Asset Pricing Models and the Norwegian Stock Market

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1 Introduction

In this master thesis I will primarily look at whether real business cycle variables and the Carhart factors affect asset return in the Norwegian stock market differently at different times. This will be done by comparing the factors` effect on asset return in two periods. Using time series data, I will estimate both an unconditional and a conditional version of the capital asset pricing model (CAPM). I will also construct a real business cycle model, enabling me to test for stability in how stock return is affected by factors which possibly covary with an investors stochastic discount factor and a company's cash flow. The complete sample period will be divided into two periods, where I will use portfolios of stocks sorted on specific characteristics when constructing the dependent variables. This enables me to test whether any patterns in asset return can be detected, and then compare the results of the two periods. While the CAPM and real business cycle variables are tested directly, I will retrieve information on the other factors by using portfolios sorted on size, book-to-market ratio (henceforth B/M-ratio), momentum and industry type. The first three are the variables of the Carhart-four factor model; in the CAPM tests, the portfolio types will be of main importance, as these have characteristics possibly related to asset return. Industry portfolios are mainly included as their returns are more likely to covary with the real business cycle. I include industry sorted portfolios in the CAPM estimations and the Carhart-factors sorted portfolios in the real business cycle estimations in order to be able to compare the test results of the CAPM model with the real business cycle model. Simultaneously, this makes it possible to test for industry effects as well as whether real business cycle effects are strong enough to be detected in non-industry sorted portfolios. The excess market return (henceforth referred to as EMR) is included in the real business cycle model in order to control for an effect which appears dominant. The real business cycle variables used in my thesis have to my knowledge not previously been tested on the Norwegian stock market. For this reason, the secondary aim of the thesis lies in describing the relationship between the Norwegian stock market and the real business cycle.

Knowing whether factors affect asset returns similarly in different periods is of interest to the rational investor as it indicates whether the investor should be concerned with past returns in deciding future investments. Furthermore, it can also provide theoretical insight on the nature of risk and investor psychology. Recent research evaluating asset pricing models using Norwegian stock market data includes papers by Næs, Skjeltorp and Ødegaard (2009), Ødegaard (2013) and Jakobsen and Tjelland (2012). I use a sample length similar to previous research, although I follow Ødegaard (2013) in using an updated data series stretching to December 2012 (depending on the model tested, my data series begins in the early or in the middle of the 1980s). Using a similar period length as previous research is mainly done as the available and most commonly used data set does not include values before 1980. The disadvantage using this data set lies in it not extending back further than 1980. This may create a situation where there are regime changes in relevant asset pricing factors, while at the same time this being rejected as the periods tested in this thesis are in the same regime. The advantage of using a similar data set as previous research lies in it being easier to spot errors in the analysis, for both the reader and writer of this thesis. Previous studies have largely concentrated on the Carhart factors, finding some evidence of a size effect, but little or no B/M and momentum effects[1]. Næs et al. (2009) performed the only study of the Norwegian stock market and the real business cycle to my knowledge, finding their variables to be capable of describing asset return without being a priced factor.

In order to test the stability of various asset pricing variables, I start by using the EMR of portfolios sorted by a specific characteristic as the dependent variable. Portfolio returns are registered at a monthly frequency. The Carhart factor portfolios are all divided into decile portfolios ranked by the size of a stock's value on the corresponding variable. The industry sorted portfolios are divided into eight sectors. These portfolios will be used to test the beta- and price of risk coefficients and intercepts of the asset pricing models I estimate in this thesis. Comparing the coefficients in the two periods will indicate whether the variables are stable in their effect on pricing risk or explaining asset return between 1980 and 2012. Using characteristic sorted portfolios has been done in several asset pricing tests, including all previous Norwegian research referenced. Testing for stability in terms of how factors affect stock return by dividing the data into sub periods has been done by the majority of studies on robustness referenced in this thesis.

1 See for instance Næs et al. (2009) and Jakobsen and Tjelland (2012)

Capturing regime changes may be sensitive to the choice of periods. To get a grasp of the effect of using different period lengths, one could look at Ødegaard (2013), who performs several estimations using decade long sample periods.

My analysis will divide the data set into two periods of similar length for the majority of the CAPM estimations (February 1980-June 1996 and July 1996-December 2012). I choose these period lengths for five different reasons: Firstly, by dividing the mode sample length in two equal parts, I avoid the problem of data snooping to a larger extent than a division based on a seemingly more arbitrary principle. Secondly, by dividing the data in approximately two equally large parts I am able to have roughly the same number of observations for both periods in the models estimated in this thesis. If the numbers of observations are different for the two periods, this will favor significant parameters for the longest period, thus making the comparison between the periods more complicated. It should be mentioned the estimations of the real business cycle model do not include values before December 1985. The third reason for splitting the data this way is inspired by Jahan-Parvar and Castellani (2010), who link periods containing a financial crisis to a CAPM regime, and periods without a financial crisis to a Fama-French model regime. Fourthly, I will use the one and three month Norwegian InterBank Offered Rate (NIBOR) as variables in the real business cycle model. A regime change occurred during the 1990s, changing the primary goal of the monetary policy toward an inflation target rather than a fixed foreign exchange rate (Norges Bank 2012). This makes it of interest to test whether the NIBOR rate affect asset return differently in the two periods. Finally, this division is done close to the end of a series of papers published by Fama and French which can be considered a milestone in empirical asset pricing (Fama and French 1993, 1996). If the significance of the factors presented in these papers originated from a psychological bias in the investors, it could be argued rational investors would exploit this arbitrage opportunity once it got known, which would lead to the point where all arbitrage opportunities have been exempt, and we would therefore not see these factors present to the same extent in the second period.

In order to perform my analysis I have structured the thesis as follows:

In section 2 I look at the background of the asset pricing models. This is done by presenting the theoretical construction of the CAPM before I look at criticism of this model, leading to extensions of the CAPM. The effects the real business cycle variables may have on asset return will be presented in this section. I also look at how asset pricing models may depend on time, as well as linking this with schools of thought trying to explain asset return.

Section 3 is the data and methodology chapter. Here I present a detailed description of the data set, as well as an explanation on how I use this data to create the necessary variables tested in this thesis. I also present the econometric models needed to estimate and test the models used in the thesis.

This is followed by section 4, where I perform the empirical analysis. I present descriptive statistics on the variables, as well as testing the significance of the intercepts, coefficients and the price of risk parameters. In the CAPM estimation, my main focus lies on testing the constant. Testing the price of risk parameters, as well as the factor coefficients are of importance for the real business cycle model. In the CAPM estimations, my main focus lies in looking at the stability of how the Carhart factors affect asset return. The focus is split between describing the variables effect on stock return and testing for robustness when interpreting the results of the real business cycle model.

I conclude by finding evidence the Carhart factors are not very robust in how they affect asset return, in particular for the conditional model. They do however show signs of a stable effect on asset return as their impact is not too strong. The results from the real business cycle model show the variables are quite stable in their ability to explain asset return, the exception being the one month NIBOR rate. I also find evidence of a credit spread variable being priced in both periods, but no strong evidence is found suggesting other real business cycle variables to be priced.

2 Theoretical background

2.1 The CAPM

Modern portfolio theory, a forerunner to the Sharpe-Lintner CAPM, focus on the tradeoff between risk and return, and was first developed in the 1950s by Markowitz (1952,1959) and Roy (1952). Markowitz (1952) challenged the prevalent view that through diversification, risk could be eliminated by spreading the wealth across assets with risks independent of each other. He argued broad economic influences caused assets to be inter correlated. The implication of this could better be understood by looking at an expression of the portfolio variance:

$$\sigma_p^2 = \sum_i \sum_j w_i w_j \sigma_i \sigma_j \rho_{ij}. \tag{2.1}$$

Where the portfolio variance σ_p^2 is found as the sum of the value weighted variance each stock adds to the portfolio, $\sum_i \sum_j w_i w_j \sigma_i \sigma_j p_{ij}$. All variables in equation (2.1) except the correlation coefficient, p_{ij}, must be positive. As asset returns are inter correlated this leads the value weighted sum of the correlation coefficients to be positive for the market portfolio, and the variance does not disappear completely through diversification. On the other hand, the value weighted sum of the correlation coefficient, p_{ij}, is likely to be less than one, indicating the portfolio variance can be reduced via diversification.

Markowitz (1959) developed a model of portfolio choice. His model was a static model which assumed investors invested in a portfolio in period $t-1$, and gave a stochastic return in period t. He assumed the investors were risk averse, rational and utility maximizing who therefore wanted to choose a mean-variance efficient portfolio. A mean-variance efficient portfolio is a portfolio which minimize the variance given a certain expected return, or which maximize the expected return, given a certain portfolio variance:

$$MIN\ \sigma^2 \text{ subject to } E(R) = K \text{ or equivalently } MAX\ E(R) \text{ subject to } \sigma^2 = K,$$

where the new term, $E(R)$, is the expected return (Copeland, Weston and Shastri 2005: Chapter 5).

This model was later modified by Sharpe (1964) and Lintner (1965) who added two more assumptions to the Markowitz model. The first assumption was that all investors could lend and borrow unlimited amounts at a risk free rate. The second assumption was that of complete agreement among investors about the joint distribution of asset returns between period $t-1$ and period t (homogeneity of expectations), as well as assuming this distribution to be the true distribution. This model followed Tobin's separation theorem (Tobin 1958), assuming all rational and risk averse investors would hold a portfolio consisting of borrowing/lending and holding the same portfolio of stocks where the Sharpe-ratio is maximized (Sharpe 1966)[2]. Furthermore, the CAPM assumes a perfect capital market where the investor has no influence on the prices of the assets (Copeland et al. 2005: Chapter 6). Given the aforementioned assumptions it can be shown the value weighted market portfolio must have the maximum Sharpe-ratio. For the market to be in equilibrium, the price of each asset has to adjust until investors collectively decide to hold the exact supply of the asset. If all investors held the same proportion of assets, this proportion must be a proportion of the value weighted market portfolio (Perold 2004).

The Sharpe-Lintner CAPM measures the risk of an asset which cannot be diversified (market risk) as:

$$\beta_{im} = \frac{\operatorname{cov}(R_i, R_m)}{\operatorname{var}(R_m)}, \tag{2.2}$$

where the portfolios exposure to the market risk factor is measured by the β_{im}, which is found by dividing the covariance between the return on portfolio i and the market portfolio m with the variance of the market return.

2 For an optimal portfolio, one should maximize the risk premium divided by the standard deviation of the portfolio, otherwise known as the Sharpe-ratio: $\frac{E(R_i - R_f)}{\sigma_i}$. Where i signifies the portfolio and f signifies the risk free rate.

By identifying the risk-free rate (or equivalently, the expected return on a zero-beta portfolio) one arrives at the Sharpe-Lintner CAPM equation:

$$E(R_i) = R_f + \beta_{im}(E(R_m) - R_f), \tag{2.3}$$

Equation (2.3) could be written as:

$$E(R_i) - R_f = \lambda_m \beta_{im}. \tag{2.4}$$

In equation (2.4), λ_{mt} is interpreted as the market price of risk. The difference between equation (2.3) and (2.4) lies in the way the estimated coefficient is interpreted. A significant beta in equation (2.3) indicates knowing the value of the EMR variable is helpful in explaining the return of individual groups of stocks in the same period. A significant λ_{mt} in equation (2.4) indicates the knowledge of an assets beta, without the knowledge of the value of the EMR variable, is helpful in explaining expected excess asset return (Cochrane 2005:Chapter 9). Jensen (1968) noted the CAPM could be tested using time series regression:

$$R_{it} - R_{ft} = \alpha_i + \beta_{im}(R_{mt} - R_{ft}) + \varepsilon_{it}, \tag{2.5}$$

Where ε_{it} is an idiosyncratic error term and α_i is the intercept. If the CAPM is specified correctly, Jensen's alpha (α_i) would be zero for all assets and portfolios of assets, regardless of their individual characteristics (Fama and French 2004).

2.2 Criticism and extensions of the CAPM

The intertemporal CAPM (ICAPM) is an extension of the CAPM. Developed by Merton (1973), this model extends from the static one period framework of the Sharpe-Lintner CAPM to assuming investors are concerned about lifelong investment opportunities. This implies investors might want to hedge against changes leading to a worsened future opportunity investment set or lower future consumption. Ross (1976) developed the Arbitrage Pricing Theory (APT). This model uses the realized returns and arbitrage restrictions to find the pricing factors. The priced factors could express the discount factor, m_t ,a counter cyclical variable which is large in bad times and small in good times.

$$m_{t+1} = \beta E_t\left[\frac{u'(c_{t+1})}{u'(c_t)}\right], \tag{2.6}$$

where m_{t+1} is the stochastic discount factor, β is a discount factor in regards to time, while the last part shows the marginal utility at time $t+1$, $(u'(c_{t+1}))$ divided by that at time t, $(u'(c_t))$.

Asset return could be expressed as:

$$P_{i,t} = E_t(m_{t+1}X_{i,t+1}), \tag{2.7}$$

where the price of the asset today, $P_{i,t}$, is equal to the expected discounted value at time t of the assets value at time $t+1$, $X_{i,t+1}$. Real business cycle variables may effect current price both through the stochastic discount rate, m_{t+1} as well as through cash flow effects affecting $X_{i,t+1}$.

(Cochrane 2005:Chapter 9).

The Sharpe-Lintner CAPM has also been tested thoroughly on an empirical level. Early tests of it rejected the model, as the intercept was higher than the risk free rate, while the beta coefficient was less than average EMR[3]. Since the late 1970s, several studies have revealed other empirical shortcomings with the CAPM. Basu (1977) finds that stocks with high earnings-price (E/P)-ratio achieve a higher than predicted return. Banz (1981) shows the same to be true for stocks with a small market capitalization, while Bhandari (1988) documents a debt-to-equity factor, where assets with high (low) debt-to-equity ratios have a positive (negative) alpha. Stattman (1980) and Rosenberg, Reid and Lanstein (1985) show that stocks with high (low) book-to-market ratios have a positive (negative) abnormal return as measured by CAPM. These findings indicate the parsimonious theory of risk which the CAPM is founded on leads to an underspecified model.

3 See for instance Douglas (1968), Black, Jensen and Scholes (1972), Miller and Scholes (1972), Blume and Friend (1973), Fama and MacBeth (1973).

2.3 The Fama-French three factor model

Fama-French (1993, 1996) proposed a three factor model to capture stock market return;

$$E(R_i) - R_f = b_1(E(R_m) - R_f) + b_2 SMB + b_3 HML. \tag{2.8}$$

In this model, HML is the difference in return between portfolios of assets with high B/M-ratio and low B/M-ratio. SMB is the difference in return between portfolios of assets with small market capitalization and big market capitalization. If this model is superior to the CAPM, we would expect significant coefficients for either SMB or HML in the following regression:

$$R_{it} - R_{ft} = \alpha_1 + \beta_{im}(E(R_{mt}) - R_{ft}) + \beta_{is} SMB_t + \beta_{hs} HML_t + \varepsilon_{it}. \tag{2.9}$$

This is an extension of equation (2.5), adding size and B/M variables. Unlike its predecessor, the CAPM, Fama-French (1993, 1996) based their asset pricing model mainly on empirical research, as their model was successful in capturing the variance of asset returns, rather than relying on solely on economic axioms. This makes it more difficult to interpret the findings in a theoretical context. They found that firms with low (high) earnings tend to have a high (low) B/M-ratio, and a positive (negative) slope on HML, while the SMB factor proved successful in capturing variance in asset return. Fama and French (1998) found evidence this model is an improvement over the CAPM internationally as well, as the three-factor model explains stock returns in a more accurate way than the CAPM in 13 major markets. Griffin (2002) argues the Fama-French factors are country specific rather than global, reflecting the difference in effect they have in different stock markets.

