22)	-0.005433	0.003599	-1.509760	0.1314
C(23)	1.000278	0.090596	11.04105	0.0000
C(24)	-0.585712	0.200906	-2.915352	0.0036
C(25)	1.230596	0.289330	4.253260	0.0000
C(26)	1.146638	0.362778	3.160720	0.0016
C(27)	0.206061	0.385447	0.534602	0.5930
C(28)	0.194829	0.092424	2.107997	0.0352
C(29)	0.001019	0.001587	0.642119	0.5209
C(30)	1.113735	0.039956	27.87422	0.0000
C(31)	-0.102227	0.088606	-1.153723	0.2488
C(32)	0.570996	0.127603	4.474768	0.0000
C(33)	-0.833738	0.159996	-5.210990	0.0000
C(34)	-0.297237	0.169994	-1.748512	0.0806
C(35)	0.068509	0.040762	1.680709	0.0931
C(36)	0.002409	0.002049	1.175670	0.2400
C(37)	0.850546	0.051584	16.48856	0.0000
C(38)	-0.419275	0.114393	-3.665226	0.0003
C(39)	-0.726939	0.164740	-4.412653	0.0000
C(40)	0.008255	0.206560	0.039963	0.9681
C(41)	0.678460	0.219467	3.091393	0.0020
C(42)	-0.000338	0.052625	-0.006417	0.9949
C(43)	-0.000500	0.001288	-0.388237	0.6979
C(44)	1.114266	0.032434	34.35510	0.0000
C(45)	0.044775	0.071925	0.622520	0.5337
C(46)	0.085917	0.103581	0.829468	0.4070
C(47)	0.291486	0.129876	2.244350	0.0250
C(48)	-0.248600	0.137992	-1.801558	0.0719
C(49)	-0.066090	0.033088	-1.997392	0.0460
C(50)	0.001871	0.002463	0.759580	0.4476
C(51)	1.127889	0.062007	18.18983	0.0000
C(52)	-0.028878	0.137506	-0.210012	0.8337
C(53)	-0.283472	0.198025	-1.431492	0.1525
C(54)	-0.108058	0.248295	-0.435200	0.6635
C(55)	-0.373114	0.263811	-1.414324	0.1575

C(56)	0.039138	0.063258	0.618714	0.5362
C(57)	-0.003009	0.002633	-1.142695	0.2534
C(58)	1.159543	0.066298	17.48987	0.0000
C(59)	-0.005894	0.147022	-0.040086	0.9680
C(60)	-0.034990	0.211731	-0.165257	0.8688
C(61)	-0.295822	0.265479	-1.114295	0.2654
C(62)	-0.415620	0.282069	-1.473469	0.1409
C(63)	0.057595	0.067636	0.851549	0.3946
C(64)	-0.003495	0.003113	-1.122710	0.2618
C(65)	1.169732	0.078372	14.92539	0.0000
C(66)	0.005027	0.173798	0.028924	0.9769
C(67)	-0.623731	0.250290	-2.492031	0.0128
C(68)	-0.172210	0.313827	-0.548742	0.5833
C(69)	0.453066	0.333438	1.358769	0.1745
C(70)	0.133672	0.079953	1.671881	0.0948
C(71)	0.001641	0.002932	0.559861	0.5757
C(72)	0.801373	0.073814	10.85667	0.0000
C(73)	-0.360676	0.163690	-2.203412	0.0277
C(74)	0.304262	0.235734	1.290702	0.1970
C(75)	0.700784	0.295576	2.370914	0.0179
C(76)	0.308678	0.314046	0.982908	0.3258
C(77)	-0.129945	0.075303	-1.725621	0.0847

Determinant residual covariance 1.07E-37

Equation: COMMUNICATIONS_SERVICES = C(1) + C(2)*MKT_RF + C(3)*SMB + C(4)*HML + C(5)*RMW + C(6)*CMA + C(7)*BS_CHANGE
Observations: 120

R-squared	0.721419	Mean dependent var	0.001166
Adjusted R-squared	0.706627	S.D. dependent var	0.049677
S.E. of regression	0.026907	Sum squared resid	0.081812
Durbin-Watson stat	1.975635		

