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How Does the Three-Factor Model Perform and What Explains its Performance?

Empirical tests on Swedish stock portfolios

M.Sc. Data Analytics and Business Economics

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Abstract

In this study the three-factor model of Fama and French (1992; 1993) is evaluated on portfolios of Swedish stocks. Both a cross-section and time series approach are used to evaluate the model. The results show that beta, size, and book-to-market are significant variables in explaining excess returns of Swedish stock portfolios. The three-factor model can explain variations in stock returns on the Swedish market, though the performance is lower than when using the model to explain excess returns in for example the US, Europe, and Japan (Fama & French, 1992; 1993; 2012). In addition to evaluating the performance of the three-factor model, this study also analyses what affects the performance and the coefficients of the model on the Swedish stock market. This is done by testing a number of macroeconomic variables related to the Swedish market to see whether they have significant relationships with the performance of the three-factor model and the effects of the model's independent variables. The macroeconomic variables included in these tests are GDP growth, inflation rate, oil prices, change in money supply, stock market returns, industrial production growth and unemployment rate. This study concludes that change in money supply is a significant variable in explaining the performance of the model, with a negative relationship. In explaining the coefficients of beta, size and book-to-market, GDP growth is a significant variable in all cases, while industrial production growth is significant in explaining the size and beta coefficients.

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1. Introduction

1.1 Background

Asset pricing is an important topic in finance, and it is a subject that has preoccupied researchers in the field for decades. Much research has been done trying to determine how asset returns can be explained and predicted, and many different models have been developed with the aim of correctly explaining asset prices and returns. Such examples are the capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965), the arbitrage pricing theory of Ross (1976), the three-factor model of Fama and French (1992), the four-factor model of Carhart (1997), and the five-factor model of Fama and French (2015). Most of the asset pricing models assume there is a relationship between the risk of an asset and its return: a higher risk should be compensated with higher average returns. The difference between the asset pricing models lies in how the risk is measured. The CAPM uses the asset beta as a risk factor (Fama & French, 2004), while the three-factor model adds size and book-to-market ratio as additional risk factors to the CAPM (Fama & French, 1992). Carhart's four-factor model aims to improve the three-factor model using a fourth variable, namely momentum as this adds to the accuracy in explaining stock returns (Carhart, 1997). The five-factor model adds the risk factors investments and profitability to the three-factor model, which according to Fama and French (2015) improves the performance in comparison to the three-factor model. The arbitrage pricing theory uses a selection of macroeconomic factors as measures for risk, such as for example inflation rate, industrial production, and the spread between long and short interest rates, as specified by Chen, Roll and Ross (1986).

Empirical tests of these models show varying results. In early empirical tests, the CAPM had some success in explaining asset returns (Fama & MacBeth, 1973). In later trials however, when other time periods were used for the tests, CAPM performed poorly in explaining stock returns (Reinganum, 1981). CAPM uses only an asset's beta to explain variations in stock returns. However, several studies have found other variables that have significant relationships with stock returns, such as size (Banz, 1981), price-per-earnings (Basu, 1983), book-to-market (Fama & French, 1992), momentum (Carhart, 1997) and profitability (Fama & French, 2015). Because variables besides beta have been shown to have a significant effect on stock returns, Fama and French (1992) test additional variables to find if any of these can improve the CAPM. They find that size and book-to-market indeed have a significant explanatory power on the variance in stock returns. These variables are therefore added to the CAPM, creating the three-factor model. Initially the three-factor model was tested on the US market, where it showed strong results (Fama & French, 1992; 1993). Later they tested the model on the Japanese, European and Asia Pacific market where the model also performed well (Fama & French, 2012). The performance of the model has also shown strong results in for example China (Xie & Qu, 2016), and Nigeria (Evbayiro-Osagie & Osamwonyi, 2017).

Although the three-factor model generally performs well in empirical tests (and improves on its predecessor CAPM), the performance and the factors' effects vary between markets and periods of time. For example, beta had a significant effect on returns before 1963 (Fama & French, 1992), but not between 1963 and 1990 (Fama & French, 1992). Size was a significant explanatory variable of excess returns in the US in 1963-1990 (Fama & French, 1992), but it was not significant in the same market (or in Europe, Japan, and Asia Pacific) between 1990-2010 (Fama & French, 2012). Dimson, Marsh and Staunton (2011 cited in Crain, 2011) show that the size effect indeed disappears for long periods of time. The strength in the effects of the variables also differs between markets (Fama & French, 2012).

1.2 Problem

Reviewing the research that has been done testing the Fama-French three-factor model, it becomes apparent that most studies have been made on large markets such as the US, Europe, China, and Japan. To this background, it is interesting to evaluate the Fama-French three-factor model using a different market and time period than most previous research. In this study, the three-factor model will be tested on the Swedish stock market, and the time period used will be 1987-2019.

Previous research also shows that the effects of the three-factor model's variables seem to vary between markets and time periods. An interesting question is why these effects vary, and how the variation can be explained. As stock returns can be affected by numerous macroeconomic events and changes, one possible explanation is that macroeconomic events affect these varying effects. Such macroeconomic variables that have been known to affect stock returns are, for example, inflation (Kuvshinov, Schularick & Taylor, 2019), GDP growth (Singh, Mehta & Varsha, 2011), Brent oil prices (Fedorova & Pankratov, 2010), and money supply (Humpe & Macmillan, 2009).

1.3 Purpose

The purpose of this study is to test the three-factor model of Fama and French (1992; 1993) on the Swedish stock market between the years 1987-2019. The performance of the model on Swedish stocks will be compared to its performance in other markets to see whether there is a difference in explanatory power of the model between the Swedish stock market and other stock markets. To evaluate the model, both a time series and cross-section approach will be used.

This study also aims to assess multiple macroeconomic variables to see if they have correlations with the performance and the coefficients of size, book-to-market, and beta of the three-factor model on the Swedish market. For this purpose, regression analysis will be used. This is done in order to detect variables that may be used to explain the variance in model performance and factor coefficients of the three-factor model. The macroeconomic variables included in these tests are inflation, GDP growth, changes in money supply, unemployment rate, industrial production growth, stock market return, and oil prices. The macroeconomic variables all apply to the Swedish market, except for the oil prices, which applies to Europe.

1.4 Limitations

This study tests the three-factor model of Fama and French (1992; 1993) on Swedish stocks for a time period of 33 years. The years in the study period are 1987-2019. Only stocks listed on the Stockholm Stock Exchange are included in the study. No attempts are made to test the model or explain variations in its performance and coefficients in markets other than the Swedish, or in time periods outside the scope of this study.