The Fama-French three-factor model has also been criticized on an empirical level. Jegadeesh and Titman (1993) found evidence stocks which performed well over the last three to twelve months, earn a higher than expected return in the following three to twelve months. Similarly, stocks which previously performed poorly continue to perform poorly. Carhart (1997) proposed a solution to this problem, as the Carhart four-factor model added momentum as an extra factor to the Fama-French model. Evidence that stocks show long term reversal in return has also been shown by using the cumulative returns of the past one to five years (Titman and Jegadeesh 2001)

2.4 Models based on conditional information

A common assumption when estimating models is that of homoscedasticity. A homoscedastic process is characterized by a constant variance:

$$VAR(\varepsilon_t \mid X) = \sigma^2. \tag{2.10}$$

Contrary to this assumption, many time series show signs of having a time-varying volatility:

$$VAR(\varepsilon_t \mid X) = \sigma_t^2. \tag{2.11}$$

(Nelson 1991)

In a model where the sizes of the parameters are affected by the variance term, this will lead to biased estimators. To mitigate this problem, it is possible to estimate a conditional model taking the following form:

$$E(r_{i,t+1} \mid \Omega_t) = \sum_{i=1}^{j} \beta_{it} * E(f_{i,t+1} \mid \Omega_t). \tag{2.12}$$

In equation (2.12), the left hand side is the expected excess return $E(r_{i,t+1} \mid \Omega_t)$ (return subtracted by the risk free rate). The right hand side is the sum of j variables multiplied with the betas of the factors $\sum_{i=1}^{j} \beta_{it} * E(f_{i,t+1} \mid \Omega_t)$, all of which are conditioned on information in period t. In the special case of a conditional CAPM model, it could be written as follows:

$$E(r_{i,t+1} \mid \Omega_t) = \beta_{mt} * E(EMR_{t+1} \mid \Omega_t). \tag{2.13}$$

The interpretation is similar to equation (2.3), the difference being all factors are now conditioned on information at time t . By not assuming constant volatility we allow the size of the risk factors to vary over time and it could therefore be a more accurate calculation of the beta values. (Wu 2002)

Econometrically, there are several approaches in creating a conditional asset pricing model, many of which have strong similarities. A large group of these models, such as the one tested in this thesis, use state variables to represent the information set of investors[4]. A second group lays their main focus in choosing the right window size to estimate the factor sizes at time t[5]. This approach assumes recent data is more appropriate when calculating the current factor sizes. A problem using this approach lies in determining the optimal window sizes; Old observations may be very inaccurate compared to new observations. At the same time, including old observations will increase the sample size and through that will improve the accuracy of the estimation.

Empirical research on the performance of the conditional asset pricing models has achieved mixed results. Conditional CAPM models have largely been rejected in the case where the values depend on the window size, while it has been more successful for models conditioned on state variables (Li and Yang 2011). Jakobsen and Tjelland (2012) use an approach in the state variable group, and argue their conditional CAPM (which is very similar to the conditional CAPM model used in this thesis) offers a slight improvement over their unconditional model using Norwegian stocks.

2.5 Using macro variables

It is conceivable asset return covaries with macro variables which represent the real business cycle. Some international research has focused on identifying proxies representing the real business cycle, and testing whether this helps in predict asset return[6]. Næs et al. (2009) use real business cycle variables in an unconditional setting in the Norwegian stock market. They find signs of cash flow effects, but few signs of identifying a time-varying stochastic discount factor.

2.6 Asset pricing models and period dependent factors

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4 Previous studies using this approach include Ferson et al. (1987), Shanken (1990), Ferson and Harvey (1991), Cochrane (1996), Jagannathan and Wang (1996), Lettau and Ludvigson (2001), Wu (200x), Wang (2003), Petkova and Zhang (2005) and Santos and Veronesi (2006)

5 See for instance Foster and Nelson (1996), Grundy and Martin (2001), Lewellen and Nagel (2006), Ang and Kristensen (2012) and Li and Yang (2011)

6 See for instance Wu (2002), Ferson and Harvey (1991) and Harvey (1989), who use similar proxies as those in this thesis.

To my knowledge, besides decade long test results presented in Ødegaard (2013), it does not exist other research on the stability factors have in explaining asset return in the Norwegian stock market. Internationally, a field of asset pricing research has looked at the robustness of such models, in particular of the Carhart factors. Pinfold, Wilson and Li (2001) notes the study of both the size effect and B/M effect is highly dependent on the time frame selected for the study. Fama and French (2006) show the B/M effect is insignificant using US stocks for the period 1926-1963. The study of Ang and Chen (2007) reconfirms the finding of Fama and French as well as providing evidence that a B/M effect can be captured using a conditional CAPM for the post 1963 period. Jahan-Parvar and Castellani (2010) argue the same effect is insignificant using the sample period 1987-2009 as well. They argue periods containing a financial crisis appear to follow the CAPM specification, while periods not containing financial crises are better explained by the Fama-French model, arguing this could be as investors switch to a simpler model in periods of crisis, and that systematic risk dominates all other risks dominantly during these periods. The three latter articles lay their focus not only on the B/M effect, but how this effect might be related to stocks of a certain size.

Various interpretations have been made on the statistical relevance of the Fama-French factors. The first argues these factors are detected due to the sample used[7]. It is therefore argued these variables are an in-sample bias unlikely to consistently be found out of sample. Later research has shown these factors to be relevant using other samples as well[8], indicating this explanation is incorrect. If this explanation was correct, all differences in explaining the cross section of stock return in the two periods tested in this thesis would arise because of statistical chance rather than for theoretical reasons (hence it is unlikely that other factors than the EMR factor will significantly influence stock return). A second explanation argues the relevance of the Fama-French factors arise due to a psychological bias[9]. For instance, the B/M effect is argued to arise

7 Examples of proponents of this theory includes Black (1993), Lo and MacKinley (1990), Mackinley (1995)

8 See for instance the studies by Chan, Hamoa and Lanishok (1991), Capaul, Rowley and Sharpe (1993), Davis (1994) and Fama and French (1998)

9 See for instance DeBondt and Thaler (1987), Lakonishok, Schleifer and Vishny (1994), Haugen (1995) and LaPorta (1996)

because investors irrationally overvalue stocks which have shown rapid growth in earnings, and likewise undervalue stocks which have performed poorly. The correction for this causes the B/M effect (Pinfold et al. 2001). A consequence of this psychological bias is that investors could exploit this market inefficiency and thereby eliminating or at least reducing the value premium once the information got known. Others, such as Barberis, Schleifer and Vishny (1998), Daniel, Hirshleifer, and Subrahmanyam (1998), and Hong and Stein (1999) argue the momentum effect exists because of biases investors have when interpreting information. In the framework of my thesis, the implied prediction here is that the Fama-French factors, if significant at all, are likely to be more relevant until the extensive literature documenting them, and not as relevant afterward. This prediction relies on the psychological bias being similar in Norway as the places where the Fama-French factors have been documented, as well as the assumption of rational investors trying to exploit these mispricings once the overreaction effects have been documented in international markets. A third explanation is that the Fama-French factors reflect risk. This is the view of Fama and French (1993, 1996). If this view was correct, one would predict the Fama-French factors to have similar effects on stock return regardless of sample used.

From the ICAPM and APT perspective, the real business cycle variables will be robust in terms of asset return if the price of risk parameters are similar in the two periods. It is worth noticing a lack of robustness could occur both if investors' marginal utility is not equally sensitive to the variable in the two periods, and if the proxy reflects a different information set in the two periods.

3 Methodology and data

3.1Data

In order to test the asset pricing models I have retrieved data on the monthly NIBOR rate and information on all stocks listed on OSE (except for the least liquid and smallest stocks) from January 1980 to December 2012 from Professor Bernt Arne Ødegaards website[10]. This data set includes all necessary information in order to test the CAPM models. For the real business cycle variables, I have retrieved data from Norges Bank, the website of Professor Bernt Arne Ødegaard as well as the Federal Reserve Bank of St. Louis. Several of the real business cycle variables do not contain data far enough backward in time, making December 1985- December 2012 the sample length for my real business cycle model. Like Jakobsen and Tjelland (2012) and Næs et al. (2009) I use monthly returns as the window size of my regressions. This might yield different results than research done with daily data as in Jakobsen and Tjelland (2012). See Appendix 1 for more information on the variables.

3.1.1 Asset specific variables

I report results from two different measures of the market. The value weighted EMR is the actual return used in the CAPM. However, the Norwegian stock market is characterized by a few very large companies (Næs et al. 2009), I therefore choose to include results from an estimation using equally weighted portfolios as well[11]. In order to perform the estimations, I need to create the independent variables for the value weighted EMR and the equally weighted EMR. This is found by subtracting the one month NIBOR rate of the holding period from the market return. In addition to this, I report data statistics on the Carhart four-factor model variables. These are created in the same way as in Fama and French (1998) (see Appendix 1 for further description of how the Carhart factors are constructed). The first factor on which descriptive data is reported is an assets book-to-market ratio (HML). This shows the excess return of assets with a high B/M

10 http://finance.bi.no/~bernt/financial_data/ose_asset_pricing_data/index.html

11 The studies of both Jakobsen and Tjelland (2012) and Næs et al. (2009) include test scores of equally weighted return series.

ratio subtracted by that of assets with low B/M ratios. The second factor is the market capitalization of a company (SMB). This variable measures the size effect (excess return of assets with a low market value subtracted by that of assets with high market value). Finally, an assets historical return will also be applied to create the third variable, the momentum effect (MOM). This variable shows the difference in return of stocks which have had a high previous return subtracted by the return of stocks which has had low return.

In addition to the previously mentioned variables I use data on value weighted and equally weighted portfolios of stocks sorted by industry, size, B/M value and momentum. The exception to this is value weighted size portfolios, as I was unable to produce results which were similar to previous research, as well as having an economical interpretation. All but the B/M portfolios have data stretching back to January 1980, while the B/M portfolios are reported from January 1981. These portfolios will be used as the dependent variable, where their return is subtracted by the one month NIBOR rate, creating excess portfolio return values from February 1980. They will also test whether any pattern in abnormal return can be detected. All values show monthly return. I have chosen to include a fairly large number of portfolios in this thesis. This might increase the accuracy of the analysis, as well as making it easier to compare the results to previous papers using similar portfolios; it might however decrease the intuitive simplicity in terms of reaching a conclusion.

3.1.2 Real business cycle variables

For the real business cycle variables I have used historical data on the return of the stock market, the one- and three month NIBOR rates, the credit spread on US bonds and lagged EMR.

The first real business cycle variable is the one month lagged EMR (EMR-1). Subtracting the one month NIBOR rate from the three month NIBOR rate creates the second variable (ni31). The third variable is the one month NIBOR rate (ni1). Finally, the fourth variable, the credit spread (credit) is found by subtracting the return on Aaa rated bonds from the rate of return on Baa rated bonds.

I construct the real business cycle variables in a similar way as Wu (2001), Harvey (1989) and Ferson and Harvey (1991). These real business cycle variables have been screened extensively for their predictive powers in explaining asset return, as they carry information on the state of the economy (Ferson and Foerster 1994). The relevance of my analysis thus largely relies on these variables having a similar effect in Norway. Unlike them, I do not construct a variable based on the dividend yield. This is because the dividend yield in Norway has largely been affected by tax motives[12].

12 For example, in 1989, 70% of the OSE companies did not pay dividends, making it likely the dividend yield gives different signals in the Norwegian case. I also choose to use the US credit spread as the equivalent Norwegian series does not contain data stretching far back in time (Næs et al. 2009). This could lead to an underestimation of the effect reflected by the credit spread.

3.2 Methodology

3.2.1Time series properties

I will first test the time series properties of the Norwegian stock market data. The time series is strictly stationary if its distribution is independent of time:

$$f(y_t,...,y_{t+k}) = f(y_{t+m},...,y_{t+m+k}). \tag{3.1}$$

A distribution which is more likely to be observed is that of weak stationarity. In a weakly stationary series, the following moments are required to be constant and independent of time:

$$E(y_t) = E(y_{t+m}) = \mu_y, \tag{3.2}$$

$$VAR(y_t) = E((y_t - \mu_y)^2) = E((y_{t+m} - \mu_y)^2), \tag{3.3}$$

$$COV(y_t, y_{t+k}) = E((y_{t+k} - \mu_y)(y_{t+k+m} - \mu_y)). \tag{3.4}$$

If these requirements are satisfied, we have an integrated series of order $I(0)$. In the case of a non-stationary series, these series will often become stationary if they are differenced d times. Such a series is said to be stationary of order d (Brooks 2008: Chapter 5).

$$y_t : I(d) \leftrightarrow \Delta^d y_t : I(0)$$

Testing for stationarity

To test whether a series is stationary, one tests if the series has roots equal to, or bigger than one. The unit root test used in this thesis is the Augmented Dickey-Fuller (ADF) test. This test is an extension of the Dickey-Fuller test where a variables lagged differences are included on the right hand side of the equation. This is done to remove serial correlation to secure the white noise properties of the error term. If present, auto correlation would affect the standard errors, and make the critical values of the standard inference tests invalid. Using OLS, the Dickey Fuller-test can be applied by estimating:

$$y_t = \theta_0 + \theta_1 t + \delta y_{t-1} + \varepsilon_t. \tag{3.5}$$

In equation (3.5), the trend term may be omitted in the case of no evidence of any trend. The test could also be estimated by its augmented version:

$$\Delta y_t = \theta_0 + \theta_1 t + \omega y_{t-1} + \sum_{j=1}^{\kappa} \kappa_j \Delta y_{t-j} + \varepsilon_t, \tag{3.6}$$

where:

$$\omega = \delta - 1 \tag{3.7}$$

and κ is the number of lagged differences included in the regression.

The hypothesis is:

$H_0 : \delta = 1$ in equation (3.5) or equivalently $\omega = 0$ in equation (3.6). This is a non-stationary series.

$H_0 : \delta < 1$ in equation (3.5) or equivalently $\omega < 0$ in equation (3.6). This is a stationary series.

The test statistics for the Dickey Fuller test is given by:

$$\textit{Test Statistics} = \frac{\omega}{S.E.(\omega)}$$

This does not follow the standard t and F-distribution, therefore other critical values are applied to the ADF-test. In determining lag length, I primarily base it on the Portmanteau test of auto correlation. By including more lagged differences, the problem of auto correlation is reduced. The downside is that many lags decreases the degrees of freedom. All results of the ADF tests are reported in Appendix 2.