Equation: CONSUMER_SERVICES = C(8) + C(9)*MKT_RF + C(10)*SMB + C(11)*HML + C(12)*RMW + C(13)*CMA + C(14)*BS_CHANGE
Observations: 120

R-squared	0.743680	Mean dependent var	0.006387
Adjusted R-squared	0.730070	S.D. dependent var	0.057777
S.E. of regression	0.030018	Sum squared resid	0.101820
Durbin-Watson stat	2.082036		

Equation: CONSUMER_STAPLES = C(15) + C(16)*MKT_RF + C(17)*SMB + C(18)*HML + C(19)*RMW + C(20)*CMA + C(21)*BS_CHANGE
Observations: 120

R-squared	0.832060	Mean dependent var	0.006333
Adjusted R-squared	0.823143	S.D. dependent var	0.039031
S.E. of regression	0.016414	Sum squared resid	0.030445
Durbin-Watson stat	2.263768		

Equation: ENERGY = C(22) + C(23)*MKT_RF + C(24)*SMB + C(25)*HML + C(26)*RMW + C(27)*CMA + C(28)*BS_CHANGE
Observations: 120

R-squared	0.726657	Mean dependent var	0.000636
Adjusted R-squared	0.712143	S.D. dependent var	0.068431
S.E. of regression	0.036715	Sum squared resid	0.152321
Durbin-Watson stat	2.216288		

Equation: FINANCIALS = C(29) + C(30)*MKT_RF + C(31)*SMB + C(32)*HML + C(33)*RMW + C(34)*CMA + C(35)*BS_CHANGE
Observations: 120

R-squared	0.948407	Mean dependent var	0.003375
Adjusted R-squared	0.945667	S.D. dependent var	0.069467
S.E. of regression	0.016192	Sum squared resid	0.029628
Durbin-Watson stat	2.107520		

Equation: HEALTH_CARE = C(36) + C(37)*MKT_RF + C(38)*SMB + C(39)
*HML + C(40)*RMW + C(41)*CMA + C(42)*BS_CHANGE
Observations: 120

R-squared	0.738887	Mean dependent var	0.008078
Adjusted R-squared	0.725023	S.D. dependent var	0.039865
S.E. of regression	0.020905	Sum squared resid	0.049382
Durbin-Watson stat	1.973133		

Equation: INDUSTRIALS = C(43) + C(44)*MKT_RF + C(45)*SMB + C(46)
*HML + C(47)*RMW + C(48)*CMA + C(49)*BS_CHANGE
Observations: 120

R-squared	0.947209	Mean dependent var	0.006901
Adjusted R-squared	0.944406	S.D. dependent var	0.055746
S.E. of regression	0.013144	Sum squared resid	0.019522
Durbin-Watson stat	2.079426		

Equation: INFORMATION_TECHNOLOGY = C(50) + C(51)*MKT_RF + C(52)
*SMB + C(53)*HML + C(54)*RMW + C(55)*CMA + C(56)*BS_CHANGE
Observations: 120

R-squared	0.815500	Mean dependent var	0.010403
Adjusted R-squared	0.805704	S.D. dependent var	0.057008
S.E. of regression	0.025129	Sum squared resid	0.071353
Durbin-Watson stat	2.295553		

Equation: MATERIALS = C(57) + C(58)*MKT_RF + C(59)*SMB + C(60)*HML
+ C(61)*RMW + C(62)*CMA + C(63)*BS_CHANGE
Observations: 120

R-squared	0.821934	Mean dependent var	0.004356
Adjusted R-squared	0.812479	S.D. dependent var	0.062045
S.E. of regression	0.026868	Sum squared resid	0.081572
Durbin-Watson stat	1.986269		

Equation: RETAILING = C(64) + C(65)*MKT_RF + C(66)*SMB + C(67)*HML
+ C(68)*RMW + C(69)*CMA + C(70)*BS_CHANGE
Observations: 120

