MSB635
Term Project - Nordic Semiconductor

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June 16, 2020

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1 Introduction

For the term project, I have chosen to look at the company Nordic Semiconductor. Nordic Semiconductor is a fabless semiconductor company specializing in wireless technology that powers the "Internet of Things (IoT)", and the company's award-winning Bluetooth LE solutions have made it the market leader. Nordic Semiconductor has its headquarters in Trondheim, Norway and is listed on the Oslo stock exchange (OSX: NOD).

First, the cost of capital for Nordic Semiconductor will be estimated using the Capital Asset Pricing Model (CAPM). Then, an analysis stating my opinion on the investment in the company's stock in the near future will be made.

2 Capital Asset Pricing Model

The CAPM describes the relationship between systematic risk and expected returns for assets, particularly stocks. In finance, CAPM is widely used for pricing risky securities and generating expected returns for assets given the risk of those assets and cost of capital. The CAPM uses the principle of Modern Portfolio Theory, together with assumptions about investors behaviour, risk and return distributions and market fundamentals, to determine if a security is fairly valued.

The formula for calculating expected return for a risky asset i is given as

$$E(r_i) = r_f + \beta[E(r_m) - r_f] \tag{1}$$

where $E(r_i)$ is the expected return on the investment, r_f is the risk-free rate, β is the beta of the investment and $[E(r_m) - r_f]$ is the market risk premium. As seen from eq. (1), investors expect to be compensated for both risk taking and the time value of money. The risk-free rate accounts for the time value of money, while the other terms account for the investors taking on additional risk. The goal of the CAPM formula is to check if a stock is fairly priced when its risk and time value of money is compared to its expected return.

Beta is a measure of the volatility of a security or portfolio compared to the market as a whole. This is often referred to as systematic risk. In other words, beta measures the extent to which returns on stock and the market moves together. The definition of beta for a stock i is given as the following

$$\beta = \frac{Cov(r_i, r_m)}{\sigma_m^2} \tag{2}$$

where σ_m^2 is the total variance - or risk - of the market portfolio and $Cov(r_i, r_m)$ is the contribution of stock i to the variance of the market portfolio. The beta can also be calculated by finding the slope of the line where an individual stock's returns are plotted against the return of the market as a whole. Looking at eq. (2), the beta of the market portfolio will be equal to one, and if a stock is riskier than the market it will have a beta larger than one.

3 CAPM and Nordic Semiconductor

In order to apply the CAPM to estimate the cost of capital of Nordic Semiconductor, it is first needed to estimate the values of the different components in eq. (1). Due to Nordic Semiconductor being listed on the Oslo Stock Exchange, the OSEBX index was used to represent the market portfolio. It could be argued that OSEBX is not a sufficient substitute for the market, and better results could might be achieved by rather using a broader index such as S&P 500.

The value of the stock's beta was estimated using the Python code presented in listing 1. The data for Nordic Semiconductor's stock price and the value of the OSEBX index were taken from Yahoo Finance [1] and Oslo Stock Exchange [2], respectively. The data contained daily prices of the stock in the 5 year timespan stretching from the 22nd of May 2015 to the 22nd of May 2020. Using the formula presented in eq. (2), the beta was estimated to be

$$\beta = 1.06 \tag{3}$$

For comparison, on Yahoo Finance the beta is estimated to be 1.37.

In order to verify the calculated result, a scatter plot was made. The plot is shown in fig. 1 and shows Nordic Semiconductor's stock returns plotted against the returns of OSEBX. The slope of the line was calculated to be 1.06, which is equal to the result obtained from eq. (2). The coefficient of determination R^2 for the plot was calculated to be 0.20. The coefficient explains how much variability of one factor can be caused by its relationship to another related factor. Hence, only 20% of the variability of the stock's returns is caused by OSEBX. This could be an argument for OSEBX being a poor substitute for the market, or that there exists other hidden factors that might affect the returns of the stock.

The value of the risk-free rate is often chosen to be the interest rate for a 10 year government bond. Since the interest rate for government bonds are volatile, a normalized risk-free rate is usually used instead. More specifically, the normalized risk-free rate is the average 10-year bond rate over the last 30 years. The market is chosen to be the index of the Oslo Stock Exchange, and the risk-free rate was chosen accordingly. That is, the risk-free rate was chosen as the interest rate for 10 year Norwegian government bonds [3]. Recently, the interest rate has dropped significantly due to the COVID19 pandemic. It can be argued whether the effect of the pandemic should be included in the cost of capital estimation. Regardless, the risk-free rate was chosen as the normalized risk-free rate of Norwegian government bonds. In other words,

$$r_f = 3.0\% \tag{4}$$

A report conducted by the consultant firm PwC concluded that the market risk premium in the Norwegian market in 2019 was 5.0% and unchanged from the previous year [4]. Hence, the market risk premium was chosen to be the following