Testing of stationarity is important, as non-stationary series have the following characteristics (Brooks (2008) Chapter 5)

:

- Shocks have a permanent effect, and one does not return to an equilibrium
- It may give rise to spurious relationships. If two variables are unrelated, but they both follow a trend, this may lead to an estimate where the explanatory variable seems able to explain much of the variation in the dependent variable (High R^2).
- The assumption of absence of auto correlation is violated. This invalidates the standard t-tests and F-tests

3.2.2 GARCH

To estimate the conditional CAPM model I construct this econometrically in the same manner as Engle (2002) and Jakobsen and Tjelland (2012). This model is estimated using a DCC-GARCH model which makes it possible to estimate the dynamic structure of the volatility. A GARCH model assumes the condition of constant volatility in equation (2.10) is violated. To adjust for this, an ARCH model, as developed by Engle (1982) can be estimated. An ARCH (q) model estimates volatility as a function of q lagged squared error terms:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \varepsilon_t, \tag{3.8}$$

$$\{\alpha_0, \alpha_1, \ldots, \alpha_q\} > 0, \tag{3.9}$$

$$1 - \sum_{i=1}^{q} \alpha_i > 0, \tag{3.10}$$

where the constant term is positive and the q coefficients are positive, but their sum is less than one if the equation is to be given an economic interpretation. This model may be improved further by introducing a GARCH (p,q) model, developed by Bollerslev (1986). This model extends the ARCH (q) model by including p variables containing information about the size of the lagged variance:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \beta_i \sigma_{t-i}^2 + \varepsilon_t, \tag{3.11}$$

$$\{\alpha_0, \alpha_1, \ldots, \alpha_q, \beta_1, \ldots, \beta_p\} > 0, \tag{3.12}$$

$$1 - \sum_{i=1}^{q} \alpha_i - \sum_{i=1}^{p} \beta_i > 0. \tag{3.13}$$

Similar to the ARCH model, the constant and all coefficients are assumed positive, as is the sum of the coefficients, if the equation is to provide a rational economic interpretation. Assuming a GARCH (1,1) model and stationary volatility, we can set the model in equilibrium and use iteration to gain some additional insight in the way volatility is modeled:

$$\sigma_t^2 = + \frac{\alpha_0}{1 - \beta_1} + \alpha_1(\varepsilon_{t-1}^2 + \beta_1 \varepsilon_{t-2}^2 + \beta_1^2 \varepsilon_{t-3} + \ldots). \tag{3.14}$$

From equation (3.14) it is quite clear that the GARCH (1,1) model is a more parsimonious way of writing an infinite ARCH model, assuming a geometrically decaying effect of the lagged square error terms on current period volatility.

3.2.3 The Conditional CAPM using a Dynamic Conditional Correlations GARCH model

Like Jakobsen and Tjelland (2012) I construct a conditional CAPM using a DCC-GARCH model. They use daily data, arguing daily data is more volatile, and thus better at charting time varying betas. Unlike their paper, my analysis uses monthly data. The monthly data finds at least one variable significant at the 1% level for most portfolios, suggesting the series contain a sufficient amount of volatility. In addition to this, monthly data makes it easier to compare the results with the results of the unconditioned model. It may also increase the reliability of my results, as I have not found a data set on the daily risk-free rate constructed in the same way as the other variables.

I start out constructing the model as following:

$$R_{i,t+1} = \alpha_i + \varepsilon_{i,t+1}, \tag{3.15}$$

$$R_{m,t+1} = \alpha_m + \varepsilon_{m,t+1}, \tag{3.16}$$

$$\sigma^2_{i,t+1} = \gamma^i_0 + \gamma^i_1 \varepsilon^2_{i,t} + \gamma^i_2 \sigma^2_{i,t}, \tag{3.17}$$

$$\sigma^2_{m,t+1} = \gamma^m_0 + \gamma^m_1 \varepsilon^2_{m,t} + \gamma^m_2 \sigma^2_{m,t}. \tag{3.18}$$

Equation (3.15) shows the return on portfolio i at time $t+1$ as a function of a constant, α_i as well as a white noise term, ε_t , while equation (3.16) shows the same results for the estimation of the market portfolio. Equation (3.17) and (3.18) models the volatility of the portfolio returns and the market portfolio return using a GARCH (1,1) model as shown in equation (3.11). The choice of GARCH model is partly based on information criteria tests (Bayesian and Akaike), which can be found in the Appendix 3. Although the optimal specification varies depending on portfolio tested, a GARCH (1,1) portfolio is chosen as it rarely is too inferior to other specifications using the information criteria, it is theoretically interesting as it reflects both long term and short term effects of volatility (compared to a more parsimonious model), as well as being more successful in achieving convergence in the log likelihood function (compared to a less parsimonious model), thus making it easier to standardize the sample length tested for the various portfolios (although the sample length for this reason will be changed for some of the portfolios. See Appendix 3 for more information on this.)

To calculate the betas of the portfolios I find the conditional correlation between each portfolio and the market portfolio:

$$p_{in,t+1} = \frac{q_{im,t+1}}{\sqrt{q_{ii,t+1} * q_{mm,t+1}}}, \tag{3.19}$$

where the $q_{i,j,t+1}$ terms are elements of the quasi-correlation matrix[13].

13 For a more thorough explanation, see (Engle 2002)

Having found the correlation between the portfolio volatility and the market volatility at time $t+1$, $\rho_{im,t+1}$, I can estimate the covariance as:

$$\sigma_{im,t+1} = \rho_{im,t+1}\sigma_{i,t+1}\sigma_{m,t+1}. \tag{3.20}$$

This makes it possible to specify beta and write the full model as:

$$\beta_{i,t+1} = \frac{\sigma_{im,t+1}}{\sigma^2_{m,t+1}}, \tag{3.21}$$

$$\alpha_{i,t+1} = R_{i,t+1} - \beta_{i,t+1}R_{m,t+1}. \tag{3.22}$$

The alpha estimated in equation (3.22) is the average abnormal return and is the coefficient of main interest. Unlike the other models estimated in this paper it is assumed volatility itself is a factor as well as being heteroscedastic. For this reason I estimate this model using Maximum likelihood rather than OLS.

3.2.4 Estimation and testing

To estimate the CAPM and the real business cycle model I first estimate the betas in the following regression using OLS:

$$R_{i,t+1} = \alpha_0 + \sum_{i=1}^{j} \beta_{if} f_i + \varepsilon_{it}, \tag{3.23}$$

where the excess return is estimated as a function of j factors and a constant. The beta values are then used to run a cross sectional estimation using generalized method of moments (GMM):

$$r^i = \lambda_0 + \sum_{j=1}^{j} \lambda_j \beta^i_j + \varepsilon^i. \tag{3.24}$$

Equation (3.24) measures the excess return and enables me to test the price of risk parameters. The benefit of estimating equation (3.24) using GMM lies in the way it satisfies multiple moment conditions simultaneously. We are thus able to make sure the explanatory variables always have an expected error term of zero. In addition, GMM does not require the errors to be independent and identically distributed. The conditional model is estimated as shown in section 3.2.3. I then use the generated betas to calculate equation (3.24) using GMM.

All tests in this thesis will be tested at a 1%, 5% and 10% significance level. Significant findings of interest will be highlighted in bold writing.

In order to evaluate the models, I first test whether each models alpha is significantly different from zero.

$H_0 : \alpha_0 = 0,$

$H_1 : \alpha_0 \neq 0.$

If the null hypothesis is rejected for any portfolio using the t-test, there exists a pricing error, and it indicates an underspecified model. The alpha is primarily of interest in the two CAPM models, where a significant alpha is a sign of an underspecified model.

Secondly, I test whether the factors are individually significant in explaining asset return. This is done by using the t-test on the following hypotheses:

$H_0 : \beta_j = 0,$

$H_1 : \beta_j \neq 0.$

Likewise I test whether the factors are priced with a t-test on the following hypotheses:

$H_0 : \lambda_j = 0,$

$H_1 : \lambda_j \neq 0.$

If the β_j is significantly deviating from zero, we reject the null-hypothesis of the factor not being able to explain asset return. If λ_j is significantly different from zero there is evidence of the factor being a priced risk.

I lastly use an F-test to test the joint significance of the variables in all estimated models as well as the joint significance of the real business cycle variables. The joint significance of the real business cycle variables will be tested by comparing the test results of the real business cycle model with an estimation of the same periods including only the EMR variable:

$H_0: \beta_1 = \beta_2 = \ldots = \beta_q = 0,$

$H_1: \beta_1 \neq \beta_2 \neq \ldots \neq \beta_q \neq 0.$

The results of the F-test of joint significance of the real business cycle variables are presented in Appendix 3.

This paper uses a multiple of test portfolios to test whether there are differences in how to model excess stock market return in two different periods. For this reason I retrieve information on many alphas and factor-coefficients. Testing the same coefficients and alphas on the same model may yield results where the significance depends on the portfolio used. This makes it possible to judge a model based on the number of anomalies.

4 Empirical results

4.1 Descriptive statistics: The Carhart factors

Panel 4.1 presents the value of the high-minus-low, small-minus-big, momentum and excess market return (equally- and value weighted) variables graphically. Below is the descriptive statistics for the variables, calculated separately for each period.

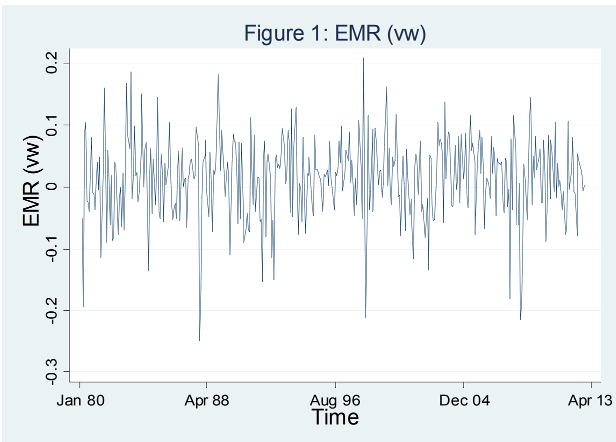


Figure 1: EMR (vw)

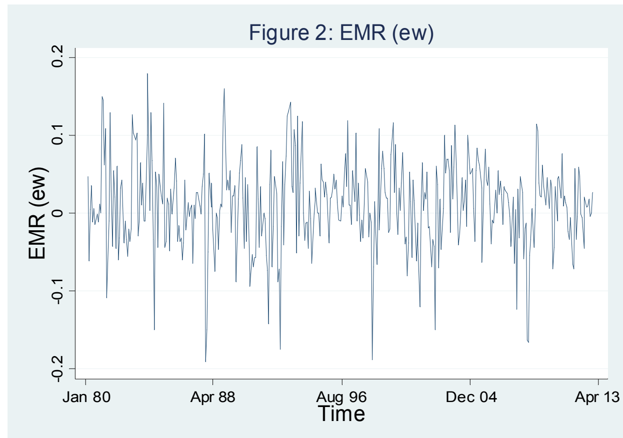


Figure 2: EMR (ew)

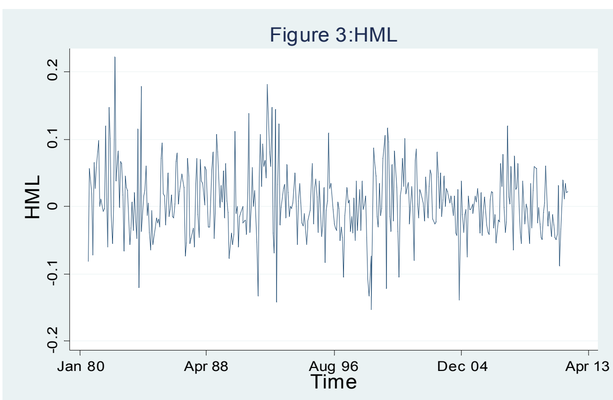


Figure 3:HML

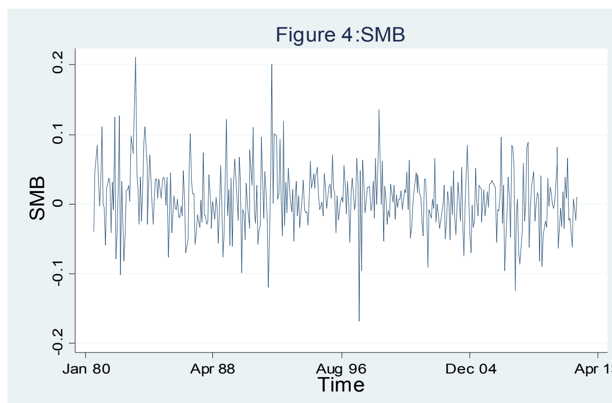


Figure 4:SMB

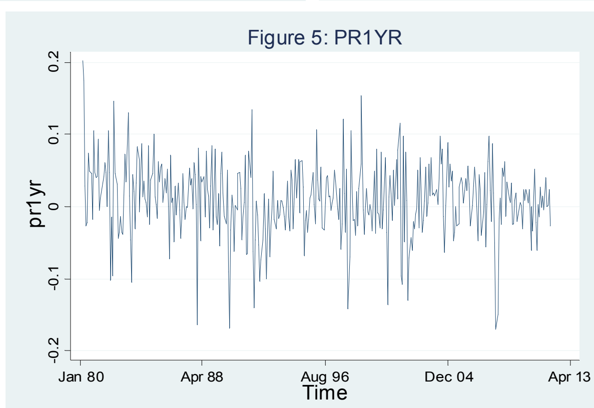


Figure 5: PR1YR

Table 1: Descriptive statistics: The Carhart factors						
variable	Mean	std. dev.	Min	Max	sample	N
EMR (vw)	0.0110	0.067	-0.249	0.186	Feb 80 - Jun 96	197
EMR (ew)	0.0108	0.061	-0.190	0.180	Feb 80 - Jun 96	197
EMR (vw)	0.0156	0.063	-0.215	0.209	Jul 96 - Dec 12	198
EMR (ew)	0.0104	0.051	-0.188	0.120	Jul 96 - Dec 12	198
SMB	0.0118	0.050	-0.119	0.211	Jul 80 - Jun 96	192
HML	0.0134	0.058	-0.143	0.222	Jul 80 - Jun 96	192
PR1YR	0.0107	0.054	-0.168	0.203	Jan 80 - Jun 96	197
SMB	0.0026	0.043	-0.167	0.136	Jul 96 - Dec 11	186
HML	-0.0006	0.047	-0.153	0.120	Jul 96 - Dec 11	186
PR1YR	0.0065	0.049	-0.169	0.154	Jul 96 - Dec 11	186

As expected, the mean for EMR is large and positive for all periods. This is an indication that the market risk affects the expected return, assuming no other variables or a constant is capable of explaining the positive mean excess return. Despite this, the standard error is large compared to the mean, reflecting the large volatility of the series.

The mean of the Carhart factors are positive and of roughly the same size as the EMR factor in the first period, while the mean is closer to zero in the second period. A different mean in the two periods could imply differences in how relevant the factor is in an asset pricing model. This depends on how the factors covary with the EMR factor in the two periods. The standard error of the Carhart factors are large compared to their mean, reflecting the large volatility of these factors as well.

4.2 Test results: the CAPM

4.2.1 The unconditional CAPM

Panel 4.2: Estimation of the CAPM using portfolios sorted by industry, size, book-to-market and momentum.

The results using equally weighted portfolios are shown at the left hand side, while the right hand side shows the results using value weighted portfolios. The price of risk parameters are divided into groups of four, divided on whether the betas are generated from the first period (Feb 80/Jan 81 – Jun 96) or the second period (Jul 96 – Dec 12) and whether they are found using equally or value weighted portfolios.