R-squared	0.709533	Mean dependent var	0.005691
Adjusted R-squared	0.694110	S.D. dependent var	0.057426
S.E. of regression	0.031761	Sum squared resid	0.113988
Durbin-Watson stat	1.857532		

Equation: UTILITIES = C(71) + C(72)*MKT_RF + C(73)*SMB + C(74)*HML +
C(75)*RMW + C(76)*CMA + C(77)*BS_CHANGE
Observations: 120

R-squared	0.667191	Mean dependent var	0.005290
Adjusted R-squared	0.649519	S.D. dependent var	0.050529
S.E. of regression	0.029914	Sum squared resid	0.101115
Durbin-Watson stat	2.063298		

Appendix 4. Five-Factor model with dummy and BS change output

System: SUR_DUMMY_BSCHANGE
Estimation Method: Seemingly Unrelated Regression
Date: 09/06/21 Time: 15:57
Sample: 2011M01 2020M12

Included observations: 120
Total system (balanced) observations 1320
Linear estimation after one-step weighting matrix

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.003608	0.002729	-1.321961	0.1864
C(100)	0.013342	0.008937	1.492892	0.1357
C(2)	0.864512	0.065805	13.13754	0.0000
C(3)	-0.463638	0.146539	-3.163922	0.0016
C(4)	0.108940	0.211391	0.515347	0.6064
C(5)	0.562425	0.272060	2.067284	0.0389
C(6)	0.890479	0.292244	3.047034	0.0024
C(7)	-0.071136	0.067459	-1.054506	0.2919
C(8)	-0.001429	0.003060	-0.466991	0.6406
C(101)	-0.010166	0.010019	-1.014647	0.3105
C(9)	1.040050	0.073775	14.09763	0.0000
C(10)	0.515272	0.164287	3.136406	0.0018
C(11)	0.149813	0.236994	0.632136	0.5274
C(12)	0.749663	0.305011	2.457824	0.0141
C(13)	0.261805	0.327640	0.799061	0.4244
C(14)	-0.024232	0.075630	-0.320398	0.7487
C(15)	-0.000642	0.001679	-0.382481	0.7022
C(102)	-0.002381	0.005498	-0.433079	0.6650
C(16)	0.882954	0.040482	21.81107	0.0000
C(17)	-0.396722	0.090148	-4.400775	0.0000
C(18)	-0.679868	0.130044	-5.227972	0.0000
C(19)	0.369201	0.167366	2.205943	0.0276
C(20)	0.664429	0.179784	3.695712	0.0002
C(21)	0.005574	0.041500	0.134304	0.8932
C(22)	-0.005457	0.003759	-1.451837	0.1468
C(103)	0.000273	0.012307	0.022181	0.9823
C(23)	1.000232	0.090620	11.03763	0.0000
C(24)	-0.586133	0.201800	-2.904527	0.0037
C(25)	1.231309	0.291108	4.229726	0.0000
C(26)	1.148714	0.374655	3.066056	0.0022
C(27)	0.208629	0.402452	0.518394	0.6043
C(28)	0.194621	0.092898	2.094992	0.0364
C(29)	0.001566	0.001649	0.949612	0.3425
C(104)	-0.006196	0.005398	-1.147816	0.2513
C(30)	1.114787	0.039749	28.04582	0.0000
C(31)	-0.092673	0.088516	-1.046971	0.2953
C(32)	0.554818	0.127689	4.345071	0.0000
C(33)	-0.880859	0.164335	-5.360134	0.0000
C(34)	-0.355514	0.176528	-2.013928	0.0442
C(35)	0.073230	0.040748	1.797152	0.0726
C(36)	0.002749	0.002137	1.286012	0.1987
C(105)	-0.003853	0.006999	-0.550613	0.5820
C(37)	0.851200	0.051533	16.51768	0.0000
C(38)	-0.413333	0.114757	-3.601820	0.0003
C(39)	-0.737001	0.165544	-4.452002	0.0000
C(40)	-0.021051	0.213054	-0.098805	0.9213
C(41)	0.642216	0.228861	2.806142	0.0051
C(42)	0.002599	0.052828	0.049194	0.9608
C(43)	-0.000530	0.001346	-0.393797	0.6938
C(106)	0.000337	0.004406	0.076503	0.9390
C(44)	1.114208	0.032442	34.34505	0.0000
C(45)	0.044255	0.072243	0.612584	0.5403
C(46)	0.086797	0.104216	0.832864	0.4051
C(47)	0.294050	0.134125	2.192356	0.0285
C(48)	-0.245430	0.144076	-1.703473	0.0887
C(49)	-0.066347	0.033257	-1.994959	0.0463