1.5 Research question

The questions this study aims to answer are:

1. Can the Fama-French three-factor model explain variations in stock portfolio's excess returns on the Swedish stock market?
2. Can the macroeconomic variables inflation, GDP growth, oil prices, money supply, industrial production growth, market stock returns and unemployment rate explain variations in performance and factor coefficients of the Fama-French three-factor model on the Swedish market?

2. Literature review

2.1 CAPM

The capital asset pricing model (CAPM) was created by Sharpe (1964) and Lintner (1965). The model builds on Markowitz's work on portfolio selection from the 1950's which states that investors choose a portfolio that is mean-variance efficient, meaning the returns of the portfolio is maximised given its level of variance (Fama & French, 2004). According to the CAPM, the expected return of a portfolio of stocks depends on the risk-free rate, the portfolio's market beta and the market return (Fama & French, 2004). To calculate the predicted return of a portfolio, the risk premium is multiplied with the asset beta, which in turn is added to the risk-free rate. The risk premium equals the market return subtracted by the risk-free rate. The expected return on asset or portfolio *i* according to the CAPM is presented in Formula 2.1 (Fama & French, 2004).

Formula 2.1: CAPM

$$E(R_i) = R_f + [E(R_M) - R_f]\beta_{iM}$$

In Formula 2.1, $E(R_i)$ is the expected return for asset i, R_f is the risk-free rate, $E(R_M)$ is the expected return of the market, and β_{iM} is the market beta of asset *i*. The difference between the expected market return and the risk-free rate, $[E(R_M) - R_f]$, is the risk premium.

The market beta is calculated according to Formula 2.2. It is equal to the covariance of the market return and the return of asset *i*, divided by the variance of the market return (Fama & French, 2004).

Formula 2.2: Beta

$$\beta_{iM} = \frac{cov(R_i, R_M)}{\sigma^2(R_M)}$$

The performance of CAPM has been evaluated extensively. In early trials the model showed promising results, as Fama and MacBeth (1973) found a linear relationship between beta and stock returns. The fact that early trials of the model showed promising results of the model's ability to predict stock returns, together with its simplicity, is likely what led to the model's popularity. The CAPM is used by many firms to estimate the cost of capital (Graham & Harvey, 2001; Fama & French, 2004), and it is taught in many business university programmes as a method for predicting stock returns (Fama & French, 2004). However, more recent tests of the CAPM does not favour its practical use, as the results show poor performance of the model. According to Fama and French (1992), the relationship between beta and stock returns found in earlier studies disappears between 1963-1990, invalidating use of the model at least for this period of time. On the Indian stock market, Basu and Chawla (2010) test the CAPM on ten portfolios sorted on beta and find the model fails to explain the returns of all the portfolios. That the CAPM fails to explain stock returns of Indian stocks is confirmed by Chaudhary (2016). Fama and French (2004) state that the poor record of the CAPM in empirical tests invalidates most applications of the model. The poor empirical results of the model may have several explanations. One possible explanation is that the model relies on simplified assumptions (Fama & French, 2004), such as investors having homogeneous expectations which would make it possible to determine the expected return of the market (Fernandez, 2015). Another explanation could be that there is no good proxy for the market portfolio, which Roll (1977) argues makes it impossible to actually test the CAPM properly. A third possible reason why the CAPM performs poorly is that there are multiple variables besides beta that have a documented relationship with stock returns. Basu (1983) finds a negative relationship between price-per-earnings (P/E) and returns. Bhandari (1988) finds a significant relationship between leverage and returns. Banz (1981) finds a negative relationship between size and returns. Rosenberg, Reid and Lanstein (1985 cited in Fama & French, 1992) find the ratio between the book value of a firm and its market value (book-to-market) has a significant impact on stock return. Fama and French (1992) confirm that size and the book-to-market ratio are indeed significant variables for explaining stock returns, but the effects of P/E and leverage disappear when controlling for size.

Because of the weak, or in some periods non-existing, relationship between beta and stock returns, together with the evidence of other variables having significant relationships with stock returns, it is widely believed that the CAPM is not a good model for accurately explaining stock returns and that better models are needed. Many attempts to improve the CAPM by making modifications to it have been made. An example of this is Merton's (1973) intertemporal CAPM. He argues that investors try to maximise their utility in terms of consumption over many time periods, something that the static CAPM does not account for. Another example is the consumption-based CAPM, which instead of the market beta uses a beta based on the per capita consumption (Breeden 1979).

2.2 Multi-factor models

There are also numerous models that add other variables to the original CAPM to improve the ability to explain stock returns. For example, Fama and French (1992; 1993) suggest adding size and book-to-market to improve the model, as they find that stocks of small firms and high book-to-market firms (value stocks) on average have higher returns than stocks of big and low book-to-market firms. In order to compute the expected excess return of stocks they add two components to the standard CAPM (Fama & French, 1993). The first is small-minus big (SMB), which is the difference between the excess return of small stocks and the excess return of big stocks. The second component is high-minus-low (HML) which is the difference in excess returns of stocks with high book-to-market ratios and stocks with low book-to-market ratios. In the formula for the excess return according to the three-factor model (presented in Formula 2.3), SMB and HML are multiplied with a size-beta (s), and a value-beta (h), respectively, while the ordinary beta, as in the CAPM, is multiplied with the risk premium (RMRF) of the market (Fama & French, 1993). Formula 2.3 includes an error term, e_{it}, to account for the residuals of the model's predictions in time t. By removing the error term, we get the predicted return of the model, while including the error term gives us the actual return. As the residuals are only known ex post, we can not compute the actual return of a portfolio on beforehand.

If small stocks on average have higher returns than big stocks, SMB should be a positive value. Likewise, if high book-to-market stocks have higher returns than low book-to-market stocks, HML should be a positive value. The size risk factor coefficient (s) and book-to-market risk factor coefficient (h) should be larger for small stocks and for high book-to-market stocks if these indeed have higher average returns.

Formula 2.3: Fama-French three-factor model

$$R_{it} - RF_t = a_i + b_i[RMRF_t] + s_i SMB_t + h_i HML_t + e_{it}$$

Jegadeesh and Titman (1993) argue that momentum plays a role in stock returns. They find that stocks that have performed well in the past tend to, in the short term, outperform stocks that have performed poorly in the past, suggesting an investment strategy of buying winners and selling losers can lead to higher returns. Inspired by Jagadeesh and Titman (1993), Carhart (1997) adds a momentum variable, PR1YR, to the three-factor model of Fama and French, creating the four-factor model. PR1YR is the difference in returns between the 30% of stocks with the highest returns in the past eleven months and the 30% of stocks with the lowest returns in the past eleven months (Carhart, 1997). In the formula for calculating the excess return of an asset in time *t* according to the four-factor model, PR1YR is multiplied by a momentum beta, p. RMRF, SMB and HML are multiplied with their respective betas, as in the three-factor model. The error term, e_{it}, includes the residuals in returns not explained by the model.

