Construction of the Fama-French-Carhart four factors model for the Swedish Stock Market using the Finbas data

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Abstract: This document explains the construction of the four-factor model using stock price and accounting data of Swedish listed companies following the Fama and French (1993) and the Carhart (1997) four-factor model. It uses data from the Finbas dataset collected and distributed by the SHoF National Data Center Website from 1983 to 2019. The variables used to construct stock portfolios and risk factors are defined and explained in detail.

[1] For feedback and questions please contact the SHoF National Data Center. (https://support.data.houseoffinance.se/)

1. Introduction

The Stockholm Stock Exchange was established in 1863 and it is one of the oldest stock exchanges in the world. This note explains the data and methodology used to construct the Fama-French-Carhart's four factors model for the Swedish stock market, which is available on a daily, weekly and monthly frequency and regularly updated on the SHoF National Data Center Website.

The Capital Asset Pricing Model (CAPM), which is based on the works of Markowitz (1952), Sharpe (1964), Lintner (1965) and others, is still one of the most popular asset pricing models among professionals and academics. The CAPM model implies the following one factor model:

$$R_{it} - Rf_t = \beta_i(Rm_t - Rf_t) + e_{it},$$

where R_{it} is the return on asset *i*, Rf_t is the risk-free rate, Rm_t is the return on the market index, $(Rm_t - Rf_t)$ is the market risk premium, e_{it} is asset *i* residual at time *t*, and the beta coefficient

$$\beta_i = Cov(Rm_t - Rf_t, R_{it} - Rf_t)/Var(Rm_t - Rf_t)$$

is the sensitivity of stock *i* to the excess return of the market portfolio (market beta).

Fama and French (1993) find that the market capitalization and the book-to-market value of stocks are important factors explaining stock returns in addition to market beta. The Fama French (1993) three factor model has the following structure:

$$R_{it} - Rf_t = \beta_i(Rm_t - Rf_t) + s_i SMB_t + h_i HML_t + e_{it},$$

where SMB_t is size factor and HML_t is value factor.

The Carhart (1997) model is an extension of the Fama French (1993) three factor model and adds the momentum factor to size and value. The Carhart (1997) four factor model has the following structure:

$$R_{it} - Rf_t = \beta_i(Rm_t - Rf_t) + s_i SMB_t + h_i HML_t + u_i UMD_t + e_{it},$$

The size factor (SMB: Small Minus Big) is constructed sorting stocks on market capitalization, the value factor (HML: High Minus Low) on book-to-market ratio and the momentum factor (UMD: Winners Minus Losers) on one-year past return.

The remainder of the note is structured as follows. Section 2 explains the data selection and variable definitions. Section 3 describes the construction of portfolios, and section 4 details how each factor is estimated.

2. Data and Variable Definitions

2.1. Data

The factors are constructed using the database Finbas which is maintained by the Data Center of the Swedish House of Finance. We use return and accounting data at various frequencies from January 1979 to December 2019 for all stocks traded in all Swedish stock markets, such as Atlas Copco, Astra Zeneca, Electrolux, Ericsson, ICA, Saab, Swedbank and Volvo. The Swedish stock market has had historically 21 market segments such as SSELAR (Large Cap), SSEMID (Mid Cap), SSESMA (Small Cap), and SSEVÄN (Waiting list). Table 1 reports the 21 stock market segments in Sweden. In order to avoid very illiquid stocks, and in line with Fama and French (1992), we exclude the four small market segments: SSEUTL, SSEA2U, EXTERN, and INOFF. The segments SSEUTL, SSEA2U, EXTERN contain small foreign stocks, whereas INOFF is the unofficial quotations list. The remaining 17 market segments are in our data.

Table 1. Swedish Stock Market Segments

Market Name	Description
ATORG	Aktieorget
EXTERN	SSE External List
FONDH	Swedish Securities Dealers Association's Stock List
IM	Innovations Market
INOFF	Unofficial quotations list
NGM	Nordic Growth Market
NOROTC	NGM Nordic MTF
NYAMAR	SSE New Market
SSE	Stockholm Stock Exchange
SBI	SSE Information
SSEA2	SSE A2-List
SSEA2U	SSE Foreign stocks
SSEFN	SSE First North
SSELAR	SSE Large Cap
SSEMID	SSE Mid Cap
SSEOBS	SSE Observation list
SSEOLI	SSE O-list
SSEOTC	SSE OTC-list
SSESMA	SSE Small Cap
SSEUTL	SSE Foreign Stocks
SSEVÄN	SSE Waiting List