Table 2: CAPM estimations								
B/M sorted portfolios (1st period) (ew)					(vw)			
	constant	p-value	Coefficient	p-value	constant	p-value	Coefficient	p-value
1(low)	0.00108	0.851	1.02	0	0.00464	0.379	0.90	0
2	-0.00009	0.980	1.05	0	0.00969	0.182	0.83	0
3	-0.00337	0.262	1.00	0	-0.00650	0.102	0.90	0
4	**-0.00855**	0.022	0.95	0	-0.00084	0.821	0.97	0
5	0.00219	0.552	0.92	0	0.00107	0.813	1.06	0
6	-0.00086	0.839	1.08	0	0.00185	0.678	1.01	0
7	0.00115	0.734	1.05	0	0.00538	0.235	1.06	0
8	0.00138	0.718	1.23	0	0.00635	0.150	1.20	0
9	**0.00884**	0.017	1.11	0	0.00878	0.177	1.31	0
10(high)	**0.01092**	0.043	1.11	0	**0.01544**	0.001	1.07	0
	(2nd period) (ew)				(vw)			
1(low)	-0.00351	0.289	1.29	0	0.00330	0.434	1.02	0
2	-0.00286	0.402	1.35	0	0.00313	0.616	0.96	0
3	-0.00042	0.861	1.04	0	-0.00490	0.173	0.82	0
4	0.00103	0.689	0.98	0	0.00012	0.972	0.96	0
5	-0.00055	0.778	1.09	0	-0.00147	0.649	1.00	0
6	-0.00281	0.228	0.94	0	-0.00297	0.430	1.00	0
7	**0.00500**	0.052	1.00	0	0.00346	0.371	0.94	0
8	0.00232	0.272	0.89	0	-0.00001	0.998	1.07	0
9	0.00139	0.534	0.83	0	**0.00754**	0.056	0.83	0
10(high)	0.00189	0.448	0.65	0	0.00642	0.174	0.76	0

Table 2: CAPM estimations								
momentum sorted portfolios (1st period) (ew)					(vw)			
	constant	p-value	Coefficient	p-value	constant	p-value	Coefficient	p-value
1(low)	-0.00395	0.254	1.03	0	-0.00226	0.593	0.90	0
2	0.00404	0.354	1.04	0	**0.01091**	0.073	1.03	0
3	-0.00269	0.407	1.01	0	-0.00309	0.419	0.85	0
4	0.00150	0.646	1.06	0	0.00162	0.658	0.87	0
5	-0.00154	0.534	0.91	0	-0.00100	0.758	0.90	0
6	-0.00135	0.649	0.89	0	0.00089	0.772	0.94	0
7	-0.00039	0.876	0.92	0	0.00354	0.231	0.84	0
8	-0.00339	0.123	0.88	0	-0.00276	0.328	0.88	0
9	0.00197	0.533	1.05	0	-0.00245	0.476	0.99	0
10(high)	**0.00610**	0.074	1.01	0	**0.00702**	0.074	0.95	0
	(2nd period) (ew)				(vw)			
1(low)	0.00283	0.366	1.09	0	**0.01404**	0.007	1.00	0
2	-0.00019	0.954	1.32	0	0.00075	0.893	1.06	0
3	0.00127	0.573	0.93	0	0.00627	0.116	0.85	0
4	**-0.00591**	0.003	0.81	0	**-0.00725**	0.053	0.84	0
5	-0.00201	0.343	0.87	0	0.00022	0.946	0.83	0
6	-0.00108	0.504	0.81	0	0.00145	0.657	0.84	0
7	0.00049	0.822	0.79	0	-0.00262	0.486	0.83	0
8	0.00177	0.373	0.82	0	0.00028	0.914	0.80	0
9	0.00120	0.546	1.18	0	-0.00118	0.746	0.93	0
10(high)	0.00238	0.385	1.30	0	**-0.00678**	0.014	1.06	0

Table 2: CAPM estimations								
industry sorted portfolios (1st period) (ew)					(vw)			
	constant	p-value	Coefficient	p-value	constant	p-value	Coefficient	p-value
energy	0.00068	0.842	1.25	0	-0.00117	0.717	1.10	0
materials	0.00345	0.359	1.16	0	0.00260	0.492	1.12	0
industrials	0.00007	0.970	1.01	0	-0.00307	0.168	1.11	0
Con. Disc.	0.00317	0.334	0.90	0	**0.01051**	0.028	0.81	0
Con. Stapl.	**0.00781**	0.017	0.71	0	**0.00972**	0.007	0.77	0
health	0.00336	0.532	0.72	0	0.00605	0.297	0.79	0
financials	-0.00271	0.253	0.79	0	0.00053	0.838	0.68	0
IT	**-0.01385**	0.003	0.95	0	-0.00376	0.441	0.85	0
	(2nd period) (ew)				(vw)			
energy	0.00164	0.485	1.32	0	-0.00288	0.183	0.96	0
materials	0.00630	0.144	0.82	0	-0.00056	0.906	0.61	0
industrials	-0.00033	0.842	0.96	0	-0.00177	0.549	0.94	0
Con. Disc.	-0.00154	0.629	0.95	0	-0.00235	0.697	1.03	0
Con. Stapl.	-0.00170	0.587	1.02	0	-0.00166	0.618	0.9	0
health	0.00277	0.762	1.14	0	-0.00506	0.232	0.66	0
financials	-0.00035	0.806	0.62	0	-0.00127	0.704	0.77	0
IT	-0.00313	0.429	1.39	0	-0.00539	0.362	1.24	0

Table 2: CAPM estimations				
size sorted portfolios (1st period) (ew)				
	constant	p-value	coefficient	p-value
1(low)	**0.02254**	0.000	1.06	0
2	**0.01038**	0.001	0.94	0
3	-0.00346	0.287	1.06	0
4	-0.00341	0.286	1.06	0
5	0.00028	0.936	0.98	0
6	-0.00063	0.835	0.94	0
7	**-0.00651**	0.049	1.07	0
8	**-0.00613**	0.035	0.99	0
9	**-0.00559**	0.082	1.11	0
10(high)	**-0.00827**	0.020	0.84	0
(2nd period) (ew)				
1(low)	**0.00492**	0.014	0.47	0
2	0.00213	0.417	0.83	0
3	0.00290	0.201	0.87	0
4	0.00030	0.911	0.93	0
5	**0.00427**	0.077	1.01	0
6	0.00123	0.573	1.03	0
7	-0.00159	0.430	1.09	0
8	-0.00024	0.919	1.14	0
9	**-0.00887**	0.000	1.29	0
10(high)	-0.00260	0.552	1.21	0

Table 3: Price of Risk: CAPM		
Price of risk CAPM		
	price of risk	p-value
per1vw	0.015393	**0**
per2vw	0.016227	**0**
per1ew	0.011899	**0**
per2ew	0.010394	**0**

Panel 4.2 presents the test results of the CAPM estimations for the two periods. The findings are similar to previous research as I find only weak evidence of the CAPM being rejected, as it could possibly be underspecified. As predicted by the CAPM, I reject the null-hypothesis of a zero beta coefficient at the 1% significance level for all portfolios. The beta-exposure is also found to be a price of risk at a 1% significance level for all estimations.

B/M-portfolios: In the first period I find a positive alpha for the 10th value weighted portfolio at the 1% significance level as well as a positive constant on the 9th and 10th equally weighted portfolios, both at a 5% significance level. This is weak evidence of a B/M-effect in the first period, where a high B/M-ratio is associated with higher return. In the second period we find a positive constant for both the 9th value weighted portfolio and 7th equally weighted portfolio using a 10% significance level. The results from the second period indicate a weaker B/M-effect compared to the first period, although it is weak in the first period as well.

It could be argued the results are not sensitive to time, as there is a minor return premium connected to stocks with a high B/M ratio in both periods. More importantly, the B/M effect is small in both periods. The relatively stronger effect of B/M-ratio on asset return in the first period could be used as evidence against B/M affecting asset return similarly regardless of period tested. In addition to the previously mentioned anomalies, the 4th equally weighted portfolio in the first period show a negative abnormal return at a 5% significance level.

Momentum portfolios: In the first period I find a positive abnormal return for the 2nd and 10th ranked value weighted portfolios using a 1% significance level. The 10th equally weighted portfolio shows a positive abnormal return, while the 8th shows a negative abnormal return, both at a 10% significance level. This indicates at best weak signs of a momentum effect in the first period. In the second period I find a positive abnormal return on 1st ranked value weighted portfolio and a negative abnormal return for the 4th ranked portfolio using both equally and value weighted portfolios, all at a 5% significance level. The results in the second period do not provide evidence of a momentum effect.

These findings are similar as the results using the B/M portfolios, although a pattern is more difficult to detect. It could be argued the relevance of momentum is somewhat period specific as a very minor momentum effect is seen in the first period. The total number of anomalies suggests asset return is robust in terms of the effect of momentum on asset return, as it is small in both periods.

Industry portfolios: In the first period the consumer staples sector is found to have a positive abnormal return at a 1% significance level using both equally and value weighted portfolios. In addition the IT-sector is found to have a positive abnormal return using equally weighted portfolios at the 10% significance level. I find no evidence of abnormal return in the second period. I have therefore found some evidence against stability in how industry sectors affect asset return, as the consumer staples sector (and to a smaller extent the IT sector) has a positive abnormal return which does not persist in the second period. Besides the consumer staples sector, I do not find strong evidence of industry effects in either period.

Size portfolios: Using the equally weighted size portfolios I find evidence of smaller firms achieving higher returns in the first period. The two smallest decile size portfolios achieve a positive abnormal return, finding the alpha to be non-zero using a 1% significance level. Likewise, I find the four portfolios with largest stocks having a negative abnormal return, as I reject the null-hypothesis of zero abnormal return at the 5% level for the 7th, 8th and 10th decile portfolios, and a 10% significance level for the 9th ranked portfolio. The positive abnormal return seems to be strong and concentrated among the smallest stocks, while a bigger group of large stocks have a minor negative abnormal return. In the second period I find weaker evidence of a size effect. In addition to finding the 5th decile portfolio to have a positive abnormal return at the 10% level, I find the 1st decile portfolio to have a positive return using a 5% significance level, and the 9th decile portfolio to have a negative return at the 1% level. This could be viewed as evidence of a size effect. Although the direction and existence of the effect seems to not depend on period tested, the impact of the effect is stronger in the first period.

Conclusion: In total, I only find weak evidence of anomalies in the CAPM. For both periods, there seems to be a premium connected to small size. In addition, it could be argued a very small premium is connected to a high B/M ratio and momentum stocks in the first period. Evidence against asset return being robust include a premium connected to some industry portfolios in the first period, and not the second period, as well as the declining impact of in particular size, but also B/M-ratio and momentum in the second period. In aggregate I do however find fairly robust results testing for the Carhart and industry factors. I also find the EMR variable to be robust in respect to its ability to price risk, rejecting the null-hypothesis of EMR having zero effect on pricing an asset at the 1% significance level for the both the equally- and value weighted portfolios in both periods, finding the risk premium to have a fairly similar impact in both periods, showing a higher beta is reflected in higher expected return.

Theoretical interpretation: As the impact of the B/M and momentum are weak, it could be argued they do not reflect risk in the Norwegian stock market or that investors in the Norwegian stock market do not have a psychological bias in regards to these two factors. It could also be used as evidence that these two effects are likely to be there as a result of an in sample chance. The size factor could be slightly valued among investors in the Norwegian stock market, although it is unclear why this would decline in effect in the second period. It appears to be too strong for an in- sample chance, but it could be argued a changed psychological bias explains the decline in this effect, as well as the minor decline in the momentum and B/M effects.

4.2.2 The DCC-GARCH CAPM

Panel 4.3: Estimation of the conditional CAPM using portfolios sorted by industry, size, book-to-market and momentum.

The results using equally weighted portfolios are shown at the left hand side, while the right hand side shows the results using value weighted portfolios. The price of risk parameters are divided into groups of four, divided on whether the betas are generated from the first period (Feb 80/Jan 81 – Jun 96) or the second period (Jul 96 – Dec 12) and whether they are found using equally or value weighted portfolios.

Table 4: DCC-GARCH CAPM estimations								
	B/M sorted portfolios (1st period) (ew)				(vw)			
	constant	p-value	Coefficient	p-value	constant	p-value	Coefficient	p-value
1(low)	0.00195	0.660	0.82	0	0.00293	0.511	0.84	0
2	0.00207	0.467	1.04	0	-0.00477	0.217	0.83	0
3	**-0.00914**	0.001	0.94	0	**-0.00601**	0.058	1.10	0
4	-0.00823	0.027	0.95	0	-0.00070	0.842	0.98	0
5	0.00196	0.587	0.92	0	0.00190	0.635	1.01	0
6	-0.00218	0.404	1.01	0	0.00165	0.716	0.99	0
7	0.00130	0.703	1.04	0	0.00515	0.246	1.06	0
8	0.00725	0.040	1.12	0	**0.00948**	0.014	1.10	0
9	0.00724	0.047	1.08	0	0.00615	0.268	1.31	0
10(high)	0.01024	0.044	1.05	0	**0.01405**	0.001	1.04	0
	(2nd period) (ew)				(vw)			
1(low)	-0.00036	0.893	1.13	0	0.00381	0.39	0.99	0
2	-0.00436	0.161	1.32	0	0.00169	0.794	0.97	0
3	0.00189	0.468	1.03	0	-0.00019	0.945	0.72	0
4	0.00123	0.636	0.99	0	0.00281	0.319	0.93	0
5	-0.00068	0.742	1.08	0	-0.00152	0.617	1.02	0
6	-0.00242	0.279	0.95	0	-0.00321	0.34	1.00	0
7	**0.00457**	0.068	1.01	0	0.00386	0.313	0.92	0
8	0.00235	0.261	0.90	0	0.00180	0.636	0.96	0
9	0.00156	0.492	0.84	0	**0.00747**	0.058	0.83	0
10(high)	0.00243	0.301	0.62	0	0.00166	0.712	0.63	0

Table 4: DCC-GARCH CAPM estimations								
momentum sorted portfolios (1st period) (ew)					(vw)			
	constant	p-value	Coefficient	p-value	constant	p-value	Coefficient	p-value
1(low)	-0.00395	0.254	1.03	0	-0.00226	0.593	0.90	0
2	0.00404	0.354	1.04	0	**0.01091**	0.073	1.03	0
3	-0.00269	0.407	1.01	0	-0.00309	0.419	0.85	0
4	0.00150	0.646	1.06	0	0.00162	0.658	0.87	0
5	-0.00154	0.534	0.91	0	-0.00100	0.758	0.90	0
6	-0.00135	0.649	0.89	0	0.00089	0.772	0.94	0
7	-0.00039	0.876	0.92	0	0.00354	0.231	0.84	0
8	-0.00339	0.123	0.88	0	-0.00276	0.328	0.88	0
9	0.00197	0.533	1.05	0	-0.00245	0.476	0.99	0
10(high)	**0.00610**	0.074	1.01	0	**0.00702**	0.074	0.95	0
	(2nd period) (ew)				(vw)			
1(low)	0.00283	0.366	1.09	0	**0.01404**	0.007	1.00	0
2	-0.00019	0.954	1.32	0	0.00075	0.893	1.06	0
3	0.00127	0.573	0.93	0	0.00627	0.116	0.85	0
4	**-0.00591**	0.003	0.81	0	**-0.00725**	0.053	0.84	0
5	-0.00201	0.343	0.87	0	0.00022	0.946	0.83	0
6	-0.00108	0.504	0.81	0	0.00145	0.657	0.84	0
7	0.00049	0.822	0.79	0	-0.00262	0.486	0.83	0
8	0.00177	0.373	0.82	0	0.00028	0.914	0.80	0
9	0.00120	0.546	1.18	0	-0.00118	0.746	0.93	0
10(high)	0.00238	0.385	1.30	0	**-0.00678**	0.014	1.06	0