Formula 2.4: Carhart's four-factor model

$$R_{it} - RF_t = a_i + b_i[RMRF_t] + s_i SMB_t + h_i HML_t + p_i PR1YR_t + e_{it}$$

Other variables that have been found to have relationships with stock returns are the firm's capital investments and profitability. Titman, Wei and Xie (2004) document a negative relationship between capital investments and stock returns. According to the authors, the firms that increase their capital investments the most generally have lower returns on their stocks. Novy-Marx (2013) finds that profitability of a firm affects its stock returns. On average, profitable firms have significantly higher returns than non-profitable firms. According to Novy-Marx (2013), the profitability effect on stock returns is as strong as the book-to-market effect.

As profitability and investment have documented significant effects on average returns, Fama and French (2015) builds on their three-factor model by adding variables for investment and profitability, creating the five-factor model. They add robust-minus-weak (RMW) representing the difference in returns between stocks with robust profitability and stocks with weak profitability, and conservative-minus-aggressive (CMA) which is the difference between the returns of stocks with low investments (conservative) and high investments (aggressive) (Fama & French, 2015). The formula for calculating excess returns according to the five-factor model is presented in Formula 2.5.

Formula 2.5: Fama-French five-factor model

$$R_{it} - RF_t = a_i + b_i[RMRF_t] + s_iSMB_t + h_iHML_t + r_iRMW_t + c_iCMA_t + e_{it}$$

2.3 Stock returns and macroeconomic variables

There are numerous studies showing significant relationships between stock returns and different macroeconomic variables. One such variable is inflation. Several studies have shown that there is a negative relationship between inflation and stock returns (Bodie, 1976; Fama & Schwert, 1977; Fama, 1981; Jordà, Knoll, Kuvshinov, Schularick, & Taylor, 2019). According to Sharpe (2002), the negative relationship can be explained by lowered expectations on real returns and growth as a result of increased expected inflation, as well as increased required returns by investors when inflation expectations increase. When inflation increases, the valuation of stocks falls, leading to reduced P/E-ratio for stocks (Sharpe, 2002). Another reason why inflation may affect stock prices is because central banks can change their monetary policy in order to control the level of inflation. The changes in monetary policy can affect stock prices. In Sweden, the Riksbank uses monetary policy to achieve the targeted inflation rate of two percent (Riksbank, 2023a). This includes changing the policy rates, which in turn affects the interest rates. When inflation gets too high, the policy rate is increased which leads to higher interest rates. This generally leads to increased household savings, as the return on savings increases. Also, household consumption decreases as spending on loans increases. This in turn affects stock prices negatively, both because less household consumption reduces revenues for firms, and because the demand for investing in stocks is reduced because of a lower risk premium when the risk-free rate increases. In times of low inflation, the Riksbank instead lowers the policy rate, leading to increased stock valuations (Riksbanken, 2023a).

Other variables with documented effects on stock returns are the unemployment rate, which Flannery and Protopapadakis (2002) can affect the volatility of stock returns, and GDP growth, which has been shown to affect stock returns in the Swiss stock market (Hess, 2003) and in Taiwan's stock market (Singh, Mehta & Varsha, 2011).

Chen, Ross and Roll (1986) also suggest industrial production growth is one variable that is significant in explaining stock returns. This is confirmed by Humpe and Macmillan (2009) that find a positive relationship between industrial production and stock returns in the US and in Japan. Fedorova and Pankratov (2003) suggest that oil prices can affect stock returns, as they find a significant relationship between oil prices and stock prices.

Money supply is yet another variable that have documented relationships with stock returns. Money supply can be measured in several ways, and the measures are generally referred to as M0, M1, M2 and M3 (Riksbanken, 2023b). M0 measures the value of the notes and coins in society. M1 adds demand deposits to this, and M2 further adds certain deposits within Swedish financial institutions. To this, M3 adds repos, fixed income securities with maturities up to two years, and shares in money market funds (Riksbanken, 2023b). Flannery and Protopapadakis (2002) documents that the money supply measure M1 affects both the level and the volatility of stock returns. Chen (2007) tests whether the annual growth in M2 has a significant relationship with stock returns and finds that it does not. According to Humpe and Macmillan (2009) money supply is a significant variable in explaining stock returns in Japan, but not in the US.

3. Methodology

3.1 Data

The stock data used in this study is collected from Eikon Datastream accessed through Lund University. Data for all stocks listed at some point between 1987 and 2019 on the Stockholm stock exchange is collected, except for fourteen stocks using different currencies than the Swedish krona. These fourteen stocks are removed so that the market value of all stocks included in the data is comparable. Stocks that have been unlisted from the Stockholm stock exchange during the study period are included in the downloaded stock data, since excluding these stocks would potentially lead to a survival bias, as bankrupted firms (which have experienced large negative returns) would not be included in the sample. Monthly data is used, and the variables collected from Eikon Datastream are 'Market value (Capital)', 'Historic beta', 'Price - trade', and 'Market-to-book'. The dataset was downloaded on June 1st 2023. The market value variable is used as the firm size measure in this study. The market-to-book variable has before the empirical tests of this study been converted to book-to-market by taking 1 and dividing it with the market-to-book value. This is done so that the results can be compared to the results of Fama and French (1992; 1993). The price variable is used to calculate the monthly returns of each stock by calculating the difference between the price in month *t* compared to the price in month *t-1*. The excess returns are then calculated by subtracting the risk-free rate (RMRF) from the returns of each stock.

Even though all stocks (except for the removed fourteen stocks previously mentioned) from the Stockholm stock exchange listed at some point between 1987 and 2019 are downloaded from Eikon Datastream, some of these have later been removed from the sample for various reasons. Some stocks have some variables missing for the entire period and are therefore removed. Stocks with a large number of missing values are also removed from the sample as the reliability of their average stock returns would be low. Also, some stocks are removed because they had observations spanning less than twelve months. After cleaning and pre-processing the data, the resulting dataset used in this study contained 1030 stocks, each having four variables: Monthly excess return, size, book-to-market, and beta.

The Fama-French risk factors SMB, HML and RMRF for the Swedish market used in this study are taken from Sodini, Fu, and Aytug (2022). The dataset can be accessed through the Swedish House of Finance (Swedish House of Finance, n.d) website. The data also contains the Swedish market return measured by the SIXRX index, the risk-free rate measured by the 1-month Swedish T-bill, and both value weighted and equally weighted risk factors for size, book-to-market, and momentum. As this study does not make any value weighting in the formation of the stock portfolios, the equally weighted risk factors will be used. At the Swedish House of Finance, daily, weekly, and monthly Fama-French risk factors are available. Monthly data is used in this study.