C(50)	0.002319	0.002569	0.903004	0.3667
C(107)	-0.005087	0.008410	-0.604855	0.5454
C(51)	1.128752	0.061929	18.22664	0.0000
C(52)	-0.021034	0.137908	-0.152525	0.8788
C(53)	-0.296754	0.198940	-1.491677	0.1360
C(54)	-0.146745	0.256035	-0.573143	0.5667
C(55)	-0.420960	0.275031	-1.530592	0.1261
C(56)	0.043015	0.063486	0.677553	0.4982
C(57)	-0.003134	0.002750	-1.139497	0.2547
C(108)	0.001415	0.009005	0.157133	0.8752
C(58)	1.159303	0.066309	17.48340	0.0000
C(59)	-0.008075	0.147662	-0.054687	0.9564
C(60)	-0.031295	0.213011	-0.146919	0.8832
C(61)	-0.285061	0.274144	-1.039823	0.2986
C(62)	-0.402311	0.294483	-1.366160	0.1721
C(63)	0.056517	0.067976	0.831422	0.4059
C(64)	-0.004341	0.003241	-1.339508	0.1807
C(109)	0.009588	0.010610	0.903691	0.3663
C(65)	1.168105	0.078127	14.95129	0.0000
C(66)	-0.009757	0.173980	-0.056080	0.9553
C(67)	-0.598696	0.250977	-2.385464	0.0172
C(68)	-0.099291	0.323006	-0.307397	0.7586
C(69)	0.543249	0.346970	1.565692	0.1177
C(70)	0.126365	0.080092	1.577760	0.1149
C(71)	-0.001320	0.002916	-0.452852	0.6507
C(110)	0.033580	0.009547	3.517347	0.0005
C(72)	0.795674	0.070299	11.31850	0.0000
C(73)	-0.412451	0.156546	-2.634691	0.0085
C(74)	0.391941	0.225827	1.735577	0.0829
C(75)	0.956161	0.290639	3.289856	0.0010
C(76)	0.624516	0.312202	2.000358	0.0457
C(77)	-0.155534	0.072066	-2.158220	0.0311

Determinant residual covariance	9.08E-38

Equation: COMMUNICATIONS_SERVICES = C(1)+C(100)*COVID_DUMMY + C(2)*MKT_RF + C(3)*SMB + C(4)*HML + C(5)*RMW + C(6)*CMA + C(7)*BS_CHANGE
Observations: 120

R-squared	0.726498	Mean dependent var	0.001166
Adjusted R-squared	0.709404	S.D. dependent var	0.049677
S.E. of regression	0.026779	Sum squared resid	0.080320
Durbin-Watson stat	2.000632		

Equation: CONSUMER_SERVICES = C(8)+C(101)*COVID_DUMMY + C(9)*MKT_RF + C(10)*SMB + C(11)*HML + C(12)*RMW + C(13)*CMA + C(14)*BS_CHANGE
Observations: 120

R-squared	0.745860	Mean dependent var	0.006387
Adjusted R-squared	0.729977	S.D. dependent var	0.057777
S.E. of regression	0.030023	Sum squared resid	0.100954
Durbin-Watson stat	2.072535		

Equation: CONSUMER_STAPLES = C(15)+C(102)*COVID_DUMMY + C(16)*MKT_RF + C(17)*SMB + C(18)*HML + C(19)*RMW + C(20)*CMA + C(21)*BS_CHANGE
Observations: 120