Table 4: DCC-GARCH CAPM estimations								
industry sorted portfolios (1st period) (ew)					(vw)			
	constant	p-value	Coefficient	p-value	constant	p-value	Coefficient	p-value
Energy	0.00068	0.842	1.25	0	-0.00117	0.717	1.10	0
Materials	0.00345	0.359	1.16	0	0.00260	0.492	1.12	0
Industrials	0.00007	0.970	1.01	0	-0.00307	0.168	1.11	0
Con. Disc.	0.00317	0.334	0.90	0	**0.01051**	0.028	0.81	0
Con. Stapl.	**0.00781**	0.017	0.71	0	**0.00972**	0.007	0.77	0
Health	0.00336	0.532	0.72	0	0.00605	0.297	0.79	0
Financials	-0.00271	0.253	0.79	0	0.00053	0.838	0.68	0
IT	**-0.01385**	0.003	0.95	0	-0.00376	0.441	0.85	0
(2nd period) (ew)					(vw)			
Energy	0.00164	0.485	1.32	0	-0.00288	0.183	0.96	0
Materials	0.00630	0.144	0.82	0	-0.00056	0.906	0.61	0
Industrials	-0.00033	0.842	0.96	0	-0.00177	0.549	0.94	0
Con. Disc.	-0.00154	0.629	0.95	0	-0.00235	0.697	1.03	0
Con. Stapl.	-0.00170	0.587	1.02	0	-0.00166	0.618	0.90	0
Health	0.00277	0.762	1.14	0	-0.00506	0.232	0.66	0
Financials	-0.00035	0.806	0.62	0	-0.00127	0.704	0.77	0
IT	-0.00313	0.429	1.39	0	-0.00539	0.362	1.24	0

Table 4: DCC-GARCH CAPM estimations				
size sorted portfolios (1st period) (ew)				
	constant	p-value	coefficient	p-value
1(low)	**0.02337**	0.00	1.07	0
2	**0.00955**	0.011	0.92	0
3	-0.00198	0.446	0.97	0
4	-0.00277	0.404	1.10	0
5	-0.00107	0.644	0.86	0
6	-0.00273	0.313	0.91	0
7	-0.00367	0.144	1.09	0
8	**-0.00700**	0.005	0.97	0
9	**-0.00487**	0.072	1.10	0
10(high)	**-0.00629**	0.061	0.86	0
2nd period (ew)				
1(low)	**0.00435**	0.025	0.46	0
2	0.00057	0.826	0.82	0
3	0.00290	0.154	0.85	0
4	-0.00021	0.935	0.89	0
5	**0.00587**	0.004	0.93	0
6	0.00270	0.230	0.98	0
7	-0.00176	0.388	1.09	0
8	-0.00144	0.511	1.12	0
9	**-0.00748**	0.00	1.31	0
10(high)	-0.00196	0.654	1.18	0

Table 5: Price of Risk: CCAPM		
Price of risk ccapm		
	price of risk	p-value
per1vw	0.015719	**0**
per2vw	0.017525	**0**
per1ew	0.012224	**0**
per2ew	0.010655	**0**

Panel 4.3 presents the results of the estimations of the conditional CAPM for the two periods. The EMR variable is significant at the 1% significance level both in terms of explaining realized returns and in being a priced risk factor regardless of portfolio or period tested. By calculating the beta in this manner we are able to detect some effects more easily.

B/M-portfolios: In the first period I find evidence of a B/M-effect. Using value weighted portfolios, the 3rd decile portfolio gives an abnormal negative return at the 10% level, while the 8th and the 10th decile portfolios are positive and significant at the 5%- and 1% level. The results are similar using the equally weighted portfolios, finding a negative abnormal return on the 3rd and 4th decile portfolios using a 1- and 5% significance level, while a positive abnormal return is found for the 8th, 9th and 10th decile portfolios, all at the 5% significance level. This is stronger evidence of a B/M-effect than that detected with the traditional CAPM. In the second period I find a positive abnormal return for the 7th equally weighted portfolio and the 9th value weighted portfolio, both using a 10% significance level. As with the unconditional model, I fail to find evidence of a B/M-effect in the 2nd period. Assuming the DCC-GARCH estimation I performed is an accurate calculation of the beta, it could be argued asset return is sensitive to the period tested in terms of the B/M effect as it disappears after the first period.

Momentum portfolios: Using momentum portfolios we now reject the null-hypothesis of zero abnormal return for the 10th decile portfolio, finding a positive abnormal return using both equally- and value weighted portfolios in the first period at a 10% significance level. In addition the 2nd value weighted decile portfolio shows a positive abnormal return using a 10% significance level. In other words, momentum appears to not be a relevant factor in the first period. The second period shows some anomalies using value weighted portfolios. The 1st decile portfolio shows a positive abnormal return, while the 10th decile portfolios show negative abnormal return, having rejected the null-hypothesis at the 1%- and 5% level. In addition to this, the 4th decile portfolio is negative, both using value- and equally weighted portfolios, using a significance level of 10- and 1%. These findings are an indication of a minor reversal effect in the second period, which is not registered in the first period, indicating Norwegian asset return is not robust in terms of how it is affected by momentum. Furthermore, it is worth noting the deviations are not too far from zero, indicating the effect to be minor.

Industry portfolios: Using value weighted industry portfolios I find the CAPM not to be robust in terms of premiums connected to a stocks industry sector. In the first period I find a positive abnormal return for both the consumer discretionary and consumer staples sectors, rejecting the null-hypothesis of zero abnormal return at the 5- and 1% significance level. In the second period I find no evidence of industry effects. Using equally weighted portfolios; the results for the first period show a positive abnormal return for the consumer staples sector, and a negative for IT, at the 5- and 1% significance level, while no anomalies are detected in the second period. A possible interpretation is that investors in the first period kept being too pessimistic or optimistic in terms of a stocks return if it was in the consumer staples or consumer discretionary sectors, but that such views largely have been adjusted for in the second period.

Size portfolios: The results using size portfolios are very similar to the one found in the unconditional model. I find evidence of smaller stocks having higher returns in the first period, rejecting the null-hypothesis at a 1- and 5% significance level finding the 1st and 2nd decile portfolio giving a positive abnormal return, while the 8th decile portfolio gives a negative abnormal return. In addition the 9th and 10th decile portfolios have a negative abnormal return using a 10% significance level. In the second period I find the 5th decile portfolio to be positive and significant at the 1% level, although it is difficult finding any economic explanation for this result. The 1st decile portfolio has a positive alpha, rejecting the null-hypothesis with a 5% significance level, while the 9th decile portfolio has a negative alpha rejected at the 1% level. My findings suggest a conditional model is incapable of explaining the small size effect, which exists and influence stock return in the same direction in all periods, but has a larger impact in the first period.

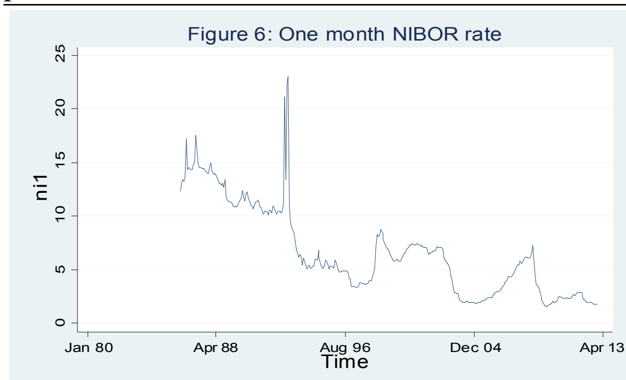
Conclusion: Using a DCC-GARCH (1,1) model to estimate the beta I have found some evidence against the hypothesis that relevant factors explaining Norwegian asset return is independent of period tested. In the first period I find some evidence of a B/M and industry effect, and no momentum effect. In the second period I find some evidence of a reversal effect, but little evidence of B/M or industry effects. It should be noted the reversal effect is weak. In terms of the size portfolios, I find stronger evidence of a size effect in the first period compared to the second period, although the direction of this effect is the same in both periods. Although this can be viewed as evidence against CAPM (assuming this way of calculating beta is correct), it is worth noting none of the effects are dominating nearly as much as the EMR variable, thus they can be viewed as robust in terms of having a minor impact. The market is also robust in regards to the price of market risk being significantly priced, having rejected the null-hypothesis of a zero coefficient on price of market is rejected at the 1% significance level for both periods using both equally- and value weighted portfolios. The findings unsurprisingly show a higher expected return the higher the portfolios beta is.

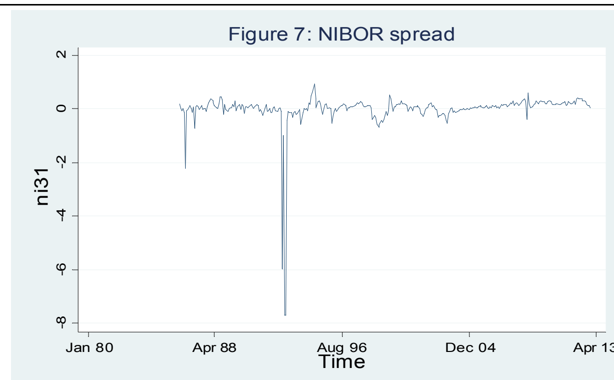
Theoretical interpretation: Besides EMR, size is the only factor which appears to be a risk variable in both periods. A behaviorist explanation could be able to explain the changed (declining) effect of B/M, size and arguably momentum. The momentum effect could be explained by an in sample chance, while both the B/M effect in the first period as well as the size effect appears strong, reducing the probability of it being a result of statistical chance.

4.3 Descriptive statistics: Real business cycle variables

In this section I present descriptive data on the real business cycle variables. I use these variables as explanatory variables, as I regress them on the excess portfolio return of the same period. The effect of these real business cycle variables could be through an assets stochastic discount rate or it could be through the company's cash flow.

Panel 4.4 presents the value of the credit spread, term rate and the term spread variables graphically. Below is the descriptive statistics for the variables, calculated separately for each period.





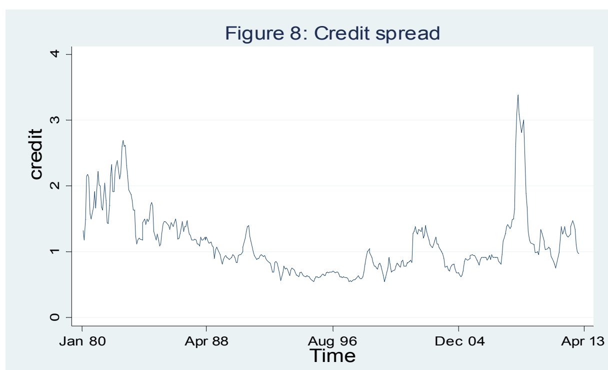


Table 6: Descriptive statistics: The real business cycle factors						
Variable	Mean	std. dev.	min	max	Sample	N
Credit	0.940079	0.25742	0.55	1.5	Dec 85 - Jun 96	127
ni1	10.55496	3.88373	4.78	23.09	Dec 85 - Jun 96	127
ni31	-0.155535	1.13215	-7.67318	0.9419	Dec 85 - Jun 96	127
Credit	1.034798	0.47037	0.55	3.38	Jul 96 - Dec 12	198
ni1	4.28298	2.04883	1.61	8.79	Jul 96 - Dec 13	198
ni31	0.080073	0.20253	-0.668	0.5885	Jul 96 - Dec 14	198

4.3.1 The Credit spread

The development of the credit spread is found by subtracting the return on Aaa rated bonds with that of Baa rated bonds and is shown graphically in figure 8. Aaa rated bonds are assumed to be the most secure investments, while Baa rated bonds have medium security and are classified in the group just above junk bonds (Berk and DeMarzo 2007: Chapter 8). In periods of uncertainty it could be assumed the credit spread would increase, as the "risk free" Aaa rated bonds are assumed to stay risk free, while the Baa rated bonds become more insecure (and thus require a larger premium) in bad times. This spread may be viewed as a real business cycle variable measuring the possibility of large downside economic risk. The spread is characterized by stability and smooth changes, except a rapid increase and then decline around the financial crisis. I fail to reject the null-hypothesis of no stationarity at the 10% significance level in the 2nd period. Although the US credit spread increased during adverse periods in the Norwegian economy, this effect may be exaggerated as the Norwegian economy was arguably less affected by the financial crisis. Beyond this, it is difficult saying both how appropriate the minor deviations in the remaining periods are for the Norwegian stock market and how strong its correlation between a similar data series, using Norwegian data to capture the same effects in Norway would be. All values of the credit spread takes on positive values. The higher a portfolios credit beta is, the higher (lower) they will have in return in bad (good) periods. Assuming a time varying stochastic discount factor we would assume the price of risk to be negative, meaning portfolios which have a higher (lower) return in periods of high downside risk are expected to have a lower (higher) return in the long run.

4.3.2 Previous return

Lagged EMR (see panel 4.1) reflect information on the current real business cycle by taking into account on how the real business cycle were, as measured through its effect on the EMR, at the beginning of the holding period. As seen earlier the development of both measures of excess market return is fairly stable over both periods. Assuming periods of low (high) excess return reflects negative (positive) news about the real business cycle in the next period, we would expect portfolios with a high (low) beta to have a higher (lower) return in periods of a good (bad) state of the economy. For this reason, the price of risk parameter could be assumed to be positive.

4.3.3 The one month NIBOR rate

The value of the one month NIBOR rate may reflect the real business cycle as it is likely to reflect both the federal interest rate and the downside risk in the banking sector. The dynamic relationship between the real business cycle and interest rate setting in addition to the complexity in how the interest rate is set, and the importance of possible downside risk in the banking sector makes it difficult to explain which exact part of the real business cycle it reflects.

Graphically we see a downward trend in the NIBOR rate in time, reflecting different inflation rates and interest regimes. The trend effect appears not as strong within the two sub samples. The first period is characterized by a downward trend interrupted by a sharp increase and then a decline in the NIBOR rate late in the period. The second period is characterized by sharp plateau shifts which ideally reflect the state of the economy. It is worth emphasizing the term rate failed to have its null-hypothesis rejected at the 10% significance level in the second period, indicating non-stationarity. If the real interest rate is the main factor in stimulating the economy, this would suggest the analysis could be strengthened by either using inflation adjusted data or by adjusting the data for regime changes.

4.3.4 The difference between the one- and the three month NIBOR rate

The term spread is found by taking the three month NIBOR rate and then subtracting this by the one month NIBOR rate. This spread is likely to reflect information on the future development of the economy. As with the one month NIBOR variable, there is ambiguity in which parts of the real business cycle it reflects. Some have noted an inverted yield curve, where the short term rate is higher than the long term rate, is an indicator of recession (Wright 2006), although this effect may be more detectable when including a term rate for a longer time horizon. Graphically the variable is characterized by rapid shifts and a period of large deviation where the one month NIBOR rate was substantially larger than the three month rate. This variable most likely reflect adjustments to the expectation of the future state of the economy, as it includes forward looking variables and tend to fluctuate a lot.

4.4 Test results using the real business cycle model

Panel 4.5: Estimation of the real business cycle model using portfolios sorted by industry, book-to-market and momentum.

The results using equally weighted portfolios are shown above the results using value weighted portfolios. The results from the first period (Dec 1985 – Jun 96) are shown in the upper halves of the tables while the results from the second period (Jul 96 – Dec 2012) are shown on the bottom halves of the tables. The price of risk parameters are divided into groups of four, divided on whether the betas are generated from the first period or the second period and whether they are found using equally or value weighted portfolios.

