A Study to Examine During what Market Conditions it has been Profitable with Home Bias for a Swedish Fund Manager

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Abstract

This thesis in applied statistics and industrial economics examines the correlation between a number of market conditions on the Swedish and Global market and the yield difference between the Swedish stock market and the Global stock market. The report is based on data from the index MSCI Sweden Net Return, MSCI World Net Return and the Volatility index S&P 500. The market conditions that have been examined are Bull markets, Bear markets, periods of high volatility. We also examined how the appreciation of the SEK in comparison to the USD and the yield of the Swedish stock market correlated with the yield difference between the Swedish Stock Market and the Global stock market. The correlation was examined using multiple linear regression. The results indicated a positive correlation between the yield difference between the Swedish stock market and the Global stock market and the yield of the Swedish stock market, the appreciation of the SEK compared to the USD and Bull markets. We found a negative correlation with Bear markets and no correlation at all with the volatility.

The results are in line with what could be expected and give a stronger statistical ground for the idea that the Swedish stock market has larger fluctuations than the Global stock market during large-scale market fluctuations.

Keywords: Home Bias, Stock Market Condition, Correlation, Bull, Bear, VIX, Mutual Fund, Multiple Regression Analysis
Sammanfattning


Resultaten är i linje med vad som kunde förväntas och ger en starkare statistisk grund till att den Svenska aktiemarknaden har större svängningar än den Globala aktiemarknaden vid stora marknadsfluktuationer.

Nyckelord: Home Bias, Aktiemarknadens Beteende, Korrelation, Bull, Bear, VIX, Fond, Multipel Linjär Regressionsanalys
Preface

We would like to thank our supervisors at KTH, Daniel Berglund for helping us with the mathematical parts of the thesis and Hans Lööf for giving us inspiration towards the subject. We would also like to thank Anders Brommesson and his colleagues at Avanza Fonder for giving us this opportunity and for making this project possible.
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1 Introduction

1.1 Background

To achieve the greatest long-term returns within their risk tolerance is a frequent goal that investors have when constructing their portfolios, higher-risk investments may have the potential for higher returns, but also for greater losses (Wells Fargo advisors 2018). For long it has been known that diversification can be used to reduce the risk of your investments (Solnik 1974) and is today one of two common strategies to lower the risk of investments, the second one is hedging. Diversification can be achieved by dividing the investments among different asset classes such as stocks, bonds and real estate. It can also be reached by investing in several different industries, different sized companies and across borders. Contradictory to the information available that diversifying your investments lowers risk, a large portion of investors still keeps a home bias within their portfolios.

Home bias means that investors prefer to invest a larger portion of their capital in domestic securities, thus increasing the risk of their portfolio. In the 90s the proportion invested in domestic assets of the three large economies: U.S, Japan and Britain were 98, 94 and 82 percent respectively, indicating a strong home bias (French and Porteba 1991). The reason according to French and Porteba was due to investor preferences rather than institutional constraints. Though more recent studies have shown that there has been a reduction in home bias and the trend is moving towards more diversified portfolios. This is mainly due to the rise of the Internet and growth in popularity of mutual funds (Amadi 2004).

Home bias still occurs today, even though on a smaller scale than 20 years ago. Looking at some of the largest mutual funds in Sweden we can see that they still have a strong home bias. For example, Swedbank Robur has within some of their funds divided the investments 30 percent domestically and 70 percent across borders (Morningstar 2018). Sweden’s capitalization on the global market is less than one percent (MSCI 2018) yet there is a rare sight within Swedish funds to see the equivalent weight in the portfolios. Having a home bias seems to have been a profitable strategy the last 40 years.

Looking back historically from 1969 to present the value of the Swedish markets has increased by a larger margin than the Global markets, on average 3 percent a year (MSCI 2018). Thus a home bias has been profitable for a Swedish fund manager given that they have been invested in the Swedish index over the past 40 years instead of the Global index. What we are looking to find information on in this thesis is if there exists a correlation between the condition of the stock market and Swedish home bias being profitable or not.
2 Project description

To understand if there is a correlation between the condition of the stock market and home bias being profitable or not a multiple linear regression analysis will be made. The response variable for the analysis will be what we have chosen to call home bias spread. The independent variables will be the different market conditions: Bull markets, Bear markets, high volatility, the Swedish stock market index and the appreciation of the SEK compared to the USD.

2.1 Research question

The purpose of this project is to determine under what market conditions the Swedish stock market has outperformed the Global stock market. This is done to understand under what market conditions home bias has historically been profitable for a Swedish fund manager. The research question can be stated as follows:

*This study aims to examine the correlation between specific market conditions and the home bias spread of the Swedish and Global stock market indexes*

2.2 Goal and purpose

Today there is limited information on the subject and fund managers can therefore be forced to make decisions without adequate knowledge. The potential impact of this project is that Swedish fund managers will be able to use the information gained to decide when home bias is more likely to be profitable. This could then result in them being more likely to make profitable investment decisions.

This can first and foremost be seen as a prestudy that aims to give an understanding of the different market conditions effects on home bias being profitable or not, due to the time limitations of this project. Future research might include other market conditions, different time intervals and specifically methods to predict when and how often and by how much the portfolio manager should adjust the home bias ratio within the fund.
3 Mathematical and Economical theory

3.1 Stock market conditions

Trends such as bull and bear markets can be used to describe the condition of the stock markets as a whole. It can also be used to describe the state of a specific sector or country or even a single security. In this thesis the interest lies in the condition of the Swedish and the Global stock market as a whole.

3.1.1 Bull market

When the optimism is high and the general trend on the stock market is upwards we are in what we call a bull market. There are more buyers than sellers and the prices of securities rises over time. A bull market generally starts off with the public being pessimistic, not believing in the stock market. The pessimism then changes to hope followed by optimism and later euphoria. A typical bull market lasts for 9 years with an average return of 474 percent (First Trust Portfolios 2018) based on data from 1926 to 2018 of the U.S stock market.