Data for a number of macroeconomic variables relating to the Swedish market is used in order to determine their effect on the performance of the three-factor model. The variables used are GDP growth, retrieved from World Bank (2023), Money supply and inflation rate retrieved from Statistics Sweden (2023a; 2023b), Brent oil prices (for the European market), industrial production, and unemployment rate, retrieved from Federal Reserve Economic Data (2023a; 2023b, 2023c), and market returns (SIXRX) retrieved from Swedish House of Finance (n.d).

3.2 Time series regression

As in Fama and French (1993), the stocks in the data set are divided into twenty-five portfolios based on their size and book-to-market quintiles. Size quintile 1 contains the one fifth of the stocks with the smallest size, while size quintile 5 contains the one fifth of the stocks with the largest size. Likewise, the first book-to-market quintile contains the one fifth of the stocks with the lowest book-to-market ratio, while the fifth book-to-market quintile contains the stocks with the highest book-to-market ratio. The portfolios are updated each year in January. For each portfolio, the average monthly excess returns are calculated for every month in the study period. Excess returns are used instead of actual returns because when using excess returns an accurate asset pricing model should produce intercepts equal to zero (Fama & French, 1993). The regression results will then clearly show if the three-factor model accurately explains average excess returns, or whether it underestimates or overestimates the average excess returns.

This results in twenty-five vectors of average monthly portfolio returns, each of which is then regressed onto the monthly small-minus-big (SMB), high-minus-low (HML) and excess market return (RMRF) as the independent variables. The resulting regression output contains coefficients for the market risk factor (*b*), size risk factor (*s*) and the book-to-market risk factor (*h*), as well as for the intercept. Each risk factor coefficient has a p-value that indicates its significance. The regressions also produce R-squared values which indicates how much of the variance in excess returns that can be explained by the independent variables.

The risk factor coefficients show how sensitive each portfolio is to the risk factors, and how the return of each portfolio is affected by the risk factors. The coefficients may be positive or negative, and larger absolute values of the coefficients indicate higher sensitivity to the risk factors.

3.3 Cross-section regression

In the cross-section regression, as with the time series regression, stocks are divided into twenty-five portfolios based on their size and book-to-market values. The average monthly excess return, beta, ln(size) and ln(book-to-market) during the period 1987-2019 are computed for each portfolio. In this cross-sectional regression, the natural logarithms are used for size and book-to-market to make the results more comparable to Fama and French's (1992) cross-sectional analysis of stock returns. In the regression, the average monthly excess returns of the portfolios are regressed on the average beta, ln(size) and ln(book-to-market). The regression output contains an R-squared which indicates how much of the variance in monthly excess stock returns can be explained by the included independent variables. The regression output also contains coefficients for the independent variables and the intercept, as well as their respective p-values. These are used to analyse the variables relationships with excess returns in order to understand whether excess returns can be explained by the variables, how they interact, and if the relationships are statistically significant.

3.4 Tests of macroeconomic variables' effect on three-factor model

Additional tests are conducted in order to determine whether the explanatory power of the three-factor model, as well as its factor coefficients, can be explained by the macroeconomic variables inflation, GDP growth, unemployment rate, money supply, market return, oil prices and industrial production growth. M3 is used as a measure for the money supply, as this is the only measure of the money supply available from Statistics Sweden (SCB) for the full study period (1987-2019). Both the aggregated level of M3 and its annual growth are used as independent variables in the regressions to assess whether inflation affects stock returns. The market return is measured by the SIXRX index. As a proxy for oil prices, the Brent oil price is used. These variables are selected as they have documented relationships with stock returns. Thus, it is possible they influence the three-factor model and its performance in explaining stock returns.

The performance of the three-factor model is measured using R-squared, which is obtained by making annual cross-sectional regressions. Just like in the time series and cross-section regression described earlier, stocks are divided into twenty-five portfolios based on their respective size and book-to-market. This is done for each year between 1987-2019. The average monthly excess return, beta, ln(size) and ln(book-to-market) of the twenty-five portfolios are calculated for each year. For each year, the average excess returns of the portfolios are regressed on the portfolios' respective beta, ln(size) and ln(book-to-market). This results in an R-squared value and factor coefficients for each year in the study period, a total of 33 R-squared values and factor coefficients indicating how well the model performed in explaining average excess returns for each particular year, and what effects beta, ln(size) and ln(book-to-market) had in these years. The R-squared for the years 1987-2019 are then regressed on the selected macroeconomic variables for the same years, and the regression output is analysed in order to determine the effects of the macroeconomic variables on the three-factor model's performance. To determine whether any of the macroeconomic variables can contribute to the explanation of the variation in the model's performance, their respective p-values in the regression output is used. To assess whether any of the macroeconomic variables can explain the variations in the coefficients of beta, ln(size) and ln(book-to-market), each of the annual coefficients are regressed on the macroeconomic variables. The p-values of the macroeconomic variables are used to determine whether any of them can be used to explain variation in the coefficients of the three-factor model.

4. Results

4.1 Risk factor coefficients

A time series regression has been conducted to find the risk factor coefficients. Stocks were divided into twenty-five portfolios based on their respective size and book-to-market. For each portfolio, the average monthly return was regressed onto the monthly risk factors RMRF, SMB and HML. The regression results then consisted of an intercept of the model, along with the risk factor coefficients for *b*, s and h relating to the variables' beta, size, and book-to-market's sensitivity to the risk factors RMRF, SMB and HML, respectively. An R-squared value was also obtained from each regression. The portfolios' risk factor coefficients, intercepts, and R-squared values are presented in Table 4.1.

To obtain the excess return for a portfolio in time *t*, Formula 2.3 is used (Fama & French, 1993), presented again below for convenience.

$$R_{it} - RF_t = a_i + b_i[RMRF_t] + s_i SMB_t + h_i HML_t + e_{it}$$

To calculate the expected excess return in time *t* of, for example, the portfolio consisting of the stocks in the smallest size quintile and lowest book-to-market quintile, each risk factor (RMRF, SMB, HML) is multiplied by its respective risk factor coefficient (*b*, s, h), then added together along with the intercept (a). The difference between the expected return and the actual returns is represented by the error term (e_{it}). According to the Fama French Factors data set from the Swedish House of Finance (n.d), the average monthly RMRF was 0.0076, SMB was 0.0016 and HML was 0.0086. For the small-low portfolio for example, the expected monthly excess return, $E[R_{it} - RF_t]$, in *t = 1987-2019* then becomes:

$$1.43\% = 0.006 + 1.03[0.0076] + 1.16[0.0016] - 0.16[0.0086]$$

The actual return was 1.5% for this portfolio (as presented in Table 4.1), meaning the error e_{it} = 0.07%.