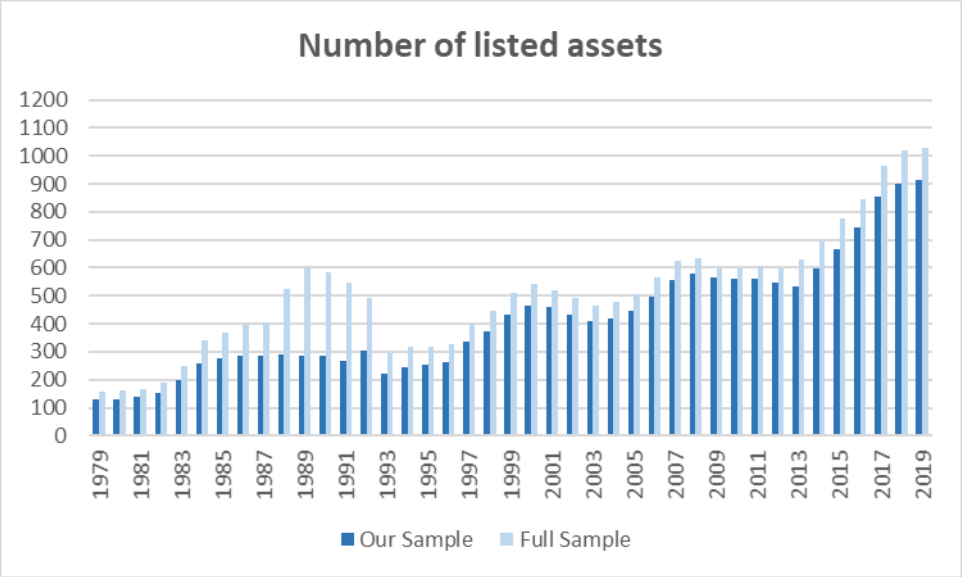
In total, there are 159 stocks listed in 1979. The number of stocks listed increases each year and reaches 1031 in 2019. Since we exclude the four small market segments, we consider a smaller number of stocks in each year when we build the factors. For instance, our sample has 130 stocks in 1979 and 915 stocks in 2019. Figure 1 reports the number of listed stocks in all the Swedish stock market segments and in our sample.

The stock prices in the Finbas database are mostly quoted in Swedish krona (SEK), apart from a small fraction of stocks that are quoted in euro. Similarly, the accounting data is reported in SEK but with some exception in different currencies. While only one percent of the market value data is reported in euro, two percent of book value data is reported in ten different currencies such as Euro, US dollar, and British pound. Values in different currencies are converted to SEK using daily exchange rates.

We proxy the risk-free rate with the one-month Swedish Treasury bill rate, as the one-month Swedish t-bill is historically more liquid than the three-month in Sweden. Since data on Swedish Treasury bill rates is available only from 1983[2], we construct the four factors over the period 1983 to the most recent update of Finbas.

[2] Data on the 1-month and 3-month Swedish Treasury bill rates is available from January 1983. Data on the 6-month Swedish Treasury bill rate is available from January 1984.

Figure 1. Number of listed assets



2.2. Variables

This subsection explains the definitions of the variables used to construct the size, value and momentum factors. The variables defined below, excluding the risk-free rate and the market return, are computed for each stock separately.

We follow the methodology used in Asness at al (2013) for the construction of size, value and momentum portfolios. They refresh the size, book-to-market and momentum breakpoints every month and consistently rebalance the factor portfolio at the same frequency. [3]

Return on the asset (R_{it})

To compute the return on stock *i* we use the last bid price of that stock during a day, which we will call the bid price for brevity. The bid price is adjusted for corporate actions such as stock dividends and stock splits.

The daily, weekly and monthly return on the asset are computed as the difference between the bid price in the current period and the bid price in the previous period divided by the bid price in the previous period. For weekly and monthly returns, the last bid price in the last day of the week and the month are used. The following formula is used to compute the return on stocks:

$$R_{it} = (\text{Bid Price Current Period} - \text{Bid Price Previous Period}) \,/\, \text{Bid Price Previous Period}$$

Risk-free rate (Rf_t)

We use the one-month Swedish Treasury bill rate as proxy for the risk-free interest rate. It is expressed on a yearly basis and in percentage. For instance, the T-bill rate on March 8, 1983 is reported as 10.45% in the data. To compute the daily risk-free rate, we first convert the T-bill rate to daily rate by dividing it by 360. Then, we estimate weekly and monthly rates by multiplying the daily rate by seven

[3] In Asness at al (2013), the breakpoints for size and book-to-market are refreshed yearly in calculating the size-sorted porfolios. However, they claim that the method used here of refreshing book-to-market monthly has a negligible impact on SMB returns.

and number of days in the month, respectively. The following formulas are used for the estimation of daily, weekly and monthly risk-free rate:

$$Rf_{t\_daily} = \text{Swedish Treasury bill rate } /360$$

$$Rf_{t\_weekly} = Rf_{t\_daily} * 7$$

$$Rf_{t\_monthly} = Rf_{t\_daily} * \text{number of days in the month}$$

Market Return (Rm_t)

We use the SIX Return Index to compute return on the market. The index is a value-weighted index of all stocks listed at the Stockholm Stock Exchange and includes reinvested dividends. The daily, weekly and monthly market returns are computed as the difference between the index in the current period and the index in the previous period divided by the index in the previous period. For weekly and monthly market returns, the last index value of the week and the month are used. The following formula is used for the estimation of daily, weekly and monthly market return:

$$Rm_t = (\text{Index Current Period} - \text{Index Previous Period}) \,/\, \text{Index Previous Period}$$