An example of a bull market is the rapid upward trend that occurred between 1995 and 2000 when the NASDAQ Composite stock index rose over 400 percent, where most of this explosive growth occurred in 99 and 00 (Investopedia 2018). It was a period when the computer and Internet usage grew swiftly. The optimism and belief in IT companies led to countless initial public offerings and investors who were eager to invest in tech companies at any valuation. This is what we today refer to as the Dot-com bubble since the 5-year growth finally came down crashing in 2000 and was followed by an almost 3-year long bear market.

3.1.2 Bear market

A bear market can be seen as the opposite of a bull market. It is a period when the stock market is declining. The general definition is that when the stock market declines at least 20 percent over a two month period or longer the market is bearish. Investors seek alternative investments outside the stock market due to fear and low expectations. From the same research described above for the average bull market, a typical bear market lasts for 1.4 years with an average loss of 41 percent.

3.1.3 Volatility

The volatility of a security or index is a statistical measure of the standard deviation. The volatility measures how much the price can come to range in the future. Higher volatility equals higher risk because of the uncertainty of the future price of the index
or security. A highly volatile market is a sign of uncertainty and fear among investors.

The most used measure of volatility is the VIX index, commonly referred to as the fear index. VIX measures the markets expectations of 30-day volatility based on a wide range of implied volatilities of S&P 500 index options (Investopedia 2018). As can be seen on the image below the VIX index have spiked high at certain events such as the collapse of the fund Long Term Capital Management, the 9/11 attacks and when Lehman Brothers declared bankruptcy.

Figure 1: VIX levels from 1990 to 2010
3.2 Multiple Linear Regression Analysis Model

3.2.1 Definition and terminology

The multiple linear regression model is specified as follows:

\[ y_i = \beta_0 + \sum_{j=1}^{k} x_{ij} \beta_j + e_i \quad i = 1, \ldots, n. \] (1)

In this specification, \( y_i \) is an observation of a random dependent variable \( y \). The value of \( y \) depends on the explanatory variables or covariates \( x_j \) and the additional random variable \( e_i \), the residual or error term. \( \beta_0 \) is the intercept of the model and the \( \beta_j \) parameters are what is called regression coefficients. These parameters are unknown and are to be estimated from observational data. The stated model (1) consists of \( n \) observations and \( k \) covariates, this can be denoted in matrix form as:

\[ Y = X \beta + e \] (2)

Where

\[
Y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}, \quad X = \begin{bmatrix} 1 & x_{11} & x_{12} & \ldots & x_{1k} \\ 1 & x_{21} & x_{22} & \ldots & x_{2k} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 1 & x_{n1} & x_{n2} & \ldots & x_{nk} \end{bmatrix}, \quad \beta = \begin{bmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_k \end{bmatrix}, \quad e = \begin{bmatrix} e_1 \\ e_2 \\ \vdots \\ e_n \end{bmatrix}
\] (3)

(Lang 2016)

3.2.2 Assumptions

The model obtained from the regression is built under the assumption that:

1. The dependent variable \( y \) can be written as a linear combination of the independent variables i.e covariates \( x_{ij} \) plus a residual term \( e \).

2. The expected value of the residual is equal to zero, \( E(e_i) = 0 \). This means that the mean of the distribution from which the error \( e \) is drawn is equal to zero. If this assumption is not met, the estimator \( \beta \) is biased.

3. All the error terms \( e_i \) have the same variance and that they are uncorrelated. This can be expressed as \( E(e_i^2) = \sigma^2 \). If this assumption is not true the regression is heteroscedastic.

4. The independent variables i.e covariates are deterministic, meaning that they’re fixed in repeated samples.
5. The number of observations are larger than the number of covariates and there are is no exact linear relationship between the covariates. If this assumption isn’t true there exists multicollinearity in the regression.

3.2.3 Covariates

There exists qualitative covariates and quantitative covariates, you have to consider both of these when building a regression model.

The quantitative covariate is a covariate measured on a numerical scale. As an example in our model, there is the accumulated appreciation of the SEK compared to the USD.

The qualitative covariate or dummy variable is a covariate that only assumes the value one or zero. An example is whether the volatility is high or not. If the VIX is at what is defined as a high level the covariate is given the value 1 and if the VIX isn’t at what’s defined as a high level the covariate is given the value 0.

3.2.4 The Ordinary Least Squares Estimation

The ordinary least squares estimation of the vector $\beta$ from (2) is the vector $\hat{\beta}$. $\hat{\beta}$ is the vector that minimizes the sum of squares of the residuals $\hat{e}^t \hat{e} = |\hat{e}|^2$, where $\hat{e}$ and $\hat{\beta}$ is defined as:

$$\hat{e} = Y - X \hat{\beta}, \quad \hat{\beta} = \begin{bmatrix} \hat{\beta}_0 \\ \hat{\beta}_1 \\ \vdots \\ \hat{\beta}_k \end{bmatrix}$$

(4)

Minimizing the sum of squared residuals in order to find $\hat{\beta}$ is achieved by solving the normal equations

$$X^t \hat{e} = 0$$

(5)

by using the equation from (4) for $\hat{e}$ in equation (5) we get the expression

$$X^t(Y - X \hat{\beta}) = 0$$

(6)

and solving for $\hat{\beta}$ gives us the equation

$$\hat{\beta} = (X^tX)^{-1}X^tY$$

(Lang 2016)
3.2.5 Multicollinearity

If at least two of the covariates in the model are perfectly linearly dependant the OLS estimate has no unique solution. Because of this the $X'X$ matrix becomes singular. This is called strict or perfect multicollinearity and causes the OLS estimation to be impossible. Often the problem is not with perfect multicollinearity but instead, with imperfect multicollinearity (Lang 2016), this is when at least one of the covariates is highly correlated with a linear combination of the other covariates.