Table 4.1: Time series regression output

Table 4.1 shows the intercept, risk factor coefficients, R-squared and average return for all twenty-five portfolios. Stocks are divided into five different size quintiles and five different book-to-market quintiles, forming twenty-five portfolios consisting of stocks with different values for size and book-to-market. For both dimensions, quintile 1 corresponds to the lowest value for size/book-to-market, while quintile five corresponds to the highest value. *b*, *s*, and *h* are the risk factor coefficients for beta, size, and book-to-market, respectively, and is a measure of the portfolio's sensitivity to the risk factors RMRF, SMB and HML. A higher absolute value indicates higher sensitivity to the risk factors.

Significance levels: *** = 0.001, ** = 0.01, * = 0.05.

	Book-to-market quintile				
Size Quintile	Low	2	3	4	High
			b		
Small	1.03***	0.79***	0.98***	0.64***	0.68***
2	1.06***	0.83***	0.92***	0.91***	0.94***
3	1.07***	1.30***	0.82***	1.08***	0.97***
4	0.99***	0.89***	0.89***	0.89***	0.91***
Big	1.03***	1.01***	0.91***	1.05***	0.93***
			s		
Small	1.16***	0.81***	1.08***	0.58***	0.76***
2	0.70***	0.57***	1.50***	0.20***	0.46***
3	0.60***	0.33***	0.17**	0.12*	0.15*
4	0.25***	-0.01	-0.05***	-0.14***	-0.08***
Big	0.03***	-0.19	-0.18**	0.03***	-0.13***
			h		
Small	-0.16	0.03	-0.02	0.06	0.08***
2	-0.44***	0.15*	0.01	0.13*	0.29***
3	-0.31***	-0.07	0.12*	0.32***	0.47***
4	-0.31***	0.07	0.26***	0.29***	0.39***
Big	-0.18***	0.07	0.14**	0.51***	0.41***
			Average return		
Small	1.5%	1.1%	3.0%	1.5%	2.9%
2	1.0%	0.8%	1.2%	1.3%	2.3%
3	-0.1%	0.7%	1.1%	1.1%	2.0%
4	0.0%	0.4%	0.5%	1.1%	1.5%
Big	-2.1%	-0.7%	0.7%	0.1%	0.8%
			Intercept		
Small	0.006	0.004	-0.005	-0.006	-0.028***
2	0.024***	0.006	0.003	-0.010**	-0.017***
3	0.023***	0.005*	0.000	0.000	-0.012***
4	0.017***	0.003	0.003	-0.003	-0.007*
Big	0.014***	0.008**	0.000	−0.004	-0.006*
			R^2		
Small	0.38	0.35	0.46	0.26	0.33
2	0.40	0.37	0.49	0.43	0.47
3	0.50	0.56	0.47	0.58	0.49
4	0.51	0.53	0.50	0.49	0.49
Big	0.67	0.62	0.66	0.58	0.49

The results presented in Table 4.1 shows small stocks are generally more sensitive to the size risk factor than big stocks. Small stocks have an average size risk coefficient (*s*) of 0.87, while for big stocks it is -0.09, indicating that small stocks are generally more sensitive to the size risk factor than large stocks. Since SMB is assumed to be positive as small stocks outperform large stocks according to Fama and French (1992; 1993), a larger size risk factor coefficient implies higher returns for small stocks. As the average monthly SMB between 1987 and 2019 on the Swedish market was 0.0016 this means small stocks on average had monthly returns 0.16% larger than big stocks. All size risk factor coefficients except five are significant at least at the 0.05 level. The majority of them are significant at the 0.001 level. For the first three size quintiles all size risk factor coefficients are significant at least at the 0.05 level, while for the last two size quintiles only four out of ten portfolios have significant size coefficients.

For high book-to-market stocks, the average book-to-market risk factor coefficient (*h*) is 0.33, and for low book-to-market stocks it is -0.28. As mentioned, the book-to-market risk premium HML was 0.086 between 1987 and 2019, meaning high book-to-market portfolios outperformed low book-to-market portfolios. Since HML is positive, portfolios with higher *h* have higher expected returns. The majority of the book-to-market risk factor coefficients are significant at least at the 0.05 level. However, in eight of the portfolios this coefficient was not significant.

For all portfolios, the market risk factor *b* is significant at the 0.001 level. This implies that the market excess return RMRF is a highly significant variable in explaining variation in the portfolio's excess returns.

R-squared ranges between 0.26 and 0.67, and on average it is 0.48. It is generally lower for the smaller size portfolios than for the large size portfolios. The smallest size portfolios have average R-squared values of 0.36, while for the biggest size portfolios it is 0.61, implying higher explanatory power of the model for big stocks than small stocks.

The intercepts reveal whether the model accurately predicts the average returns. An intercept close to zero indicates the model accurately explains portfolio returns (Fama & French, 1993). An intercept significantly different from zero suggests the model either over- or underestimate the portfolio's excess return. If the intercept is positively (negatively) different from zero, the model underestimates (overestimates) the returns. For most of the lowest and highest book-to-market portfolios, the intercepts are significantly different from zero. For the low book-to-market portfolios the intercepts are positive, ranging between 0.014 and 0.024 (for the ones that are statistically significant), while the high book-to-market portfolios have negative intercepts ranging between -0.006 and -0.028. The three-factor model thus underestimates the excess returns of low book-to-market portfolios, while it overestimates the excess returns for high book-to-market portfolios. In the second to fourth book-to-market quintiles, most intercepts are close to zero and not significant. A similar, but weaker, pattern can be seen in the size dimension. The portfolios with smaller stocks tend to have lower intercepts than the portfolios containing larger stocks.

4.2 Cross-section results

In the cross-sectional test on the three-factor model variables' impact on portfolio excess returns the average monthly excess return for each of the twenty-five portfolios have been calculated. The average monthly excess returns of the portfolios were regressed on the portfolio's respective average beta, ln(size) and ln(book-to-market). For the size and book-to-market variables the natural logarithm was used to increase comparability to Fama and French's (1992) cross-sectional test of the three-factor model. The regression was made using the *jtools* package in R. To make sure there are no problems with multicollinearity, VIF-values are included in the regression. A high VIF-value indicates high correlation between independent variables, which can lead to multicollinearity problems. A VIF above 10 is generally considered to be problematic (Lind, Marchal & Wathen, 2017, p.510). All VIFs are below 2, indicating little risk of multicollinearity. Low multicollinearity increases the precision of the variable coefficients, leading to higher reliability in the results. The regression output is presented in Table 4.2.