Table 7: Real business cycle model estimations												
	B/M sorted portfolios (equally weighted)											
	constant	p-value	beta (-1)	p-value	Beta	p-value	ni31	p-value	ni1	p-value	credit	p-value
1(low)	0.01803	0.294	0.0302	0.692	0.69	0.000	-0.00483	0.415	-0.00320	0.199	0.0126	0.705
2	0.01460	0.266	-0.0261	0.655	0.84	0.000	**0.00800**	0.078	**0.00384**	0.044	**-0.0554**	0.030
3	-0.02257	0.066	-0.0671	0.217	0.98	0.000	0.00133	0.752	0.00265	0.135	-0.0093	0.694
4	-0.01138	0.510	-0.0031	0.968	0.88	0.000	-0.00543	0.362	**-0.00464**	0.065	0.0522	0.120
5	-0.01002	0.556	**-0.1671**	0.029	1.00	0.000	-0.00239	0.683	-0.00155	0.529	0.0306	0.353
6	-0.01471	0.501	0.0372	0.702	1.17	0.000	**-0.01376**	0.069	**-0.00562**	0.077	**0.0785**	0.065
7	-0.00343	0.820	0.0004	0.996	0.99	0.000	0.00834	0.112	0.00184	0.402	-0.0159	0.586
8	-0.03170	0.085	-0.1292	0.114	1.38	0.000	-0.00560	0.376	-0.00170	0.521	0.0543	0.127
9	0.01224	0.460	0.0407	0.580	1.22	0.000	0.00802	0.161	0.00291	0.225	-0.0343	0.285
10(high)	0.01682	0.541	0.0406	0.740	1.12	0.000	-0.00339	0.721	0.00108	0.786	-0.0190	0.721
1(low)	-0.01415	0.263	-0.0866	0.212	1.35	0.000	**0.03349**	0.065	0.00311	0.102	-0.0050	0.488
2	-0.01713	0.191	-0.0265	0.711	1.40	0.000	0.01438	0.441	**0.00416**	0.035	-0.0048	0.517
3	0.00569	0.536	**-0.0972**	0.054	1.05	0.000	0.00864	0.510	-0.00216	0.118	0.0032	0.535
4	-0.00994	0.319	0.0472	0.387	0.99	0.000	0.01514	0.288	0.00082	0.582	0.0055	0.330
5	0.01229	0.100	**-0.0913**	0.026	1.09	0.000	**-0.03120**	0.004	-0.00141	0.207	-0.0033	0.441
6	0.00197	0.828	-0.0123	0.804	0.94	0.000	-0.00107	0.934	-0.00042	0.757	-0.0026	0.609
7	-0.00447	0.648	0.0149	0.782	1.01	0.000	**-0.02393**	0.089	0.00010	0.949	**0.0104**	0.061
8	-0.00142	0.861	**0.0830**	0.062	0.86	0.000	-0.00995	0.389	-0.00072	0.554	0.0068	0.138
9	-0.01141	0.177	**0.1208**	0.010	0.81	0.000	-0.00791	0.512	-0.00021	0.867	**0.0129**	0.007
10(high)	0.01052	0.261	0.0933	0.070	0.60	0.000	**-0.03428**	0.011	-0.00092	0.511	-0.0023	0.665

Table 7: Real business cycle model estimations												
	B/M sorted portfolios (value weighted)											
	constant	p-value	beta (-1)	p-value	Beta	p-value	ni31	p-value	ni1	p-value	credit	p-value
1(low)	-0.00191	0.920	-0.0475	0.537	0.76	0.000	-0.00345	0.608	**-0.00487**	0.086	0.0601	0.111
2	0.02641	0.143	**-0.1647**	0.025	0.81	0.000	-0.00509	0.424	**0.00467**	0.081	**-0.0804**	0.025
3	-0.01333	0.377	0.0257	0.674	1.07	0.000	0.00112	0.834	0.00052	0.815	0.0041	0.891
4	0.00245	0.888	0.0464	0.510	0.94	0.000	-0.00032	0.958	-0.00131	0.612	0.0123	0.720
5	0.00458	0.801	-0.1013	0.169	1.10	0.000	0.00095	0.883	0.00284	0.291	-0.0365	0.310
6	-0.00308	0.875	0.0995	0.210	1.06	0.000	0.00347	0.616	-0.00257	0.376	0.0328	0.397
7	-0.00541	0.799	**0.1806**	0.037	1.06	0.000	-0.00964	0.200	-0.00437	0.166	0.0521	0.216
8	0.02818	0.164	0.0964	0.239	1.16	0.000	**0.01214**	0.091	-0.00009	0.976	-0.0226	0.572
9	0.02174	0.324	0.0720	0.419	1.31	0.000	0.01205	0.124	0.00295	0.367	-0.0514	0.239
10(high)	0.01440	0.544	**0.2321**	0.017	1.13	0.000	0.00805	0.339	0.00508	0.151	-0.0563	0.232
1(low)	0.01271	0.413	0.0234	0.732	1.02	0.000	0.03119	0.168	0.00186	0.420	**-0.0196**	0.031
2	-0.00543	0.815	0.1085	0.290	0.96	0.000	-0.00261	0.938	0.00340	0.325	-0.0073	0.589
3	-0.01080	0.415	0.0749	0.200	0.81	0.000	0.02818	0.144	-0.00070	0.724	0.0054	0.485
4	-0.00287	0.813	0.0003	0.995	0.95	0.000	0.01321	0.453	-0.00217	0.229	0.0109	0.122
5	0.00527	0.658	-0.0074	0.888	0.98	0.000	**-0.04014**	0.021	-0.00200	0.259	0.0052	0.452
6	-0.00233	0.868	0.0385	0.535	0.98	0.000	-0.01770	0.386	-0.00143	0.493	0.0063	0.440
7	0.01087	0.449	-0.0253	0.689	0.92	0.000	-0.03366	0.108	-0.00290	0.175	0.0081	0.333
8	-0.02322	0.125	**0.1226**	0.067	1.06	0.000	**-0.03964**	0.072	-0.00079	0.725	**0.0271**	0.002
9	-0.00694	0.614	**0.2363**	0.000	0.79	0.000	-0.03072	0.126	-0.00291	0.156	**0.0254**	0.002
10(high)	0.05093	0.002	**0.1604**	0.029	0.67	0.000	**-0.07694**	0.002	**-0.00803**	0.001	-0.0049	0.613

Table 7: Real business cycle model estimations

Momentum' sorted portfolios (equally weighted)

	constant	p-value	beta (-1)	p-value	beta	p-value	ni31	p-value	ni1	p-value	credit	p-value
1(low)	0.03361	0.041	-0.0168	0.816	1.03	0.000	**0.01365**	0.016	0.00359	0.129	**-0.0733**	0.021
2	0.01742	0.458	0.1123	0.283	1.25	0.000	-0.00169	0.834	-0.00078	0.817	-0.0005	0.991
3	-0.02225	0.152	**0.1523**	0.028	1.04	0.000	0.00223	0.676	-0.00197	0.378	0.0404	0.178
4	-0.02913	0.070	0.0462	0.517	1.03	0.000	-0.00521	0.346	**-0.00441**	0.058	**0.0816**	0.009
5	-0.00412	0.721	-0.0723	0.160	1.09	0.000	**-0.01060**	0.009	**-0.00289**	0.084	0.0346	0.123
6	-0.01948	0.091	-0.0324	0.525	0.97	0.000	-0.00417	0.292	-0.00056	0.734	0.0251	0.259
7	-0.00224	0.847	-0.0706	0.172	1.00	0.000	-0.00197	0.620	-0.00001	0.995	-0.0016	0.945
8	-0.00749	0.510	-0.0069	0.891	0.84	0.000	-0.00129	0.742	0.00031	0.849	-0.0004	0.985
9	0.00176	0.878	-0.0335	0.510	0.85	0.000	0.00470	0.234	0.00200	0.228	-0.0240	0.279
10(high)	0.02451	0.147	-0.0176	0.815	0.88	0.000	0.00536	0.356	0.00220	0.367	-0.0454	0.165
1(low)	0.00708	0.570	**-0.1758**	0.011	1.13	0.000	-0.02433	0.173	-0.00031	0.867	0.0016	0.823
2	-0.00899	0.543	-0.0801	0.322	1.30	0.000	0.01420	0.501	0.00049	0.825	0.0093	0.270
3	-0.01051	0.271	0.0276	0.598	0.96	0.000	-0.00155	0.910	-0.00071	0.623	**0.0138**	0.012
4	-0.01424	0.073	**0.0872**	0.046	0.81	0.000	-0.01530	0.178	-0.00043	0.721	**0.0116**	0.011
5	-0.01287	0.129	-0.0025	0.957	0.90	0.000	-0.00731	0.546	0.00091	0.474	0.0075	0.118
6	0.00443	0.503	-0.0206	0.569	0.81	0.000	-0.01075	0.257	-0.00072	0.467	-0.0007	0.859
7	0.00953	0.214	-0.0029	0.945	0.82	0.000	0.01314	0.230	-0.00048	0.678	**-0.0096**	0.028
8	0.01220	0.118	-0.0493	0.248	0.83	0.000	-0.00674	0.544	-0.00070	0.548	-0.0072	0.104
9	0.00114	0.909	**0.1156**	0.035	1.08	0.000	-0.00629	0.659	0.00134	0.371	-0.0066	0.244
10(high)	0.01318	0.246	0.0642	0.302	1.23	0.000	**0.02810**	0.084	0.00042	0.805	**-0.0165**	0.011

Table 7: Real business cycle model estimations

Momentum' sorted portfolios (value weighted)

	constant	p-value	beta (-1)	p-value	beta	p-value	ni31	p-value	ni1	p-value	credit	p-value
1(low)	0.04877	0.011	-0.0496	0.521	1.03	0.000	**0.01559**	0.022	**0.00522**	0.067	**-0.1101**	0.004
2	0.03051	0.295	**0.2978**	0.013	0.99	0.000	-0.00767	0.456	-0.00327	0.449	0.0177	0.758
3	-0.00479	0.803	**0.1611**	0.040	0.98	0.000	-0.00123	0.856	**-0.00587**	0.041	**0.0638**	0.094
4	-0.01001	0.609	**0.1509**	0.059	1.02	0.000	-0.00282	0.684	**-0.00552**	0.059	**0.0728**	0.062
5	0.00356	0.803	0.0389	0.501	1.02	0.000	-0.00341	0.500	-0.00074	0.728	0.0012	0.967
6	0.00317	0.831	-0.0306	0.611	1.08	0.000	-0.00800	0.129	**-0.00372**	0.093	0.0362	0.219
7	0.00377	0.784	0.0402	0.472	0.99	0.000	-0.00389	0.427	-0.00155	0.449	0.0123	0.652
8	-0.01702	0.188	0.0132	0.799	0.89	0.000	-0.00118	0.796	-0.00034	0.859	0.0141	0.580
9	-0.02404	0.106	-0.0233	0.698	1.04	0.000	0.00767	0.145	0.00087	0.691	0.0058	0.843
10(high)	0.03056	0.047	0.0351	0.571	0.85	0.000	**0.01039**	0.057	**0.00437**	0.056	**-0.0756**	0.014
1(low)	0.01338	0.513	0.0119	0.895	0.95	0.000	-0.01220	0.682	-0.00133	0.662	0.0050	0.671
2	-0.00701	0.898	-0.2889	0.230	1.81	0.000	0.03075	0.698	0.00351	0.666	-0.0015	0.962
3	0.01131	0.454	0.0851	0.202	0.90	0.000	-0.02264	0.302	**-0.00485**	0.032	**0.0147**	0.094
4	-0.01452	0.295	**0.1085**	0.077	0.84	0.000	-0.02002	0.321	-0.00034	0.871	0.0081	0.313
5	-0.00970	0.451	0.0538	0.343	0.87	0.000	-0.01434	0.443	-0.00009	0.964	0.0085	0.254
6	-0.00846	0.472	**0.0980**	0.060	0.83	0.000	-0.01899	0.267	-0.00137	0.435	**0.0155**	0.024
7	0.01787	0.211	**-0.1066**	0.091	0.83	0.000	-0.01265	0.542	-0.00323	0.129	-0.0045	0.590
8	-0.00437	0.708	0.0326	0.526	0.84	0.000	0.00196	0.908	0.00044	0.802	0.0013	0.852
9	0.01770	0.191	0.0436	0.464	0.90	0.000	-0.01116	0.570	-0.00235	0.243	-0.0078	0.318
10(high)	0.01383	0.400	0.0153	0.832	1.10	0.000	0.02815	0.239	-0.00073	0.766	-0.0119	0.211

Table 7: Real business cycle model estimations												
industry sorted portfolios (equally weighted)												
	constant	p-value	emr (-1)	p-value	emr	p-value	ni31	p-value	ni1	p-value	credit	p-value
Energy	0.00887	0.532	-0.1028	0.105	1.22	0.000	**0.00904**	0.067	**0.00531**	0.011	**-0.0644**	0.020
Materials	-0.03823	0.135	-0.0809	0.476	1.37	0.000	-0.01223	0.166	**-0.00624**	0.092	**0.1124**	0.024
Industrial	-0.00326	0.685	-0.0394	0.272	0.98	0.000	0.00411	0.140	0.00166	0.154	-0.0138	0.376
Cons. Disc.	0.01194	0.469	**0.1738**	0.019	0.85	0.000	-0.00567	0.319	-0.00382	0.111	0.0280	0.380
Cons. Stapl.	-0.00792	0.623	**-0.1318**	0.068	0.74	0.000	-0.00912	0.103	-0.00014	0.951	0.0127	0.684
Health	-0.01925	0.469	-0.1171	0.323	0.65	0.000	0.00263	0.774	0.00095	0.805	0.0105	0.838
Financials	0.00384	0.744	**0.1263**	0.017	0.90	0.000	**0.00735**	0.072	0.00222	0.194	-0.0321	0.160
IT	0.02931	0.139	0.0004	0.997	0.99	0.000	-0.01036	0.130	**-0.00584**	0.042	0.0283	0.458
Energy	0.00497	0.657	-0.0527	0.390	1.40	0.000	-0.00499	0.755	-0.00098	0.561	0.0011	0.859
Materials	-0.03652	0.293	0.0754	0.691	1.20	0.000	-0.00339	0.946	0.00324	0.534	0.0172	0.381
Industrial	0.00750	0.242	0.0170	0.628	0.92	0.000	-0.00779	0.395	-0.00016	0.868	**-0.0062**	0.089
Cons. Disc.	-0.01531	0.283	0.0531	0.496	0.96	0.000	-0.01344	0.509	-0.00058	0.785	**0.0158**	0.052
Cons. Stapl.	-0.02689	0.029	0.0319	0.635	1.02	0.000	**0.03735**	0.034	0.00079	0.670	**0.0182**	0.010
Health	0.01108	0.758	-0.2279	0.247	1.29	0.000	0.06754	0.189	0.00458	0.396	-0.0299	0.144
financials	0.00534	0.343	**0.0626**	0.043	0.58	0.000	-0.00579	0.471	-0.00094	0.264	-0.0014	0.659
IT	-0.01864	0.220	**-0.1627**	0.051	1.57	0.000	0.01125	0.604	0.00282	0.216	0.0039	0.651
industry sorted portfolios (value weighted)												
Energy	0.01950	0.207	0.0406	0.515	1.13	0.000	**0.01376**	0.013	**0.00586**	0.011	**-0.0830**	0.007
Materials	-0.02348	0.203	0.0782	0.295	1.24	0.000	-0.00607	0.352	-0.00439	0.110	**0.0717**	0.051
industrial	-0.01138	0.232	-0.0250	0.516	1.02	0.000	-0.00113	0.736	-0.00004	0.980	0.0125	0.505
Cons. Disc.	0.00665	0.804	0.1788	0.102	1.00	0.000	-0.00290	0.761	-0.00212	0.594	0.0149	0.779
Cons. Stapl.	0.00757	0.656	**-0.1568**	0.024	0.87	0.000	-0.00742	0.218	0.00094	0.710	-0.0141	0.675
Health	-0.03169	0.216	-0.1463	0.159	0.82	0.000	**0.01674**	0.066	0.00482	0.204	-0.0174	0.730
financials	0.01007	0.542	**0.1648**	0.015	0.97	0.000	0.00151	0.796	-0.00062	0.801	-0.0117	0.720
IT	0.03105	0.232	0.0545	0.603	0.89	0.000	-0.00868	0.345	**-0.00704**	0.069	0.0379	0.460
Energy	0.00897	0.464	-0.0389	0.472	0.95	0.000	-0.02201	0.217	-0.00252	0.167	0.0010	0.883
Materials	-0.04528	0.213	0.1138	0.478	0.93	0.000	-0.04060	0.442	0.00155	0.775	0.0282	0.183
industrial	-0.00105	0.920	0.0454	0.323	0.95	0.000	-0.01614	0.287	-0.00163	0.293	0.0063	0.300
Cons. Disc.	-0.02147	0.401	0.0569	0.613	1.07	0.000	-0.03489	0.347	-0.00124	0.744	**0.0265**	0.076
Cons. Stapl.	-0.01591	0.271	0.0916	0.151	0.88	0.000	**0.04432**	0.036	0.00063	0.768	0.0054	0.522
Health	0.03466	0.661	**-0.6063**	0.083	1.83	0.000	0.10939	0.342	0.00720	0.541	-0.0626	0.174
financials	-0.00318	0.807	0.0531	0.356	0.81	0.000	-0.00543	0.774	-0.00221	0.254	0.0113	0.136
IT	-0.02376	0.396	0.0808	0.513	1.46	0.000	0.02382	0.558	**0.00692**	0.097	-0.0100	0.539