$$E(r_m) - r_f = 5.0\% \tag{5}$$

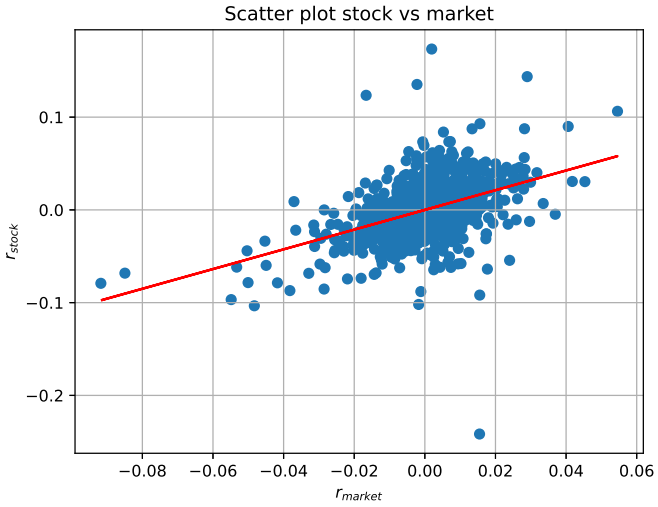

Figure 1: Scatter plot of Nordic Semiconductor's stock returns against the returns of the market (OSEBX). The value of β is given by the slope of the line.

Inserting the values found above into eq. (1) yields

$$E(r_i) = 3.0\% + 1.06 \cdot 5.0\% = \underline{8.3\%} \tag{6}$$

Hence, the cost of capital of a Nordic Semiconductor stock is 8.3%. In other words, the expected return of the stock is 8.3%.

4 Analysis

Looking at the share performance for Nordic Semiconductor [5], the return of a stock, including the dividends, equalled to 51.91% over the last four years. The formula used to calculate the annualized return yields

$$r_a = (1 + r_{tot})^{\frac{1}{t}} - 1 = (1 + 0.5191)^{\frac{1}{4}} - 1 = 0.11 \tag{7}$$

Hence, the annualized return of a Nordic Semiconductor stock over the last four years is 11%.

Even though historic data gives no guarantee for future returns, the annualized return can, however, give us an indication on the expected return of the stock over the last few years. A comparison between the expected return calculated in eq. (6) and the annualized return can therefore be made. The result of plotting the Security Market Line (SML), together with the variables found in the previous section and the annualized return, is shown in fig. 2. As seen in the figure, there is a deviation α between the estimated expected return from

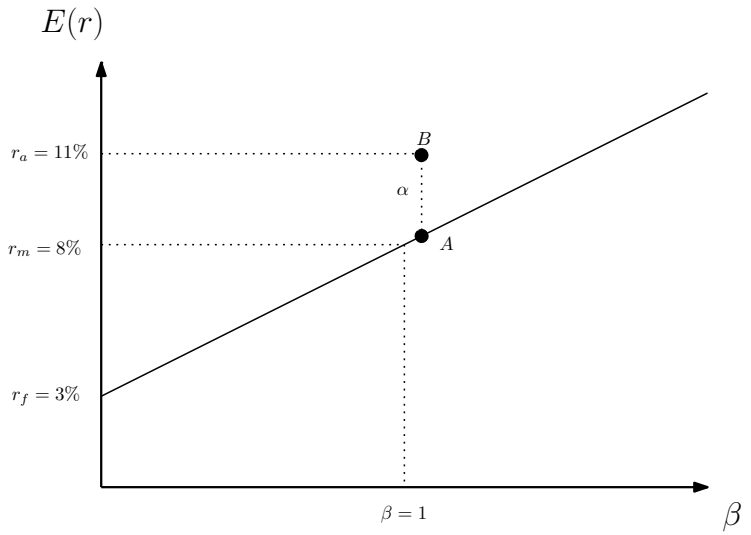

Figure 2: Security Market Line and different expected returns.

the CAPM and the annualized return denoted. Hence, the stock is perceived to be a good buy according to the CAPM. According to the model, the stock will provide a higher expected return over the fair return stipulated by the SML. In other words, the stock is offering too high of a rate of return for its level of risk and can therefore be referred to as under-priced. Note that this conclusion will still be valid with the use of Yahoo Finance's beta of 1.37.

Even though the CAPM has some empirical shortcomings, the model provides useful insights and facilitates for comparisons of different returns. As a matter of fact, the conclusion of Nordic Semiconductor stocks being under-priced is backed by several companies conducting professional analysis. For instance, both Investtech [6] and Simply Wall St. [7] thinks that the stock is under-priced. For a short-, medium- or long horizon, Investtech, based on their technical analysis, encourages to buy the stock. The technical analysis states that the stock lies in an increasing trend. It should be noted, however, that the stock has been classified as somewhat volatile.