In Table 4.2 all the independent variables are significant. The p-values for beta, ln(size) and ln(book-to-market) are 0.0037, 0.0000 and 0.0003, respectively. Beta has an estimated coefficient of 0.0321, meaning high beta stocks on average have higher returns, consistent with the CAPM. The regression also shows a negative relationship between returns and ln(size), and a positive relationship between returns and ln(book-to-market), consistent with the assumptions of the three-factor model. The coefficient for ln(size) is -0.0047, and for ln(book-to-market) it is 0.0055. Small stocks and stocks with high book-to-markets have on average had higher returns than big stocks and low book-to-market stocks.

Table 4.2: Cross-section regression output

Table 4.2 shows the output from the cross-sectional regression with average portfolio excess returns between 1987-2019 as the dependent variable, and the portfolios' respective average beta, ln(size) and ln(book-to-market) as the independent variables. The regression includes twenty-five portfolios formed on size and book-to-market. The portfolios are formed in the beginning of January each year.

MODEL INFO:
Observations: 25
Dependent Variable: Excess return
Type: OLS linear regression

MODEL FIT:
$F(3,21) = 42.092$, $p = 0.000$
$R^2 = 0.857$
Adj. $R^2 = 0.837$

Standard errors: OLS

	Est.	S.E.	t val.	p	VIF
(Intercept)	0.0196	0.0072	2.7096	0.0131	
beta	0.0321	0.0098	3.2698	0.0037	1.7545
ln(size)	-0.0047	0.0006	-8.4165	0.0000	1.6078
ln(book-to-market)	0.0055	0.0013	4.3855	0.0003	1.2226

As presented in Table 4.2, the R-squared is 0.857, which is relatively high. This suggests that the independent variables of the three-factor model have been able to explain a large proportion of the variation in excess stock returns between the years 1987 and 2019. However, the R-squared is well below a perfect score of 1, meaning the independent variables cannot explain all of the variation, which indicates there may be other variables related to excess returns not included in the model. Inclusion of additional variables may therefore lead to a more accurate model able to explain more of the variation in stock returns.

4.3 Tests of macroeconomic variables' relationship with the three-factor model

To assess whether some macroeconomic variables can explain the variation in three-factor model performance, the R-squared of the model for each year between 1987 and 2019 was regressed on the selected macroeconomic variables for the same years. To mitigate problems related to omitted variable bias all the selected variables are included in the regressions. However, it is still possible there are macroeconomic variables not included in the selection for this study that may potentially explain the three-factor model performance, so the risk of omitted variable bias is not completely eliminated. When including many independent variables in a linear regression model problems with multicollinearity may arise if there is a high correlation between the independent variables. For this reason, VIF-values are computed to determine whether there is a risk of multicollinearity. The regression results are presented in Table 4.3.

Table 4.3: Model performance and macroeconomic variables

Table 4.3 shows the regression output of the time series regression where the R-squared value of the three-factor model for each year between 1987 and 2019 is used as the dependent variable, and a selection of macroeconomic variables are used as independent variables.

MODEL INFO:
Observations: 33
Dependent Variable: R-squared
Type: OLS linear regression

MODEL FIT:
$F(8,24) = 1.533$, $p = 0.198$
$R^2 = 0.338$
$Adj.\ R^2 = 0.118$

Standard errors: OLS

	Est.	S.E.	t val.	p	VIF
(Intercept)	0.316	0.226	1.399	0.175	
Inflation rate (%)	-0.005	0.023	-0.198	0.845	4.059
Brent oil price	0.002	0.001	1.135	0.268	2.430
M3 change (%)	-0.016	0.008	-1.914	0.037	1.153
Market return (%)	0.001	0.001	0.617	0.543	1.203
GDP growth (%)	0.000	0.021	0.006	0.995	2.603
Industrial production growth (%)	-0.000	0.008	-0.001	0.999	2.380
Unemployment rate (%)	0.004	0.023	0.196	0.846	3.041
M3	0.000	0.000	0.519	0.608	2.544

Only one independent variable is significant in explaining the performance of the three-factor model, namely the change in M3 money supply (M3 change (%)). As seen in Table 4.3 the M3 change has a p-value of 0.037. Its relationship with the dependent variable is negative with a coefficient of -0.016. The remaining independent variables in Table 4.3 have p-values well above 0.05, meaning there is not enough evidence to assume they can explain the performance of the three-factor model.

Table 4.4: Size effect and macroeconomic variables

The dependent variable used in the regression is the size coefficient for each year between 1987-2019 which was obtained by performing a cross-section regression for every year in the study period. In the cross-section regressions, monthly excess returns for twenty-five portfolios formed on size and book-to-market were regressed on the portfolio's respective beta, ln(size) and ln(book-to-market). This resulted in thirty-three annual size coefficients, which were regressed on a selection of macroeconomic variables as the independent variables in order to find whether there are any significant relationships between the size coefficient and the macroeconomic variables.

MODEL INFO:
Observations: 33
Dependent Variable: Size effect
Type: OLS linear regression

MODEL FIT:
$F(8,24) = 3.102$, $p = 0.015$
$R^2 = 0.508$
Adj. $R^2 = 0.344$

Standard errors: OLS

	Est.	S.E.	t val.	p
(Intercept)	0.014	0.009	1.503	0.146
Inflation rate (%)	0.000	0.001	0.312	0.758
Brent oil price	-0.000	0.000	-0.048	0.962
M3 change (%)	-0.000	0.000	-0.478	0.637
Market return (%)	0.000	0.000	1.244	0.226
GDP growth (%)	-0.003	0.001	-3.082	0.005
Industrial production growth (%)	0.001	0.000	2.235	0.035
Unemployment rate (%)	-0.001	0.001	-1.313	0.202
M3	-0.000	0.000	-0.068	0.946

In addition to testing whether any of the macroeconomic variables in the selection have relationships with the performance of the three-factor model, potential relationships between the macroeconomic variables and the factor coefficients of beta, size and book-to-market were also tested. This was done in a similar fashion as the previously mentioned regression using R-squared as the dependent variable (presented in Table 4.3). The coefficients of the factors were calculated for each individual year between 1987 and 2019, and then these coefficients were individually regressed on the selection of macroeconomic variables. VIF-values are not included in these regressions because they would be identical to the previously calculated VIF-values in Table 4.3, as the same independent variables are used. The regression results are presented in Table 4.4, Table 4.5, and Table 4.6.