Imperfect multicollinearity is not a specification error, but it is a nuisance since it causes the standard errors of one or more of the regression coefficients to be very large, and hence the point estimates of those coefficients to be very imprecise. Since the standard errors decrease as the number of observations increases, multicollinearity can be aided by adding more observations.

3.2.6 Variance Inflation Factor

The variance inflation factor (VIF) is a method of detecting if multicollinearity is present in an OLS regression and its severity.

$$VIF(\hat{\beta}_i) = \frac{1}{1 - R^2_i}$$

Where $R^2_i$ is the goodness of fit for the model in which one of the covariates from the original model is regressed on all other covariates in the original model. This VIF factor is taken as a measure of multicollinearity, and one can see the rule of thumb that a covariate with a VIF value $\geq 10$ signals a problem (Lang 2016).

3.2.7 $R^2$ and adjusted $R^2$

$R^2$ is a measure of goodness of fit and is called the “coefficient of determination”, the value of $R^2$ shows the relative size of the variation explained by the covariates. The $R^2$ can be computed as

$$R^2 = \frac{|\hat{e}_s|^2 - |\hat{e}|^2}{|\hat{e}_s|^2}$$

Where $|\hat{e}|^2$ is the sum of the residuals given a regression of the independent variable $y$ on some covariates and $|\hat{e}_s|^2$ is the sum of squares when $y$ is regressed on the intercept only.

It is clear from the definition of R-squared that a higher value implies a better model since the difference between the observed values and the values predicted by the model
are smaller for a higher R-squared.

One problem with $R^2$ is that $R^2$ necessarily increases when regressors are added to a regression model. (Hansen 2016) To combat this issue there is also an adjusted $R^2$ (often denoted $\bar{R}^2$) where there is an adjustment for degrees of freedom. The adjusted $R^2$ can be computed as:

$$\bar{R}^2 = R^2 - (1 - R^2) \frac{k}{n - k - 1}$$

(10)

Where $k$ is the number of covariates and $n$ is the sample size.

### 3.2.8 AIC

A common test for choosing what covariates should enter the model is the AIC (Akaike Information Criterion) test. It’s used by computing the AIC for models with different covariates excluded, the model that has the lowest AIC value will be the closest to the ”true” model since minimizing AIC is the same as minimizing the estimated information loss. (Lang 2016) The AIC can be computed as:

$$AIC = n \ln(|\hat{e}|^2) + 2k$$

(11)

Where $k$ is the number of coefficients and $n$ the number of observations.

### 3.2.9 F-test

The F-test is used to test the null hypothesis that a number $r$ of the $\beta$-estimates is equal to zero. The test statistic for the F-test is given by:

$$F = \frac{R^2}{1 - R^2} \frac{n - k - 1}{r}$$

(12)

Where $n$ is the total number of observations, $k$ is the number of covariates and $r$ is the number of coefficients tested for zero. (Lang 2016)
3.2.10 P-Value

The p-value is defined as the probability, under the null hypothesis, of obtaining a result equal to or more extreme than what was actually observed. The smaller the p-value, the higher the significance because it indicates that the hypothesis under consideration may not adequately explain the observation.

The null hypothesis is rejected if any of these probabilities is less than or equal to a small, fixed but arbitrarily pre-defined threshold value $\alpha$, which is referred to as the level of significance. In this thesis we have used the value $\alpha = 0.05$, giving us a confidence level of 95%. The p-value can be computed as

$$ P - Value = P(F(r, n - k - 1) > F) $$

Where $F(r, n - k - 1)$ is the F-distribution, $r$ is the number of covariates tested under the null hypothesis, $n$ is the number of observations, $k$ is the total amount of covariates and $F$ is the F-statistic. (Lang 2016)

3.2.11 Pearson’s Correlation Coefficient

To find how strong the relationship is between two variables it is possible to use a correlation coefficient, the correlation coefficient is a measurement used to show how the scores from one measure relate to scores on a second measure for the same group of individuals. A high value (approaching +1.00) is a strong direct relationship, a low negative value (approaching -1.00) is a strong inverse relationship, and values near 0.00 indicate little, if any, relationship. (NCME 2018). The coefficient can be computed as:

$$ r_{xy} = \frac{n(\sum_{i=1}^{n} xy) - (\sum_{i=1}^{n} x)(\sum_{i=1}^{n} y)}{\sqrt{(n \sum_{i=1}^{n} x^2 - (\sum_{i=1}^{n} x^2))(n \sum_{i=1}^{n} y^2 - (\sum_{i=1}^{n} y^2))}} $$

(14)

Where $x$ is one dataset, $y$ is another dataset and $n$ is the number of observations.
4 Methodology

4.1 Tools and software used

In this project the main tool to execute this regression was the program R. It was used to explain our data with the various utilities it provides. In addition to R, the data used in this project was handled in Microsoft Excel.

4.2 Data selection

The data for this project was provided by the fund manager who gave us this assignment. It was the necessary information needed for us to be able to examine whether there is a correlation in home bias being profitable or not during the different market conditions. We chose to limit the scope due to the time limitation and to only handle the data presented below. Additional data could be interesting to look at for future studies, for example how the interest rates and the GDP growth of Sweden affects the home bias spread.

4.2.1 MSCI Global and Swedish index

MSCI World Net Return and MSCI Sweden Net Return consist of the historical performances of the global and Swedish stock markets. The data itself is put together by Morgan Stanley Capital International (MSCI), a provider of equity, fixed income and hedge fund stock market indexes. Their data dates back to December 1969 up until today. It provided us with the prices of the indexes every month from the start in December 1969 until February 2018. The Swedish index values are given in SEK and the Global stock index prices are given in both SEK and USD. Only the global index presented in USD was used.