Table 7: Real business cycle model estimations

	constant	p-value	beta (-1)	p-value	beta	p-value	ni31	p-value	ni1	p-value	credit	p-value
	size sorted portfolios (equally weighted)											
1(low)	0.04964	0.039	0.0816	0.443	0.82	0.000	0.01177	0.155	0.00128	0.711	-0.0456	0.324
2	0.01861	0.266	0.1002	0.179	0.92	0.000	0.00479	0.407	-0.00113	0.640	0.0038	0.905
3	0.00902	0.521	0.0656	0.296	0.89	0.000	**0.00848**	0.082	0.00180	0.377	-0.0346	0.205
4	0.00794	0.564	**0.1028**	0.095	0.97	0.000	**0.00823**	0.084	0.00206	0.302	-0.0328	0.220
5	0.00527	0.665	0.0481	0.375	0.85	0.000	-0.00286	0.497	**-0.00303**	0.087	0.0263	0.265
6	-0.01272	0.368	0.0251	0.689	0.96	0.000	**-0.00842**	0.085	0.00131	0.522	-0.0045	0.870
7	-0.02908	0.084	-0.0399	0.593	1.26	0.000	-0.00647	0.264	-0.00196	0.419	0.0468	0.150
8	-0.03346	0.028	0.0400	0.552	1.09	0.000	**-0.00875**	0.094	**-0.00414**	0.060	**0.0739**	0.012
9	-0.00267	0.860	**-0.2430**	0.000	1.32	0.000	**-0.00944**	0.072	-0.00011	0.958	-0.0006	0.983
10(high)	-0.02324	0.162	**-0.2363**	0.002	0.98	0.000	0.00168	0.769	0.00210	0.381	-0.0003	0.992
1(low)	0.01943	0.010	**0.0695**	0.092	0.42	0.000	-0.00273	0.799	-0.00141	0.211	**-0.0082**	0.055
2	-0.01218	0.228	0.0829	0.135	0.83	0.000	-0.00286	0.843	0.00142	0.350	0.0074	0.199
3	0.00335	0.703	0.0037	0.939	0.87	0.000	0.00096	0.939	0.00035	0.793	-0.0020	0.691
4	0.01208	0.232	0.0288	0.602	0.91	0.000	-0.01098	0.446	0.00050	0.744	**-0.0127**	0.028
5	0.00134	0.885	-0.0354	0.485	1.04	0.000	-0.00234	0.859	0.00191	0.171	-0.0048	0.363
6	-0.00335	0.688	**0.0831**	0.070	1.01	0.000	0.00497	0.677	-0.00073	0.559	0.0065	0.171
7	-0.00403	0.598	-0.0008	0.985	1.08	0.000	**-0.02423**	0.027	-0.00137	0.234	**0.0100**	0.022
8	0.00031	0.973	-0.0077	0.878	1.13	0.000	-0.01669	0.204	-0.00044	0.750	0.0027	0.605
9	-0.01330	0.141	**-0.1037**	0.037	1.31	0.000	-0.00567	0.660	-0.00114	0.400	**0.0102**	0.048
10(high)	-0.00352	0.832	**-0.2041**	0.026	1.29	0.000	**0.03927**	0.099	0.00142	0.570	-0.0068	0.471

Table 8: Price of Risk: Real business cycle model

Price of risk	p1vw	P2vw	p1ew	p2ew
EMR-1	0.0182	0.0068	0.0053	0.0044
p-value	0.237	0.371	0.655	0.463
emr	0.0133	0.0162	0.0122	0.0104
p-value	**0.000**	**0.000**	**0.000**	**0.000**
credit	-0.117	-0.123	-0.166	-0.067
p-value	0.228	**0.044**	**0.003**	**0.066**
ni1	-0.508	-0.350	-2.031	-0.319
p-value	0.733	0.325	**0.046**	0.351
ni31	-0.3940	-0.0291	0.1245	-0.0099
p-value	0.105	0.357	0.703	0.694

When interpreting these results it is of importance to note the difference between whether asset return covary with factor return or if it is a priced risk. As with the other models, we reject the F-test at a 1% significance level for all portfolios. Unsurprisingly, I reject the null-hypothesis of the EMR variables not being priced at a 1% level for all estimations as well, reconfirming the importance of the EMR factor. I put restrictions on the real business cycle variables by setting all but the EMR factors coefficient equal to zero. I then compare the sum of squared residuals of the real business cycle estimation to the sum of squared residuals in the CAPM, both estimated with the same number of observations. I use an F-test to test the joint significance of the real business cycle variables. In the first period I reject the null-hypothesis of no joint significance for 25 of the 66 portfolios tested at a 10% significance level. Four of these are rejected at the 1% significance level, while eleven and ten are rejected at the 5% and 10% level. In the following period, I reject the null-hypothesis for 21 of 66 portfolios using a 10% significance level. Two of these are at the 1% significance level, while ten and nine are rejected at the 5% and 10% level. My findings indicate a large amount of stability in the ability of the real business cycle variables to explain asset return, although they have slightly higher ability to explain asset return in the first period. At the same time, a large number of portfolios fail to have their null-hypothesis rejected, indicating the limited effect the real business cycle variables have in explaining asset return.

Lagged EMR: Both periods are fairly similar in return to last periods excess market return in terms of predicting expected asset return. In the first period, I reject 15 of 64 portfolios null-hypothesis of a zero coefficient on lagged EMR. Of these; 11 is rejected at the 5% significance level, two at the 10% level and two at the 1% level. Two portfolios show a negative return at the 1% significance level, while three portfolios show a negative effect of lagged EMR on asset return using a 5% significance level. All other coefficients show a positive relationship between lagged EMR and asset return. In the following period, 21 portfolios are rejected at the 10% level. Two of these are rejected at the 1% level, further eight at the 5% level and the last eleven at the 10% level. Of these portfolios, all but four at both the 10- and 5% significance level show a positive effect, The inconsistent effect of previous market return in both periods is a sign of a cash flow effect. Lagged EMR has a positive effect on most portfolios in both periods, although it is more detectable in the second period. I find a relatively small number of portfolios which have a return covarying with previous excess return in both periods, reflecting the stability of the effect. Testing whether it is a priced risk I reject the null-hypothesis of zero pricing for the factor using a 10% significance level for all estimations.

The term spread: The term spread factor has the null-hypothesis of a zero beta rejected for 16 of the portfolios at a 10% significance level in the first period. One portfolio shows the term spread has a negative effect on asset return at the 1% significance level. Three is found having a positive effect at the 5% level, while eight out of twelve portfolios rejected at the 10% level show a positive effect of the term spread on asset return. I reject the null-hypothesis of a factor beta of zero for 12 of the portfolios using a 10% significance level. Two of these show a negative effect at the 1% significance level. Of the five coefficients found to be non-zero using a 5% significance level, two show a positive effect and three show a negative effect. At the 10% level, three out of five portfolios rejected at the 10% level show a positive effect. The effect seems to go in both directions within both of the periods, although it has a slightly more positive effect in the first period. In terms of impact it also similar in both periods, being a relatively unimportant factor which is found to be significant in more cases than that assumed by statistical chance. As the results show its effect goes in both directions, we are likely to have cash flow effects. Testing whether the term spread is a priced risk I find conclusive evidence against this, as in neither period I find it to be a priced risk, using a 10% significance level.

Term rate: My results show the impact of the one month NIBOR rate depends on the period tested, while the direction of the effect depends on the portfolio tested. In the first period 19 portfolios show a non-zero coefficient at the 10% significance level. Three out of five coefficients rejected at the 5% level show a positive effect, while eleven of the fourteen rejected at the 10% level show a negative effect. In the second period I reject only four of the coefficients at the 10% significance level. I find a negative effect at the 1% level for one coefficient, while one positive and one negative coefficient is found using a 5% significance level, and finally one positive coefficient is found at the 10% level. The term rate series in the second period fails to have the null-hypothesis of random walk rejected using an ADF-test with a 10% significance level. In addition there was a regime change in the interest rate target. This could imply the change has not come as much from a change in investor behavior, but rather how efficient the term rate is in reflecting the real business cycle. Although the effect is stronger in the first period, it is still not a dominating effect, having no coefficients rejected at the 1% significance level. As with other variables in this thesis, it could therefore be argued we have a degree of stability in terms of time as the term rate does not appear to be an important variable in either period. As the direction of the effect goes in both directions, it is likely to be a cash flow effect. The term rate is found to be priced with a negative sign at the 5% significance level using equally weighted portfolios in the first period. I fail to reject the null-hypothesis of zero impact using a 10% significance level for both periods using both types of portfolios.

Credit spread: I reject the null-hypothesis of zero coefficient for the credit spread variable 14 times in the first period using a 10% significance level. Three portfolios reject it at the 1% significance level, all showing a negative effect on asset return. Further four out of the seven credit spread coefficients which had their null-hypothesis rejected at the 5% significance level show a negative effect, while the four rejected at the 10% level all show a positive effect. Similar as with the one month term rate variable I fail to reject the null-hypothesis of the credit spread being stationary in the second period. Therefore the results should be interpreted with caution. In the second period I reject the null-hypothesis at the 10% significance level for 19 of the coefficients. Four have their null-hypothesis rejected at the 1% significance level, showing a positive effect. The equivalent number of coefficients showing a positive effect using a 5% and 10% significance level is five out of nine and four out of six coefficients. The amount of negative coefficients in both periods suggests a cash flow effect is highly present, in particular in the first period. The stock market is not stable in terms of the direction of the effect, having found a dominantly positive effect in the second period, and a tendency for a more negative effect in the first period. This could be used to argue the cash flow effects dominates relatively more than the stochastic discount factor in the first period compared to the second period. I find that the credit spread is a priced risk in the first period using equally weighted portfolios at the 1% significance level, while I find a high beta in regards to the credit spread to be related to a lower expected asset return in the second period using a 5% significance level using value weighted portfolios and a 10% level using equally weighted portfolios.

Conclusion: Both lagged EMR, the term spread and the credit spread variable have a similar effect on pricing assets in both periods, as the former two are not priced in either period, while I find evidence the latter is priced in both periods. The term rate shows some evidence against being a persistent factor in pricing asset return, as I have found minor evidence the term rate is priced negatively in the first period, but not the second. It is worth emphasizing both the credit spread variable and the term rate variable have their betas generated from a possibly non-stationary time series, the results could therefore be put into question. In terms of impact I only find strong evidence of the credit spread being priced, at least in the second period. Although this appears to be priced, its impact is quite small. My findings is in line with the earlier research of Næs et al. (2009) in not finding much evidence of there being priced real business variables. I have also found some evidence of these real business cycle variables being able to explain cash flows effect, with the exception of the limited ability of the term rate variable in the second period.

5 Conclusion

In this thesis I have looked at the CAPM, a conditional CAPM as well as a model including real business cycle variables. By testing two different periods, I have been able to test both the relevance of the factors and whether their relevance depends on the period tested. I have tested both the Carhart factors and a set of real business cycle variables. My findings from the CAPM estimations indicate the Carhart factors have a slightly stronger effect on asset return in the first period, as I at best find weak evidence of a momentum and B/M-effect in the first period, but not in the second period. In addition I find stronger evidence of a size effect, although this effect declines somewhat in the second period. I have also found evidence of an industry effect in the first period as the consumer staples sector is found to achieve a positive abnormal return. The finding of these factors having a much weaker effect on stock return is in line with earlier research by Næs et al. (2009) and Jakobsen and Tjelland (2012) which find the size effect to have the strongest impact.

I have found different results in the conditional CAPM model. There is stronger evidence of a B/M effect in the first period, an effect which is not clearly detected in the second period. Using momentum portfolios I have only been capable of detecting a minor reversal effect in the second period. The size effect is similar as in the unconditional model, being quite strong, with a stronger impact in first period. Both the IT sector and the consumer staples sector is found to have a positive abnormal return in the first period, but not in the following period.

Testing for real business cycle effects, I have used a shorter sample length for the first period, using data between December 1985 and June 1996. I have found evidence of these variables affecting stock return similarly in both periods as the impact of the variables are able both jointly and individually to explain asset return with about the same accuracy in both periods. The exception to this is the term rate in the second period which is largely incapable of explaining asset returns. This may however be related to properties with the variable. The real business cycle variables are like the other variables in this thesis useful in explaining asset return, but are by far surpassed by the ability of the EMR factor. The real business cycle variables are found to influence different portfolios differently. This suggest cash flow effects are present, as the stochastic discount factor implies all portfolios of stocks being affected in the same way. Like earlier research I have not found much evidence of these real business cycles being priced. The exception to this is the credit spread variable where I have found evidence it helps in pricing assets in both periods. In addition I have found weak evidence of the term rate being a priced factor in the first period. No other evidence of priced real business cycle variables have been found. A weakness with the testing lies in the possibly non-stationary nature of the term rate- and credit spread variables in the second period.

My analysis could be altered in several ways. Firstly, I have not tested any multivariate conditional models, which may explain asset return in a more precise manner than the models estimated in this thesis. Secondly, I have used monthly data. The period length might affect the estimation results. Thirdly, the Carhart factors could have their price of risk parameters tested formally. In addition a multifactor Carhart model could reveal interesting patterns. Fourthly, the real business cycle model could be estimated with another set of variables. One possibility could be to include a variable capturing the size effect. Fifthly, a more in depth analysis of whether the cash flow effects occur on the same portfolios in the two periods could be performed. Lastly, a more complex version of the DCC-GARCH model, as well as other conditional models could reveal other patterns than my model did.