Based on both the conclusion from the CAPM and the technical analysis from Investtech and Simply Wall St. I think it would be reasonable to invest in stocks from Nordic Semiconductor. The stock market has been more uncertain than usual during the last couple of months due to the virus outbreak. However, IT companies are known to do well under recessions [8]. As of June the 16th, the price of Nordic Semiconductor stocks has risen 27% this year and the company looks to be in a good shape. Hence, I do not see any immediate concerns of investing in Nordic Semiconductor.

5 Code

The code presented below was used to estimate beta for Nordic Semiconductor's stock. First, continuous return is calculated for both the stock of Nordic semiconductor and the market. The values were then added to datasets that contained the price of Nordic Semiconductor's stock and the market, respectively. Then, a scatter plot is made from the continuous return values of Nordic Semiconductor and the market. Lastly, the beta is calculated using eq. (2).

```
import pandas as pd
import os
import math
import matplotlib.pyplot as plt
import numpy as np
from scipy import stats


def continous_return(df):
    cont_return = []
    for i in range(len(df.index)):
        try:
            value = math.log(df['Adj Close'][i] / df['Adj Close'][i
    +1])
            if math.isnan(value):
                cont_return.append(0)
            else:
                cont_return.append(value)
        except:
            cont_return.append(0)
    df['Cont Return'] = cont_return
    df.drop(df.index[-1], inplace=True)
    return df


def condition_dataset(filename, source):
    if source == 'yahoo':
        df = pd.read_csv(filename, usecols=['Date', 'Adj Close'])
        df = df[::-1]
        df.reset_index(drop=True, inplace=True)

    elif source == 'bors':
        df = pd.read_csv(filename, usecols=['OSEBX', 'Siste'])
        df.rename(columns={'OSEBX': 'Date', 'Siste': 'Adj Close'},
    inplace=True)
        for i in range(len(df.index)):
            date = df['Date'][i].split('.')
            new_date = '20'+date[2]+'-'+date[1]+'-'+date[0]
            df['Date'].replace({df['Date'][i]: new_date}, inplace=
    True)

    df = continous_return(df)    # Add a column with calculated
    continous return
    return df


def check_datasets(df1, df2):
```

```
    if len(df1.index) != len(df2.index):
        ValueError('The datasets are of different lengt!')
    for i in range(len(df1.index)):
        date1 = df1['Date'][i]
        date2 = df2['Date'][i]
        if date1 != date2:
            print(f'The datasets have inconsistent dates at row {i}.')
            print(f'The dates are {date1} and {date2}.')
            ValueError('Inconsistent dates!')


def make_scatter_plot(x, y):
    # Draw scatter points
    plt.scatter(x, y)

    # Draw regression line
    slope, intercept = np.polyfit(x, y, 1)
    plt.plot(x, x*slope + intercept, 'r')

    plt.title('Scatter plot stock vs market')
    plt.ylabel('$r_{stock}$')
    plt.xlabel('$r_{market}$')

    plt.grid()
    plt.show()

    return slope, intercept


def calculate_beta(r_market, r_stock): # Beta also equals the slope from the linear regression in make_scatter_plot()
    return (np.cov(r_market, r_stock) / np.var(r_market))[1][0]


def main(market_filename, stock_filename):
    stock_df = condition_dataset(stock_filename, 'yahoo')
    market_df = condition_dataset(market_filename, 'bors')
    check_datasets(stock_df, market_df)
    r_stock = np.array(stock_df['Cont Return'].tolist())
    r_market = np.array(market_df['Cont Return'].tolist())

    slope, intercept = make_scatter_plot(r_market, r_stock)
    beta = calculate_beta(r_market, r_stock)

    r = stats.pearsonr(r_market, r_stock)[0]
    print('Beta: ', beta)
    print('R^2: ', pow(r,2))


main('osebx.csv', 'nordic_semiconductor.csv')
```

Listing 1: Code for estimating beta

References

[1] URL: https://finance.yahoo.com/quote/NOD.OL?p=NOD.OL (visited on 05/22/2020).

[2] URL: https://www.oslobors.no/markedsaktivitet/#/details/OSEBX.OSE/overview (visited on 05/22/2020).

[3] URL: https://www.norges-bank.no/en/topics/Statistics/Interest-rates/Government-bonds-annual/ (visited on 06/14/2020).

[4] URL: https://www.pwc.no/no/publikasjoner/pwc-risikopremie-2019.pdf (visited on 06/14/2020).

[5] URL: https://www.nordicsemi.com/About-us/Investor-Relations/Shares/Share-performance (visited on 06/14/2020).

[6] URL: https://www.investtech.com/no/market.php?CompanyID=100260&product=5 (visited on 06/14/2020).

[7] URL: https://simplywall.st/stocks/no/semiconductors/ob-nod/nordic-semiconductor-shares?utm_medium=finance_user&utm_campaign=cta&utm_source=post&blueprint=872854#share-price-and-news (visited on 06/14/2020).

[8] URL: https://franchisebusinessreview.com/post/recession-proof-businesses/ (visited on 06/16/2020).