4.2.2 Accumulated data: quarterly, semiannual, annual

The monthly data from 1969 to 2018 consists of a total of 579 observations. Since the regressions were made over different length time periods i.e. monthly, quarterly, semi-annual and annual, the data have been accumulated accordingly. The data for the different time periods is calculated as shown in equation 15 below.

\[
Return \text{ three months} = \frac{1}{MSCI \text{ World Net Return month three (SEK)}} - 1 \quad (15)
\]
4.2.3 Dividing the data

Since the full data set contains points spanning over a long time period the data was divided into shorter time spans to see if it was possible to get models with better fits using fewer data. The time periods used to model were the full dataset 1969 – 2018 and then 1969 – 1992, 1992 – 2018 and 2000 – 2018. These periods will be referred to as period one, two, three and four respectively in the remaining text.

The data was divided in 1992 when the SEK exchange rate was changed from a fixed exchange rate to a floating exchange rate (SCB 2009). This had a large impact on the Swedish economy since it allowed lower interest rates whilst letting the financial market decide on the price of the SEK and leads to faster reactions to unsound policies (Tornell, Velasco 1995). It was therefore reasonable to observe period three and compare the results with the full model to see if it would give differing information or results with a stronger significance.

Period four was observed to see if the results from the model would have a stronger significance during a period where the markets have been more homogeneous.

4.2.4 SEKUSD exchange rate

From the stock market indexes, the exchange rate of SEKUSD was derived by the relation displayed below. This was done since there was not good enough data available for this time frame

\[
SEKUSD = \frac{1}{MCSIWorldNetReturn(\text{SEK}) \over MCSIWorldNetReturn(\text{USD})}
\]

In this study, the focus of the exchange rate lies in the appreciation and depreciation of the Swedish krona (SEK) relative to the US dollar (USD), not the other way around hence. This is to see the USDSEK from the perspective of a Swedish fund manager, making the results gained from the models easier to understand and apply.

4.2.5 VIX volatility index

Alongside with the stock market data and the exchange rate of SEKUSD the CBOB Volatility Index (VIX) was used for the regression. The VIX index is calculated and published by the Chicago Board Options Exchange. Unfortunately the volatility index hasn’t been available for the same time as the stock indexes from MSCI hence the observations of VIX used in this thesis starts from January 1990 giving us a total of 338 monthly data points.
4.3 Choosing and defining variables

4.3.1 Response variable - Home bias spread

Home bias spread is the difference in index growth between the Swedish Index and the Global Index during a specified time period. It can be computed as:

\[
\text{Home bias spread} = \frac{\text{Percent change of MSCI Sweden Net Return Index (SEK)}}{\text{Percent change of MSCI World Net Return Index (SEK)}}
\]

4.3.2 Regressor variables - Market Conditions

In this section the market conditions that was made into regressor variables when researching the performance of the Swedish stock market compared to the Global stock market are listed.

Accumulated percentage change in MSCI Sweden Net Return

One of the regressor variables is the change of the MSCI Sweden Net Return index. Which was displayed in percentages and looked into in different time intervals. The first interval is monthly which is simply the change in the index from month one to two. Then the accumulated changes in three, six and twelve months was obtained by calculating the percentage change from month one to three, one to six and one to twelve respectively.

Appreciation of the SEK relative to the USD

The SEKUSD exchange rate was used as a regressor variable to see how the markets react to the appreciation of the SEK relative to the USD. We choose to look at the appreciation of the SEK to see the change in the exchange rate from the perspective of a Swedish fund manager.

Since the exchange rate of the SEK was changed to be a floating exchange rate in 1992 we expect there might be differences between the effect of exchange rates before and after that point. This was taken into account by making one regression before 1992 and one after 1992.

Bear market (dummy)

The common definition of a Bear market is that it occurs when prices drop 20 % or more from their 52-week high and is the one to be used in this research project. For determining when a bear market has occurred data from MSCI Sweden Net Return Index (SEK) was used. We chose to define that the bear market has ended when the
price of the index hasn’t decreased for three months.

**Bull market (dummy)**

Since there is no general definition of a bull market as with bear markets, we chose to define it in a similar manner. A bull market will occur when prices increase 20 % or more from their 52-week low. For determining when a bull market has occurred we used data from the MSCI Sweden Net Return Index (SEK). The bull market was defined to end when the price of the index hasn’t increased for three months.

**High volatility (dummy)**

We examined the correlation between when the volatility in the market is high and the home bias spread. We defined that there is high volatility in the market when the value of the VIX was above 20 and made it into a dummy variable, where data points with a VIX value above 20 were given the value 1 and the data points where the VIX value was lower than 20 was given the value 0. As mentioned earlier the VIX index is derived from the American market and not the global. Since the volatility of the Global and American markets are highly correlated with the American markets representing 52 % (MSCI 2018) of the MSCI World index, it still gives useful information on the volatility of the global market.

Since we only had data available on the volatility from 1990 the high volatility dummy variable was only included in the regressions made on the later time intervals, i.e. from 1992 and onwards.
4.4 Initial Model

The initial model consisted of all the previously stated market conditions as covariates and with the response variable being the home bias profit. It was formulated as:

\[ y_i = \beta_0 + \beta_1 x_{i,1} + \beta_2 x_{i,2} + \beta_3 x_{i,3} + \beta_4 x_{i,4} + \beta_5 x_{i,5} + e_i \]  

Where \( i \) represents the index of the observations, \( i = 1,2,\ldots, n \), \( y_i \) the response variable home bias profit and the covariates \( x_{i,j} \) represents the corresponding market conditions as listed in Table 1.