As can be seen in Table 4.4, GDP growth (GDP growth (%)) and industrial production growth (Industrial production growth (%)) are both significant in explaining the factor coefficient of the size variable in the three-factor model. They have p-values of 0.005 and 0.035, respectively. The remaining included variables have p-values of 0.2 or above and are thus not statistically significant. GDP growth has a negative coefficient while the coefficient for industrial production growth is positive.

Table 4.5: Book-to-market effect and macroeconomic variables

The dependent variable is the book-to-market coefficient of each year between 1987-2019, obtained in the same way as the size coefficient, which is described in Table 4.4. The independent variables are a selection of macroeconomic variables.

MODEL INFO:
Observations: 33
Dependent Variable: Book-to-market effect
Type: OLS linear regression

MODEL FIT:
$F(8,24) = 2.372$, $p = 0.049$
$R^2 = 0.442$
Adj. $R^2 = 0.255$

Standard errors: OLS

	Est.	S.E.	t val.	p
(Intercept)	-0.010	0.019	-0.546	0.590
Inflation rate (%)	0.001	0.002	0.283	0.780
Brent oil price	0.000	0.000	0.366	0.718
M3 change (%)	0.001	0.001	1.539	0.137
Market return (%)	0.000	0.000	0.256	0.800
GDP growth (%)	-0.005	0.002	-2.977	0.007
Industrial production growth (%)	0.001	0.001	0.776	0.445
Unemployment rate (%)	-0.000	0.002	-0.242	0.811
M3	-0.000	0.000	-0.579	0.568

When it comes to the book-to-market coefficient, only GDP growth (GDP growth (%)) is a significant variable in explaining its variation. The GDP growth variable has a p-value of 0.007

in the regression presented in Table 4.5. Like the size coefficient, the book-to-market coefficient has a negative relationship with GDP growth. The coefficient of GDP growth is -0.003.

In explaining variation in the beta coefficient, GDP growth (GDP growth (%)) and industrial production growth (Industrial production growth (%)) are significant variables with p-values of 0.021 and 0.032, respectively, which can be seen in Table 4.6. Unlike for the size and book-to-market coefficients, the GDP growth has a positive relationship with the beta coefficient (0.012). The industrial production growth coefficient is negative (-0.004).

Table 4.6: Beta effect and macroeconomic variables

The dependent variable is the beta coefficient of each year between 1987-2019, obtained in the same way as the size coefficient, which is described in Table 4.4. The independent variables are a selection of macroeconomic variables.

MODEL INFO:
Observations: 33
Dependent Variable: Beta effect
Type: OLS linear regression

MODEL FIT:
$F(8,24) = 2.143$, $p = 0.071$
$R^2 = 0.417$
Adj. $R^2 = 0.222$

Standard errors: OLS

	Est.	S.E.	t val.	p
(Intercept)	-0.061	0.053	-1.153	0.260
Inflation rate (%)	0.001	0.005	0.251	0.804
Brent oil price	-0.000	0.000	-1.017	0.319
M3 change (%)	-0.001	0.002	-0.451	0.656
Market return (%)	0.000	0.000	0.709	0.485
GDP growth (%)	0.012	0.005	2.469	0.021
Industrial production growth (%)	-0.004	0.002	-2.274	0.032
Unemployment rate (%)	0.007	0.005	1.300	0.206
M3	0.000	0.000	0.263	0.795

5. Conclusions

5.1 Three-factor model variables

Fama and French (1992; 1993) hypothesise that size and book-to-market are risk factors that average stock returns depend on. They show that stock returns are negatively correlated with firm size, and positively correlated with the book-to-market of the firm on the US stock market in the 1963-1990 period. Unlike what was assumed by scholars prior to 1992, Fama and French (1992; 1993) show that beta has no explanatory power on average stock returns when size and book-to-market are included in the regressions. Fama and French (2012) also test whether these relationships exist in other markets, namely Europe, Japan, and Asia pacific. They use data for the years 1991-2010. While the value premium (high book-to-market stocks have higher average returns) persist in all these markets, the size premium is only observed globally and in the US. Fama and French (1993; 2012) also find a reverse size effect in the extreme growth stocks (low book-to-market), where small stocks have lower returns than big stocks, contrary to the assumptions of the three-factor model.

This study concludes that there was both a size premium and a value premium for the years 1987-2019 on the Swedish stock market. The time series regression in Chapter 4.1 showed that small stocks on average had higher average monthly returns than big stocks, and that value stocks outperformed growth stocks in terms of average monthly excess returns. This could be concluded after observing a negative relationship between size and sensitivity to SMB, and a positive relationship between book-to-market and the sensitivity to HML of the stock portfolios. Small stocks had on average stronger and more positive correlations and coefficients for SMB than big stocks, and high book-to-market stocks had on average stronger and more positive correlations and coefficients for HML. As both the average SMB and HML are positive values, larger coefficients indicate larger average returns.

The cross-section regression in Chapter 4.2 generated similar results. In the regression, average portfolio excess returns were the dependent variable, and beta, ln(size) and ln(book-to-market) were the independent variables. For the period 1987-2019 ln(size) had a negative coefficient of -0.0047, meaning as ln(size) increases by 1 the expected monthly excess return decreases by

0.47%, or 5.64% annually. ln(book-to-market) on the other hand had a positive coefficient of 0.0055, suggesting higher book-to-market ratios lead to higher average returns. An increase of 1 in ln(book-to-market) results in an increase in expected monthly excess return of 0.55%, compounded to 6.60% annually. These results are consistent with the results of Fama and French (1992; 1993) who also find a negative relationship between average excess returns and size, and a positive relationship between average excess returns and book-to-market. However, while Fama and French (1992, 1993) find that the beta's explanatory power on stock returns disappears when controlling for size and book-to-market, this study has shown that beta is a significant variable in explaining stock returns on the Swedish stock market even when size and book-to-market are included in the regressions. In the time series regression, RMRF was a significant variable at the 0.001 level in explaining average returns for all of the twenty-five portfolios. This can be compared to SMB being significant at the same significance level in only seventeen of the twenty-five portfolios, and HML being significant at the 0.001 level in only twelve of the twenty-five portfolios. This suggests that beta is an important variable in explaining average returns on Swedish stocks, even more so than size and book-to-market. The cross-section regression also showed that beta indeed is a significant variable, having a p-value of 0.0037. However, ln(size) and ln(book-to-market) had even lower p-values of 0.0000 and 0.0003, respectively. The time series and cross-section regressions are thus not conclusive on which variable is the most important one for explaining the excess returns on Swedish stock portfolios. However, they both show that beta, size, and book-to-market are all significant variables in explaining excess returns.