R-squared	0.832322	Mean dependent var	0.006333
Adjusted R-squared	0.821842	S.D. dependent var	0.039031
S.E. of regression	0.016474	Sum squared resid	0.030397
Durbin-Watson stat	2.268143		

Equation: ENERGY = C(22)+C(103)*COVID_DUMMY + C(23)*MKT_RF + C(24)*SMB + C(25)*HML + C(26)*RMW + C(27)*CMA + C(28) *BS_CHANGE
Observations: 120

R-squared	0.726658	Mean dependent var	0.000636
Adjusted R-squared	0.709574	S.D. dependent var	0.068431
S.E. of regression	0.036878	Sum squared resid	0.152320
Durbin-Watson stat	2.216240		

Equation: FINANCIALS = C(29)+C(104)*COVID_DUMMY + C(30)*MKT_RF + C(31)*SMB + C(32)*HML + C(33)*RMW + C(34)*CMA + C(35) *BS_CHANGE
Observations: 120

R-squared	0.948967	Mean dependent var	0.003375
Adjusted R-squared	0.945777	S.D. dependent var	0.069467
S.E. of regression	0.016176	Sum squared resid	0.029306
Durbin-Watson stat	2.128022		

Equation: HEALTH_CARE = C(36)+C(105)*COVID_DUMMY + C(37) *MKT_RF + C(38)*SMB + C(39)*HML + C(40)*RMW + C(41)*CMA + C(42)*BS_CHANGE
Observations: 120

R-squared	0.739545	Mean dependent var	0.008078
Adjusted R-squared	0.723267	S.D. dependent var	0.039865
S.E. of regression	0.020971	Sum squared resid	0.049258
Durbin-Watson stat	1.977103		

Equation: INDUSTRIALS = C(43)+C(106)*COVID_DUMMY + C(44)*MKT_RF + C(45)*SMB + C(46)*HML + C(47)*RMW + C(48)*CMA + C(49) *BS_CHANGE
Observations: 120

R-squared	0.947212	Mean dependent var	0.006901
Adjusted R-squared	0.943913	S.D. dependent var	0.055746
S.E. of regression	0.013202	Sum squared resid	0.019522
Durbin-Watson stat	2.079115		

Equation: INFORMATION_TECHNOLOGY = C(50)+C(107)*COVID_DUMMY + C(51)*MKT_RF + C(52)*SMB + C(53)*HML + C(54)*RMW + C(55) *CMA + C(56)*BS_CHANGE
Observations: 120

R-squared	0.816061	Mean dependent var	0.010403
Adjusted R-squared	0.804565	S.D. dependent var	0.057008
S.E. of regression	0.025202	Sum squared resid	0.071137
Durbin-Watson stat	2.303082		

Equation: MATERIALS = C(57) +C(108)*COVID_DUMMY+ C(58)*MKT_RF + C(59)*SMB + C(60)*HML + C(61)*RMW + C(62)*CMA + C(63) *BS_CHANGE
Observations: 120

R-squared	0.821971	Mean dependent var	0.004356
Adjusted R-squared	0.810844	S.D. dependent var	0.062045
S.E. of regression	0.026985	Sum squared resid	0.081555
Durbin-Watson stat	1.989219		

Equation: RETAILING = C(64)+C(109)*COVID_DUMMY + C(65)*MKT_RF + C(66)*SMB + C(67)*HML + C(68)*RMW + C(69)*CMA + C(70) *BS_CHANGE
Observations: 120

R-squared	0.711497	Mean dependent var	0.005691
Adjusted R-squared	0.693465	S.D. dependent var	0.057426

S.E. of regression	0.031794	Sum squared resid	0.113218
Durbin-Watson stat	1.881630		

Equation: UTILITIES = C(71)+C(110)*COVID_DUMMY + C(72)*MKT_RF + C(73)*SMB + C(74)*HML + C(75)*RMW + C(76)*CMA + C(77) *BS_CHANGE
Observations: 120

R-squared	0.698296	Mean dependent var	0.005290
Adjusted R-squared	0.679439	S.D. dependent var	0.050529
S.E. of regression	0.028608	Sum squared resid	0.091665
Durbin-Watson stat	2.160411		