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Market Condition</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x_{i,1} )</td>
<td>Accumulated increase in MSCI Sweden Net Return.</td>
<td>Percent %</td>
</tr>
<tr>
<td>( x_{i,2} )</td>
<td>Appreciation of the SEK relative to the USD.</td>
<td>Percent %</td>
</tr>
<tr>
<td>( x_{i,3} )</td>
<td>Variable explaining whether the volatility is high or not.</td>
<td>Dummy, 0 or 1</td>
</tr>
<tr>
<td>( x_{i,4} )</td>
<td>Variable explaining if the market is in a bull market or not.</td>
<td>Dummy, 0 or 1</td>
</tr>
<tr>
<td>( x_{i,5} )</td>
<td>Variable explaining if the market is in a bear market or not.</td>
<td>Dummy, 0 or 1</td>
</tr>
</tbody>
</table>

Table 1: Covariates

The initial model was used for four different time periods and with data accumulated monthly, quarterly, semi-annually and annually.

4.5 Initial model evaluation

In this section we look at ways of improving the model using methods for covariate testing.

4.5.1 Estimation of the initial models

To see if it was possible to limit the scope by removing time periods in which the goodness of fit was low we computed the adjusted \( R^2 \) using equations (9) and (10) for all of our models. The results we found can be seen in Table 2.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly</td>
<td>0.6344</td>
<td>0.5763</td>
<td>0.7322</td>
<td>0.7586</td>
</tr>
<tr>
<td>Quarterly</td>
<td>0.5813</td>
<td>0.4760</td>
<td>0.7173</td>
<td>0.7606</td>
</tr>
<tr>
<td>Semi-annually</td>
<td>0.6087</td>
<td>0.4803</td>
<td>0.7826</td>
<td>0.7699</td>
</tr>
<tr>
<td>Annually</td>
<td>0.6794</td>
<td>0.4851</td>
<td>0.8352</td>
<td>0.8887</td>
</tr>
</tbody>
</table>

Table 2: Adjusted \( R^2 \)
As can be seen by these results the adjusted $R^2$ is substantially lower for period one and two, this combined with that there is missing data for the VIX before 1990 and that the Swedish Krona was changed from having a fixed to a floating exchange rate in 1992 has led us to continue only looking at the time periods three and four from this point onwards.

An example of how the estimates looked for one of the models is presented in table 3 where the models estimates, p-value and confidence interval is displayed.

<table>
<thead>
<tr>
<th>Interval</th>
<th>Estimate</th>
<th>P-Value</th>
<th>Lower bound</th>
<th>Upper Bound</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_{i,1}$</td>
<td>0.543</td>
<td>0.000</td>
<td>0.487</td>
<td>0.598</td>
</tr>
<tr>
<td>$x_{i,2}$</td>
<td>-0.182</td>
<td>0.000</td>
<td>-0.287</td>
<td>-0.078</td>
</tr>
<tr>
<td>$x_{i,3}$</td>
<td>0.016</td>
<td>0.000</td>
<td>0.09</td>
<td>0.022</td>
</tr>
<tr>
<td>$x_{i,4}$</td>
<td>0.003</td>
<td>0.352</td>
<td>-0.004</td>
<td>0.010</td>
</tr>
<tr>
<td>$x_{i,5}$</td>
<td>-0.001</td>
<td>0.824</td>
<td>-0.010</td>
<td>0.008</td>
</tr>
</tbody>
</table>

Table 3: Estimates, Confidence interval and P-Values of the initial 2000 – 2018 monthly model.
4.5.2 VIF of the initial models

A VIF-test was conducted on the initial model for period three and four to check for multicollinearity between the covariates. The VIF was computed for each covariate as shown in equation (8) and results can be seen in Table 4 and Table 5.

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Monthly</th>
<th>Quarterly</th>
<th>Semi-annually</th>
<th>Annually</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_{i,1}$</td>
<td>1.808</td>
<td>1.344</td>
<td>3.553</td>
<td>4.545</td>
</tr>
<tr>
<td>$x_{i,2}$</td>
<td>1.301</td>
<td>1.222</td>
<td>1.651</td>
<td>1.713</td>
</tr>
<tr>
<td>$x_{i,3}$</td>
<td>1.159</td>
<td>1.137</td>
<td>1.349</td>
<td>1.155</td>
</tr>
<tr>
<td>$x_{i,4}$</td>
<td>1.582</td>
<td>1.427</td>
<td>1.905</td>
<td>2.605</td>
</tr>
<tr>
<td>$x_{i,5}$</td>
<td>1.675</td>
<td>1.547</td>
<td>2.178</td>
<td>1.904</td>
</tr>
</tbody>
</table>

Table 4: VIF 1992 – 2018

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Monthly</th>
<th>Quarterly</th>
<th>Semi-annually</th>
<th>Annually</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_{i,1}$</td>
<td>2.112</td>
<td>1.789</td>
<td>6.002</td>
<td>8.681</td>
</tr>
<tr>
<td>$x_{i,2}$</td>
<td>1.528</td>
<td>1.582</td>
<td>2.549</td>
<td>2.818</td>
</tr>
<tr>
<td>$x_{i,3}$</td>
<td>1.253</td>
<td>1.233</td>
<td>1.577</td>
<td>1.249</td>
</tr>
<tr>
<td>$x_{i,4}$</td>
<td>1.625</td>
<td>1.523</td>
<td>2.122</td>
<td>3.484</td>
</tr>
<tr>
<td>$x_{i,5}$</td>
<td>1.783</td>
<td>1.611</td>
<td>2.778</td>
<td>2.596</td>
</tr>
</tbody>
</table>

Table 5: VIF 2000 – 2018

The VIF values for all the covariates in the 8 models presented in Table 4 and Table 5 are all below ten, because of this none of the covariates were removed due to multicollinearity.

4.5.3 Improving the initial models

After estimating the initial models the Adjusted-$R^2$, $\Delta AIC$ and the p-values were considered to see if the models overall would benefit from removing covariates. Outside of reducing the model there was also an attempt made at transforming the model.

P-Values

The estimated p-value for each covariate was computed in the models, we found that the Bull and Bear covariates had high P-values in some of the models and therefore these were taken into consideration for removal.

Adjusted $R^2$

The Adjusted - $R^2$ was computed for every model first as the full model, then when removing the covariates bull and bear respectively. If the value of the adjusted - $R^2$
was higher for the reduced model then the full model then the goodness of fit of the reduced model was assumed to better then that of the full model.