When regressing average excess returns of portfolios formed on size and book-to-market on RMRF, SMB and HML, Fama and French (1993) achieve R-squared values ranging between 0.83 and 0.97, averaging at about 0.93. In this study however, using the same approach as Fama and French (1993) but on Swedish stock portfolios and Fama-French factors, the values for R-squared range between 0.26 and 0.67, with an average of only 0.48, far below the corresponding value of Fama and French (1993). When testing the model in Japan, Europe, and Asia Pacific, Fama and French (2012) get R-squared value ranging between 0.89 and 0.94, also far above the R-squared achieved in this study when testing the model on Swedish stock portfolios. This study does not conclude why the performance of the three-factor model is lower in this study than in Fama and French's (1993; 2012) studies. As both the time period and market differ between these studies, this might help explain the large differences in model performance. It could be that there are other risk factors not included in the three-factor model that are related to stock returns, which is suggested by for example Fama and French (2015). In that case, the excluded risk factors may have a larger impact on Swedish stocks than on US stocks, resulting in the three-factor model performing better on US stocks. For this reason, testing other asset pricing models, such as Carhart's (1997) four-factor model or Fama and French's (2015) five-factor model, on the Swedish market and comparing model performance to other markets may be a suitable subject for future research. Another explanation could be that the effects of the risk factors have shifted between time periods. The risk factor effects not being constant has been observed in other studies. For example, Fama and French (1992) argue stock returns had a relationship with beta prior 1963, but not between 1963 and 1990. According to Dimson, Marsh and Staunton (2011 cited in Crain, 2011) the size effect disappears for long periods of time. It is therefore possible that the effects of beta, size and book-to-market differs between the time periods 1963-1991 (as used by Fama and French (1993)) and 1987-2019 (as used in this study), which could explain the difference in performance between the studies.

5.2 Macroeconomic variables' effects

The regression for assessing the effects of various macroeconomic variables on the three-factor model's performance included a selection of macroeconomic variables as the independent variables. The dependent variable was the R-squared from cross-sectional regressions made for each year between 1987-2019, which used average monthly excess returns as the dependent variable, and beta, ln(size) and ln(book-to-market) as the independent variables. The R-squared values were obtained by forming twenty-five portfolios based on the stocks' size and book-to-market for each year in the study period, and then regressing the portfolios' average monthly excess returns on the three-factor model variables. This resulted in an R-squared for each year indicating how well the three-factor model could explain variations in stock returns for that particular year.

The regression showed that while inflation rate, Brent oil prices, market return, GDP growth, industrial production growth, unemployment rate and M3 were not significant variables in explaining the performance of the three-factor model, change in M3 was a significant variable. The relationship between the M3 change and R-squared values of the annual cross-sectional

regressions was negative. This suggests that the change in the M3 money supply can help explain the performance of the three-factor model on Swedish stock portfolios, and that the model performs better when the change in M3 is smaller/more negative, while a larger/more positive change in M3 leads to reduced model performance.
To assess whether the selection of macroeconomic variables could explain variations in the coefficients of the three-factor model's independent variables, three separate regressions were made. In each regression either the size, book-to-market, or beta coefficients for each year between 1987 and 2019 were used as the dependent variable. In all regressions, the same selection of macroeconomic variables was used as the independent variables meant to explain the variation in the dependent variable.

In explaining the size coefficient, GDP growth and industrial production growth were significant variables according to the regression output in Table 4.4. The coefficient of GDP growth in the regression was negative (-0.003), indicating an inverse relationship between GDP growth and the size coefficient. This means that when GDP growth is higher, the size coefficient tends to be smaller/more negative. An increase of 1 in the GDP growth (%) variable results in a decrease of 0.003 in the size coefficient. As the three-factor model assumes a negative relationship between size and return, which has been confirmed in this study, a more negative size coefficient indicates small stocks outperform big stocks to a larger extent. In times when GDP growth is high, small stocks should therefore perform better relative to big stocks, and vice versa. Conversely, industrial production growth had a positive relationship with the size coefficient. This means small stocks tend to outperform big stocks to a larger degree when the industrial production growth is low. The coefficient for industrial production growth was 0.001, meaning an increase of 1 in industrial production growth (%) results in an increase in the size coefficient of 0.001.

Like the size coefficient, the book-to market coefficient also had a negative relationship with GDP growth, as presented in Table 4.5. This means higher GDP growth generally leads to smaller book-to-market coefficients, while lower GDP growth leads to larger book-to-market coefficients. The coefficient for GDP growth was -0.005, meaning an increase of 1 in GDP growth (%) results in a decrease in the book-to-market coefficient by 0,005. A larger book-to-market coefficient would mean high book-to-market stocks outperform low book-to-market stocks to a greater extent. The negative relationship between GDP growth and the book-to-market coefficient indicates the book-to-market effect is stronger when GDP growth is lower.

In the regression output in Table 4.6 it could be seen that GDP growth and industrial production growth were significant variables in explaining variations in the beta coefficient of the three-factor model. GDP growth had a positive coefficient of 0.012 indicating a positive relationship between the beta coefficient and GDP growth. An increase of 1 in GDP growth (%) results in an increase in the beta coefficient of 0.012. A higher beta coefficient means there is a larger difference between the returns of low-beta stocks and high-beta stocks. Consequently, in periods with high GDP growth, the beta coefficient will be larger and high-beta stocks will outperform low-beta stocks to a larger extent than in periods with low GDP growth and smaller beta coefficients. Conversely, industrial production growth has a negative relationship with the beta coefficient, meaning the beta coefficient tends to increase as the industrial production growth decreases. Consequently, when industrial production growth is low, high beta stocks perform relatively better than low beta stocks than when industrial production growth is high. When industrial production growth is high, the beta coefficient is weaker, meaning the difference between low-beta and high-beta stock returns is smaller. The coefficient of industrial production growth in the regression was -0.004, meaning an increase of 1 in industrial production growth (%) results in a decrease of 0.004 in the beta coefficient.

5.3 Future research

As previously mentioned, future research could test how other asset pricing models perform on portfolios consisting of Swedish stocks. Testing whether, for example, momentum, profitability, and capital investments have other effects on Swedish excess returns than on US excess returns may result in answers to the questions why the performance of the three-factor model is lower for Swedish stock portfolios.

Additionally, expanding the selection of macroeconomic variables to test if there are variables not included in this study which can explain the performance and coefficients of the three-factor model and other asset pricing models could be subject for future research. Also, replicating the tests of macroeconomic variables’ effects on the three-factor model performance in other markets could generate insights to whether the same relationships found in this study persists in other markets.

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