Market Equity (ME)

Market equity is computed as bid price times the number of shares, excluding treasury shares. From 2000, companies have been allowed to repurchase their own shares but repurchased shares, also called treasury shares, do not have the right to receive dividends and have no voting power. Therefore, they are excluded when market equity is calculated. When there are two classes of shares, as A and B shares, the number of shares for each class is calculated separately and then they are added together to calculate the total market cap of the company. Therefore, the total market cap of the company is the same across A and B shares. If a stock class (A or B) is not quoted on the exchange, the price for the most traded stock class is used instead. Preference shares are included in the market equity if the ordinary shares also are listed. If only the preference shares are listed, no market equity value is calculated. Market equity is computed at the end of each month.

Book Equity (BE)

Book Equity is taken from the annual or interim reports. Before 1993, book equity was not included in the annual report as a single value but its components (taxed reserves, untaxed reserves and equity), were reported separately. Therefore, before 1993, we compute book equity as:

$$Book\ equity = (1 - \text{Tax rate}) * \text{Untaxed Reserves} + \text{Taxed Reserves} + \text{Equity}$$

Starting from 1993, book equity is reported as a single value.

Book-to-Market ratio (BE/ME)

Book-to-Market ratio (BE/ME) is computed by calculating BE divided by ME at the end of each month. We use the most recent book values, from both annual and interim reports, with a minimum lag of six-months. We drop companies that do not have a book value in the previous calendar year.

One-year Return (Ret_1 and Ret_2)

For the one-year return used to form momentum portolios, we follow Asness at al. (2013) and estimate it as the return over the prior 12 months, skipping the most recent month. We use the last non-zero price in the previous month, which we will call last month's price, and the last non-zero price 12

months ago, which we will call the last year's price. The one-year return is estimated as the difference between last month's price and last year's price divided by last year's price:

$$Ret_2 = (\text{Last Month's Price} - \text{Last Year's Price}) / \text{Last Year's Price}$$

With monthly rebalancing, the holding period is one month. The momentum portfolio is kept for one month and it is rebalanced every month depending on the winners and losers of the one year prior to the last month. For instance, in December, the momentum portfolio is rebalanced using the winners and losers calculated from the eleven months returns January to Novermber.

3. Construction of Portfolios

One important issue in the construction of portfolios is the determination of breakpoints. Inappropriate breakpoints may cause stock portfolios to be heavily weighted towards small and illiquid stocks. We follow Asness at al (2018) and choose: the 80th percentile of the market capitalization, the 30th and 70th percentiles of the Book-to-Market ratio, and the 10th and 90th percentiles of the one-year return as breakpoints for size, value and momentum factors, respectively.

First, we generate the SMB portfolios by assigning companies to two portfolios sorted on market equity, where the breakpoint is the 80th percentile. While companies above the 80th percentile are marked as Big, companies below this threshold are marked as Small. Second, we generate 6 HML portfolios and 4 UMD portfolio by sorting within Big and Small companies.

We generate the HML portfolios by assigning companies in each of the two size sorted portfolios to three portfolios sorted on book-to-market ratio (as described above depending on the rebalancing frequency), where the breakpoints are the 30th and 70th percentiles. Companies are marked as Growth, Neutral, Value based on their book-to-market ratio.

We generate the UMD portfolios by assigning companies in each of the two size sorted portfolios to two momentum-sorted portfolios based on their past one-year return (as described above depending on the rebalancing frequency), where the breakpoints are the 10th and 90th percentiles. Companies are marked as Winner and Loser based on their one-year return.

Our portfolios are all value-weighted.

We label the portfolios as follows:

SG: Small-Growth, SN: Small-Neutral, SV: Small-Value,

BG: Big-Growth, BN: Big-Neutral, BV: Big-Value,

SW: Small-Winners, SL: Small-Losers,

BW: Big-Winners, BL: Big-Losers.

The sets of portfolios are summarized in Table 2.

Table2. Portfolio sorts and breakpoints

Set	Sort	Breakpoints
2 x 3 sorts	6 HML portfolios on Size and BE/ME	Size: 80th percentile BE/ME: 30th and 70th percentiles
2 x 2 sorts	4 UMD portfolios on Size and 1-year Return	Size: 80th percentile Return: 10th and 90th percentiles

4. Construction of Factors

In this subsection, we define how size, value and momentum factors are constructed.

The size (SMB) factor is the average return on the 3 small portfolios minus the average return on the 3 big portfolios:

$$SMB = (SG + SN + SV) / 3 – (BG + BN + BV) / 3$$

The value (HML) is the average return on the 3 value portfolios minus the average return on the 2 big growth:

$$HML = (SV\_vw + BV) / 2 – (SG + BG) / 2$$

The momentum (UMD) is the average return on the 2 high return portfolios minus the average return on the 2 low return portfolios:

$$UMD = (SW + BW) / 2 – (SL + BL) / 2$$

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