<table>
<thead>
<tr>
<th>Interval</th>
<th>Full model</th>
<th>Bull removed</th>
<th>Bear removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly</td>
<td>0.7322</td>
<td>0.7327</td>
<td>0.7323</td>
</tr>
<tr>
<td>Quarterly</td>
<td>0.7173</td>
<td>0.7171</td>
<td>0.7198</td>
</tr>
<tr>
<td>Semi-annually</td>
<td>0.7826</td>
<td>0.7857</td>
<td>0.7504</td>
</tr>
<tr>
<td>Annually</td>
<td>0.8352</td>
<td>0.8430</td>
<td>0.7985</td>
</tr>
</tbody>
</table>

Table 6: Adjusted $- R^2$ 1992 – 2018

<table>
<thead>
<tr>
<th>Interval</th>
<th>Full model</th>
<th>Bull removed</th>
<th>Bear removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly</td>
<td>0.7564</td>
<td>0.7586</td>
<td>0.7598</td>
</tr>
<tr>
<td>Quarterly</td>
<td>0.7606</td>
<td>0.7624</td>
<td>0.7635</td>
</tr>
<tr>
<td>Semi-annually</td>
<td>0.7699</td>
<td>0.7737</td>
<td>0.7619</td>
</tr>
<tr>
<td>Annually</td>
<td>0.8887</td>
<td>0.8933</td>
<td>0.8722</td>
</tr>
</tbody>
</table>

Table 7: Adjusted $- R^2$ 2000 – 2018

In Table 6 and Table 7 we can see that the Adjusted-$R^2$ was increased for all models but one when removing the covariate Bull and for 4 of the models when removing the covariate Bear. These improvements to the goodness of fit were slight but were taken into consideration for a possibility of removing these variables.

\[ \Delta AIC \]

We defined $\Delta AIC$ as:

\[ \Delta AIC = AIC(\text{Reduced model}) - AIC(\text{Full model}). \] (18)

The reduced models consisted of all covariates from the full model except one. We found that the covariates Bull and Bear were the covariates that in some models could improve the $\Delta AIC$. The $\Delta AIC$ for the models where those covariates were removed can be seen in Table 8 and Table 9.

<table>
<thead>
<tr>
<th>Removed covariate</th>
<th>Monthly</th>
<th>Quarterly</th>
<th>Semi-annually</th>
<th>Annually</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bull</td>
<td>1.806</td>
<td>-1.439</td>
<td>-1.430</td>
<td>-1.316</td>
</tr>
<tr>
<td>Bear</td>
<td>0.759</td>
<td>-1.800</td>
<td>0.400</td>
<td>1.928</td>
</tr>
</tbody>
</table>

Table 8: AIC 2000 – 2018
The models where the \( \Delta AIC \) is negative indicates the initial model would be improved by removing the covariate.

Looking at all of these statistics we came to the conclusion that the regression model would be improved by removing the variable Bull but keeping the variable Bear in the model. Since this thesis mainly takes interest in the correlation between the variables we found that the information gained from keeping all covariates in the model was worth more than the slight improvement to the accuracy of the model found by removing them. Therefore we decided to keep all covariates from the initial model in the final model.

**Log-transform**

To see if we could improve the model by using logarithmic transformation we computed the adjusted-\( R^2 \) for all the models when taking the log of the response variable, and the quantitative covariates respectively. The results we found seemed to improve 1 of the initial 8 models when taking the log of the response variable but since the other 7 didn’t find improvement by taking the log of either of the variables we continued on without using any transformation.

\[
\begin{array}{|c|c|c|c|c|}
\hline
\text{Removed covariate} & \text{Monthly} & \text{Quarterly} & \text{Semi-annually} & \text{Annually} \\
\hline
\text{Bull} & -1.565 & -0.870 & -1.853 & -1.992 \\
\text{Bear} & -1.162 & -1.840 & 6.161 & 4.498 \\
\hline
\end{array}
\]

Table 9: AIC 1992 – 2018
5 Results

5.1 Final model

After computing the statistics we needed to analyze and improve the initial model we found that the best option for our project was to keep all of the covariates from the initial model in the full model. There was also no improvement seen from transforming the model so we kept the covariates and the response variable with no transformation.

The final model is therefore:

\[ y_i = \beta_0 + \beta_1 x_{i,1} + \beta_2 x_{i,2} + \beta_3 x_{i,3} + \beta_4 x_{i,4} + \beta_5 x_{i,5} + e_i \]  

(19)

Where \( i \) represents the index of the observations, \( i = 1, 2, \ldots, n \), \( y_i \) the response variable home bias profit and the covariates \( x_{i,j} \) represents the corresponding market conditions as listed in table 10.

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Market Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>( x_{i,1} )</td>
<td>Accumulated increase in MSCI Sweden Net Return.</td>
</tr>
<tr>
<td>( x_{i,2} )</td>
<td>Appreciation of the SEK relative to the USD.</td>
</tr>
<tr>
<td>( x_{i,3} )</td>
<td>Variable explaining whether the VIX has been high or not.</td>
</tr>
<tr>
<td>( x_{i,4} )</td>
<td>Variable explaining if the market was in a bull market or not.</td>
</tr>
<tr>
<td>( x_{i,5} )</td>
<td>Variable explaining if the market was in a bear market or not.</td>
</tr>
</tbody>
</table>

Table 10: Covariates

5.1.1 Correlation Coefficients

To see how the covariates correlated with the home bias profit we used Pearson’s Correlation Coefficient which we computed using equation (14), the correlation coefficient takes a value between -1 and 1 and a value close to 1 or -1 indicates a strong relationship whilst a value close to 0 indicates little or no relationship. The results from this computation can be found on the next page. Table 11 and Table 13 shows the correlation values and in Table 12 and Table 14 we find the confidence interval of the correlation coefficients where the format is lower bound to upper bound.
From Table 11 and Table 13 we can see that there is a strong correlation between home bias profit and the accumulated change in the Swedish market index. There is also a substantial positive correlation with the appreciation of the SEK and there being a bull market, a noticeable negative correlation with there being a bear market.
and almost no correlation at all with the VIX being high.

### 5.1.2 P-Value for correlation coefficients

The P-value corresponding to the correlation coefficients gives us a picture if the value given as the correlation coefficient has a statistical significance or not. The P-Value is computed as shown in equation (13) and the results are assumed to be significant if their correlation coefficient has a p-value less then 0.05. The P-values can be found in Table 15 and Table 16.

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Monthly</th>
<th>Quarterly</th>
<th>Semi-annually</th>
<th>Annually</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_{i,1}$</td>
<td>$&lt; 2.2 \times 10^{-16}$</td>
<td>$&lt; 2.2 \times 10^{-16}$</td>
<td>$2.599 \times 10^{-16}$</td>
<td>$6.815 \times 10^{-10}$</td>
</tr>
<tr>
<td>$x_{i,2}$</td>
<td>$9.377 \times 10^{-9}$</td>
<td>$0.00205$</td>
<td>$0.00463$</td>
<td>$0.04284$</td>
</tr>
<tr>
<td>$x_{i,3}$</td>
<td>$0.838$</td>
<td>$0.9391$</td>
<td>$0.7632$</td>
<td>$0.7213$</td>
</tr>
<tr>
<td>$x_{i,4}$</td>
<td>$2.702 \times 10^{-15}$</td>
<td>$0.109$</td>
<td>$7.069 \times 10^{-6}$</td>
<td>$6.184 \times 10^{-5}$</td>
</tr>
<tr>
<td>$x_{i,5}$</td>
<td>$6.936 \times 10^{-10}$</td>
<td>$0.03782$</td>
<td>$0.01028$</td>
<td>$0.1997$</td>
</tr>
</tbody>
</table>

Table 15: P-Values for Correlation Coefficients 1992 – 2018

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Monthly</th>
<th>Quarterly</th>
<th>Semi-annually</th>
<th>Annually</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x_{i,1}$</td>
<td>$&lt; 2.2 \times 10^{-16}$</td>
<td>$&lt; 2.2 \times 10^{-16}$</td>
<td>$3.775 \times 10^{-11}$</td>
<td>$4.726 \times 10^{-7}$</td>
</tr>
<tr>
<td>$x_{i,2}$</td>
<td>$1.248 \times 10^{-9}$</td>
<td>$1.507 \times 10^{-5}$</td>
<td>$0.00358$</td>
<td>$0.00793$</td>
</tr>
<tr>
<td>$x_{i,3}$</td>
<td>$0.9567$</td>
<td>$0.9775$</td>
<td>$0.5236$</td>
<td>$0.6774$</td>
</tr>
<tr>
<td>$x_{i,4}$</td>
<td>$9.716 \times 10^{-12}$</td>
<td>$0.0122$</td>
<td>$1.761 \times 10^{-5}$</td>
<td>$4.65 \times 10^{-5}$</td>
</tr>
<tr>
<td>$x_{i,5}$</td>
<td>$1.251 \times 10^{-8}$</td>
<td>$0.04302$</td>
<td>$0.00670$</td>
<td>$0.2335$</td>
</tr>
</tbody>
</table>

Table 16: P-Values for Correlation Coefficients 2000 – 2018

The results in Table 15 and Table 16 indicates that the covariates for the Swedish market and the SEKUSD have statistically significant correlation coefficients for all models. The Bull markets and the Bear markets have statistically significant correlation coefficients in most of the models excluding the quarterly model for the bull market and the annual model for the bear market in period three. The VIX has no model with a p-value remotely close to the 95% significance level.
5.2 Model Validation

In this section we look into the assumptions made in the theoretical part (3.2.2) and examine whether they are met in the final model. This was done on each of the eight regressions made but we will only present a handful of images and graphs to keep it somewhat brief.

5.2.1 Heteroscedasticity

To check the linearity between the response variable and the independent variables we studied the residual values against the fitted values in a scatter plot. This plot is useful to examine whether there is a clear pattern in the distribution of the residuals, if there is you can detect heteroscedasticity.

Figure 2: Monthly Res. vs Fitted 2000-2018
Figure 3: Semi-annual Res. vs Fitted 2000-2018

Figure 2 and Figure 3 indicates no clear pattern for the residuals in either of the plots for the monthly or the semi-annual residuals. We therefore see no clear indication of there being heteroscedasticity in the models.
5.2.2 Normality of the regressors

The assumption that the errors of the independent variables are normally distributed can best be checked by either a Q-Q-Plot or a histogram. A perfect linear fit would give us an expected value of 0 for the residuals.

As can be seen in figure 4 and 5 the residuals are normally distributed around 0 hence the assumptions of normality of the errors can be regarded as confirmed.
6 Discussion

In this section the results from and decisions made throughout the project will be discussed.

6.1 Reliability of the data

The data used in the project was obtained from MSCI and CBOB, their indexes are widely used and we regard them as reliable sources. From these sources we got the information for the home bias profit, the increase in the value of the Swedish market and the Volatility index. The data points for the other covariates were computed using the index data obtained from MSCI.

6.2 Removal of data points

In the initial regression made we used all of the data points that were provided to us, which included data from 1969 to 2018 for all covariates except for the volatility index where there was only data available from 1990 – 2018.

Since we had already decided, by request from our employer, to divide the data into the periods 1969 – 2018, 1969 – 1992, 1992 – 2018 and 2000 – 2018 we could only use the VIX variable in our regression for period three and four. This in combination with that the adjusted - $R^2$ value for our models in period one and two were substantially lower than for the models after 1992 made us decide to not include them in our further research.

6.3 Interpretation of results regarding Market conditions

Here we will discuss the results obtained for each of the covariates in the models. The statistic used to make a conclusion about the market conditions correlation with the home bias profit was the correlation coefficient each of the covariates had with the home bias profit.

6.3.1 Accumulated percentage change in MSCI Sweden Net Return

The accumulated percentage change in the Swedish market has a strong correlation with the home bias profit, as can be seen by the values in Table 11 and Table 13 the correlation coefficient is for all models above 0.8 which indicates a strong correlation. This was an expected result since the response variable has a direct connection with this covariate, the results obtained for this covariate also had a clear statistical significance with the p-values ranging from $1 \cdot e^{-10}$ to $< e^{-16}$ as can be seen in Tables 15 and 16.
Being that it’s very hard to predict when the market is going to increase in value the information gained on this covariate is hard to use in a productive way for a fund manager.

6.3.2 Appreciation or depreciation of the SEK relative to the USD

The SEK appreciation has a positive correlation with the home bias profit, we can see from Table 11 that the correlation coefficient for the data in period three has values ranging from 0.3 to 0.4 and in Table 13 that for period four the values are ranging from 0.4 to 0.6. These values indicates that during a period where the SEK appreciates in value the home bias profit will increase and as such make it more profitable to be invested in the Swedish market, the values for period three indicates a fairly weak correlation whilst still noticeable and the values for period four indicates a slightly stronger correlation.

The values being higher in period four could indicate that the market has been more homogeneous since 2000. the fact that the SEK exchange rate was changed to a floating exchange rate just before the start of period three might also mean that the market hadn’t fully adjusted to the floating exchange rate in the early parts of that period. The statistical significance of these results are judged by their p-values.

The P-values for the SEK appreciation in period three ranges from $1 \cdot 10^{-9}$ to 0.043 as can be seen in Table 15 which to us indicates that all of the correlation coefficients has a statistical significance and can be used to interpret the results. For period four the p-values can be seen in Table 16 and range from 0.007 to $1 \cdot 10^{-9}$ which are even lower values and also indicates that all of the correlation coefficients have a statistical significance.

6.3.3 High volatility

The dummy variable for when the market has high volatility has correlation coefficients with the home bias profit ranging from $-0.01$ to 0.07 for both period three and four as can be seen in Table 11 and Table 13. These values are very low and indicate close to no correlation at all between the market volatility and the home bias profit.

The p-values for the high volatility variable ranges from 0.52 to 0.97 over period three and four, these values are high and indicate that the results can’t be seen as statistically significant, thus the null hypothesis that there is no correlation between high volatility and the home bias spread can’t be rejected.
6.3.4 Bull market

The correlation coefficients between the dummy variable for when there is a Bull market and the home bias profit can be seen in Table 11 for period three and in Table 13 for period four. The values for period three ranges from 0.16 to 0.7 and in period four the coefficients range from 0.30 to 0.82. These are quite far apart but we can see a pattern of a fairly noticeable positive correlation.

Looking at the P-values for each of the correlation coefficients that can be found in Table 15 and Table 16 we can see that the quarterly data in both period three and four has a P-value larger than 0.05. If we remove these correlation coefficients we obtain a range of correlation coefficients for the third period from 0.43 to 0.70 and for from 0.44 to 0.82 in the fourth period. This gives us an indication of a fairly strong positive correlation between there being a bull market and the home bias profit increasing. The P-values for the remaining correlation coefficients range from $1 \cdot e^{-15}$ to $1 \cdot e^{-5}$ which indicates that they’re all statistically significant.

6.3.5 Bear market

The correlation of bear markets with the response variables ranged from $-0.21$ to $-0.36$ and $-0.24$ to $-0.46$ from the regressions made in period three and four. Indicating a fairly weak negative correlation with the home bias profit. The strongest correlations could be seen in the semi-annual time interval and all the correlation values could be seen as statistically significant on a 95% confidence level except for the regressions made with annual time intervals in both periods having p-values of 0.20 and 0.23. The lack of significance in the annual time frame can be explained by the small number of data points in that interval.
7 Conclusion

The purpose of this project was to determine if we could find a correlation between specific market conditions and the home bias spread of the Swedish and Global stock market indexes.

The results we found indicated that a positive correlation could be found during the market conditions: SEK appreciation, Bull market and periods where the Swedish Market index was increasing. Out of these the Swedish market index increasing was expected to give a positive correlation since it is directly used to compute the home bias profit. The useful results were therefore that when the SEK appreciates compared to the USD there is a statistically significant positive correlation with home bias profit increasing. When there is a Bull market there is also a statistically significant positive correlation with the home bias profit increasing. The correlation values for the SEK appreciation ranged from 0.3 - 0.6 on the regressions made in period three and four and the values for the Bull market was between 0.43 to 0.82.

These results are in accordance with what we expected to find when starting the project and gives us reinforcement in that holding a Swedish home bias has historically been more profitable in bull markets. We could also see a statistically significant but relatively weak reversed correlation with bear markets which gives an indication that the Swedish market has historically devalued more during bear markets then what the global market has.

The results showed close to no correlation between the market volatility and the home bias spread. Since the volatility index used in our models is focused on the American market it might be fair to assume we would have obtained a different result using an index focused on the Swedish market.

Analysis of the models and data also gave us reason to focus only on the time periods 1992 – 2018 and 2000 – 2018 since these models showed a higher statistical significance with a larger goodness of fit. We presume this to be because of the value of Swedish market changing in a more homogeneous way after the SEK was made to have a floating exchange rate in 1992.

As stated in the project description this can be seen as a pre-study aiming to give an understanding of the effect different market conditions have on the home bias spread. There is potential for future projects to expand the scope of this project and look to predict when in the future it would be profitable to overexposure a stock portfolio towards the Swedish Stock market and also examine how profitable specific ratios of home bias within the portfolio is during different market conditions.
8 References

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