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Appendix

The appendix is divided into 3 sections:

Appendix 1: Data

Data

All information on the portfolios, the size, B/M and momentum variables, the NIBOR rate (which is used in constructing excess return), as well as the market return have been retrieved from Bernt Arne Ødegaard`s website:

http://finance.bi.no/~bernt/financial_data/ose_asset_pricing_data/index.html

I have found excess portfolio return by subtracting the portfolio return with the one month NIBOR rate for the holding period. Similarly, the excess market return has been found by subtracting the market return with the monthly NIBOR rate. The data is created in a similar way as that of Fama and French: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

The size factor (Small Minus Big) is found by taking the average return on the three small portfolios and then subtracting the average return on the three big portfolios,

SMB = 1/3 (Small Value + Small Neutral + Small Growth) - 1/3 (Big Value + Big Neutral + Big Growth).

The B/M factor (High minus Low) is found by taking the average return on the two value portfolios (portfolios with a high B/M-ratio and then subtracting the average return on the two growth portfolios (portfolios with a low B/M-ratio).

HML =1/2 (Small Value + Big Value) - 1/2 (Small Growth + Big Growth)

The momentum factor (MOM) is found by taking the average return on the two high prior return portfolios (portfolios with a high momentum and then subtracting the average return on the two low prior return portfolios (portfolios with a low momentum)

,

Mom = 1/2 (Small High + Big High) - 1/2(Small Low + Big Low)

The B/M portfolios have data from January 1981-December 2012. The size portfolios, momentum portfolios, industry portfolios and excess market return have data from February 1980- December 2012. The High-minus-Low variable and the size variable lack data for the first six months of 1980 while the momentum variable lacks data for January 1980.

The data on the real business cycle variables stretches from December 1985 to December 2012. The credit spread has been retrieved from the Federal Reserve Bank of St. Louis:

http://research.stlouisfed.org/fred2/series/BAA

http://research.stlouisfed.org/fred2/series/AAA

where I have found the spread by subtracting the rate of return of AAA rated bonds with the return on the Baa rated bonds.

The data on the one and three month NIBOR used in the real business cycle model has been retrieved from Norges Bank:

http://www.norges-bank.no/no/prisstabilitet/rentestatistikk/styringsgrente-manedlig/

The term spread is found by subtracting the three month NIBOR rate with the one month NIBOR rate.

Appendix 2: ADF-tests

Tests

The ADF-tests show the results of the estimations of equation (3.6). In order to determine whether lagged differences should be included I test whether auto correlation is present. This is done by using the Ljung-Box test for residual autocorrelation, which uses the Portmanteau statistics.

$$Q_x(k) = T^2 \sum_{j=1}^{k} \frac{r_j^2}{T - j}$$

where k is the number of lags, r_j^2 is the autocorrelation coefficient and T is the sample size. The test is Chi^2 distributed with k degrees of freedom.

H_0: No significant signs of autocorrelation in the error term

H_1: Significant sign of autocorrelation in the error term

(Wooldridge 2006 and Brooks 2008). I include 12 lags on my portmanteau tests. I have performed three separate estimations on each variable. One for each period, and one for the complete period. Test summary for the portfolios are reported in summary separately from the other variables. All variables but the credit spread and the term rate in the second- and complete period had their null-hypothesis of non-stationarity rejected at the 10% significance level. The credit spread variable failed to have its null-hypothesis rejected at the 1% significance level, but succeeded at the 5% level.

I have used the following abbreviations in the table:

vw=value weighted

ew=equally weighted

rf suffix=excess return

bm=B/M portfolios

mo=Momentum portfolios

si=size portfolios

Table 9: ADF-tests

1st period	emrvw	emrew	pr1yr	hml	smb	credit	ni1	ni31		
lags	12	12	3	0	0	6	4+trend	3		
coefficient	-0.889	-0.665	-0.863	-0.984	-0.935	-0.061	-0.309	-0.493		
portmanteau test	23.33	34.494	60.593	41.093	39.209	900.29	860.475	71.879		
p-value	0.025	0.001	0.019	0.423	0.506	0	0	0.002		
n-k-1	173	173	193	191	191	123	123	123		
2nd period	emrvw	emrew	pr1yr	hml	smb	credit	ni1	ni31		
lags	0	4	0	0	0	12+trend	12+trend	12		
coefficient	-0.86	-0.667	-0.856	-0.86	-1.034	-0.055	-0.022	-0.183		
portmanteau test	8.774	32.731	34.377	46.137	38.385	893.554	1851.846	620.585		
p-value	0.722	0.001	0.721	0.233	0.543	0	0	0		
n-k-1	197	193	185	197	185	185	185	185		
both periods	emrvw	emrew	pr1yr	hml	smb	credit	ni1	ni31		
lags	12	12	0	0	0	12+trend	6+trend	6		
coefficient	-0.875	-0.644	-0.836	-0.932	-0.966	-0.039	-0.374	-0.834		
portmanteau test	23.65	59.705	20.149	16.358	12.311	2418.997	171.215	171.215		
p-value	0.023	0	0.064	0.175	0.421	0	0	0		
n-k-1	382	382	384	389	389	383	318	318		
1st period	bm1vwrf	bm2vwrf	bm3vwrf	bm4vwrf	bm5vwrf	bm6vwrf	bm7vwrf	bm8vwrf	bm9vwrf	bm10vwrf
lags	0	8	8	8	0	0	8	0	0	3
coefficient	-0.863	-0.763	-0.995	-1.058	-0.939	-0.759	-1.086	-0.818	-0.867	-0.856
portmanteau test	11.55	33.553	22.626	31.375	15.27	17.174	34.769	18.744	10.618	21.731
p-value	0.482	0.001	0.031	0.002	0.227	0.143	0.001	0.095	0.562	0.041
n-k-1	185	177	177	177	185	185	177	185	185	182
2nd period	bm1vwrf	bm2vwrf	bm3vwrf	bm4vwrf	bm5vwrf	bm6vwrf	bm7vwrf	bm8vwrf	bm9vwrf	bm10vwrf
lags	0	0	0	0	0	0	0	0	3	3
coefficient	-0.92	-0.921	-0.853	-0.836	-0.891	-0.844	-0.889	-0.836	-0.54	-0.499
portmanteau test	13.88	14.967	10.698	15.208	7.005	20.575	11.72	15.614	40.657	44.613
p-value	0.309	0.243	0.555	0.23	0.857	0.057	0.468	0.21	0	0
n-k-1	197	197	197	197	197	197	197	197	194	194

Table 9: ADF-tests										
both periods	bm1vwrf	bm2vwrf	bm3vwrf	bm4vwrf	bm5vwrf	bm6vwrf	bm7vwrf	bm8vwrf	bm9vwrf	bm10vwrf
lags	0	8	12	12	0	12	8	10	12	12
coefficient	-0.89	-0.768	-0.924	-1.023	-0.919	-0.857	-0.953	-0.856	-0.669	-0.522
portmanteau test	17.226	29.897	24.361	26.242	11.085	27.07	39.314	24.688	23.654	42.137
p-value	0.141	0.003	0.018	0.01	0.522	0.008	0	0.016	0.023	0
n-k-1		373	371	371	383	371	375	376	371	371
1st period	bm1ewrf	bm2ewrf	bm3ewrf	bm4ewrf	bm5ewrf	bm6ewrf	bm7ewrf	bm8ewrf	bm9ewrf	bm10ewrf
lags	8	8	0	0	0	0	0	8	12	12
coefficient	-0.668	-0.792	-0.902	-0.842	-1.019	-0.847	-0.831	-0.661	-0.73	-0.653
portmanteau test	26.321	19.117	15.618	21.423	16.809	8.266	13.848	26.098	25.923	22.602
p-value	0.01	0.086	0.209	0.045	0.157	0.764	0.311	0.01	0.011	0.031
n-k-1	177	177	185	185	185	185	185	177	173	173
2nd period	bm1ewrf	bm2ewrf	bm3ewrf	bm4ewrf	bm5ewrf	bm6ewrf	bm7ewrf	bm8ewrf	bm9ewrf	bm10ewrf
lags	0	0	0	0	3	0	0	4	12	6
coefficient	-0.883	-0.844	-0.813	-0.785	-0.689	-0.81	-0.823	-0.624	-0.543	-0.563
portmanteau test	12.935	18.801	17.421	19.629	25.239	20.906	19.422	37.377	28.707	53.019
p-value	0.374	0.093	0.134	0.074	0.014	0.052	0.079	0	0.004	0
n-k-1	197	197	197	197	194	197	197	193	185	191
both periods	bm1ewrf	bm2ewrf	bm3ewrf	bm4ewrf	bm5ewrf	bm6ewrf	bm7ewrf	bm8ewrf	bm9ewrf	bm10ewrf
lags	7	8	4	12	0	0	10	8	12	10
coefficient	-0.79	-0.758	-0.818	-0.7	-0.935	-0.835	-0.756	-0.637	-0.657	-0.672
portmanteau test	33.588	27.541	25.324	26.56	19.316	21.004	21.644	47.539	48.078	47.895
p-value	0.001	0.007	0.013	0.009	0.081	0.05	0.042	0	0	0
n-k-1	372	373	375	371	372	375	373	373	371	372
1st period	mo1vwrf	mo2vwrf	mo3vwrf	mo4vwrf	mo5vwrf	mo6vwrf	mo7vwrf	mo8vwrf	mo9vwrf	mo10vwrf
lags	8	0	8	12	0	0	0	0	0	8
coefficient	-0.919	-0.854	-0.735	-1.076	-0.817	-0.825	-0.885	-0.879	-0.942	-0.711
portmanteau test	21.143	20.385	32.114	21.709	13.015	11.004	20.871	20.926	20.735	27.002
p-value	0.048	0.06	0.001	0.041	0.368	0.529	0.052	0.052	0.054	0.008
n-k-1	188	196	188	184	196	196	196	196	196	188

Table 9: ADF-tests										
2nd period	mo1vwrf	mo2vwrf	mo3vwrf	mo4vwrf	mo5vwrf	mo6vwrf	mo7vwrf	mo8vwrf	mo9vwrf	mo10vwrf
lags	0	0	0	12	0	0	0	0	0	6
coefficient	-0.923	-1.033	-0.872	-0.685	-0.879	-0.839	-0.924	-0.965	-0.861	-0.782
portmanteau test	17.848	5.445	21.567	16.628	18.453	10.601	7.394	16.754	7.683	21.545
p-value	0.12	0.941	0.043	0.164	0.103	0.563	0.831	0.159	0.809	0.043
n-k-1	197	197	197	185	197	197	197	197	197	191
both periods	mo1vwrf	mo2vwrf	mo3vwrf	mo4vwrf	mo5vwrf	mo6vwrf	mo7vwrf	mo8vwrf	mo9vwrf	mo10vwrf
lags	8	0	12	12	4	0	0	8	12	12
coefficient	-0.873	-0.999	-0.738	-0.976	-0.85	-0.831	-0.905	-1.057	-0.856	-0.76
portmanteau test	30.252	6.741	31.862	31.618	21.472	14.323	18.344	23.973	21.597	29.043
p-value	0.003	0.874	0.002	0.002	0.044	0.281	0.106	0.021	0.042	0.004
n-k-1	386	395	388	383	389	395	395	383	392	383
1st period	mo1ewrf	mo2ewrf	mo3ewrf	mo4ewrf	mo5ewrf	mo6ewrf	mo7ewrf	mo8ewrf	mo9ewrf	mo10ewrf
lags	0	6	8	8	0	0	0	8	8	8
coefficient	-0.943	-0.808	-0.709	-0.922	-0.692	-0.828	-0.862	-0.726	-0.597	-0.652
portmanteau test	21.01	27.434	32.128	22.753	25.677	18.451	21.02	22.424	23.915	27.603
p-value	0.05	0.007	0.001	0.03	0.012	0.103	0.05	0.033	0.021	0.006
n-k-1	196	190	188	188	196	196	196	188	188	188
2nd period	mo1ewrf	mo2ewrf	mo3ewrf	mo4ewrf	mo5ewrf	mo6ewrf	mo7ewrf	mo8ewrf	mo9ewrf	mo10ewrf
lags	0	0	0	4	12	0	6	4	12	12
coefficient	-0.948	-0.891	-0.827	-0.684	-0.682	-0.789	-0.576	-0.731	-0.627	-0.584
portmanteau test	14.389	8.939	17.195	33.047	30.504	20.143	31.5	24.789	33.051	28.272
p-value	0.277	0.708	0.142	0.001	0.002	0.064	0.002	0.016	0.001	0.005
n-k-1	197	197	197	193	185	185	191	193	185	185
both periods	mo1ewrf	mo2ewrf	mo3ewrf	mo4ewrf	mo5ewrf	mo6ewrf	mo7ewrf	mo8ewrf	mo9ewrf	mo10ewrf
lags	8	8	12	12	8	8	10	8	10	12
coefficient	-0.846	-0.819	-0.723	-0.873	-0.69	-0.663	-0.604	-0.714	-0.692	-0.633
portmanteau test	26.702	29.946	43.961	42.215	47.148	30.29	38.569	38.539	48.054	47.172
p-value	0.009	0.003	0	0	0	0.003	0	0	0	0
n-k-1	387	391	383	383	383	387	385	384	385	383

Table 9: ADF-tests								
1st period	envwrf	mavwrf	invwrf	cdwrf	csvwrf	hevwrf	fivwrf	itvwrf
lags	0	8	8	0	0	8	8	12
coefficient	-0.874	-0.911	-0.966	-0.954	-0.928	-1.192	-0.712	-0.629
portmanteau test	16.643	25.059	24.488	6.981	20.419	25.38	26.016	30.795
p-value	0.164	0.015	0.017	0.859	0.06	0.013	0.011	0.002
n-k-1	196	188	188	196	196	188	188	184
2nd period	envwrf	mavwrf	invwrf	cdwrf	csvwrf	hevwrf	fivwrf	itvwrf
lags	0	0	0	0	0	0	0	0
coefficient	-0.876	-1.103	-0.822	-0.904	-0.916	-1.037	-0.837	-0.947
portmanteau test	7.34	14.004	11.625	17.827	4.855	3.261	12.14	18.376
p-value	0.834	0.301	0.476	0.121	0.963	0.993	0.435	0.105
n-k-1	197	197	197	197	197	197	197	197
both periods	envwrf	mavwrf	invwrf	cdwrf	csvwrf	hevwrf	fivwrf	itvwrf
lags	12	12	8	8	8	8	12	12
coefficient	-0.871	-1.031	-0.902	-0.989	-0.862	-1.013	-0.847	-0.736
portmanteau test	20.39	15.947	22.491	18.545	10.025	6.025	31.103	26.899
p-value	0.06	0.194	0.032	0.1	0.614	0.915	0.002	0.008
n-k-1	395	395	387	395	395	395	383	383
1st period	enewrf	maewrf	inewrf	cdewrf	csewrf	heewrf	fiewrf	itewrf
lags	8	4	12	0	8	0	12	12
coefficient	-0.653	-0.953	-0.711	-0.906	-0.658	-0.932	-0.635	-0.567
portmanteau test	24.705	21.463	30.584	16.462	30.775	16.339	39.742	55.273
p-value	0.016	0.044	0.002	0.171	0.002	0.176	0	0
n-k-1	188	192	184	196	188	196	184	184
2nd period	enewrf	maewrf	inewrf	cdewrf	csewrf	heewrf	fiewrf	itewrf
lags	0	0	8	0	3	0	4	0
coefficient	-0.77	-1.069	-0.59	-0.876	-0.705	-0.98	-0.511	-0.871
portmanteau test	20.515	8.168	27.823	18.6	24.01	7.085	63.765	20.659
p-value	0.058	0.772	0.006	0.099	0.02	0.852	0	0.056
n-k-1	197	197	189	197	194	197	193	197

Table 9: ADF-tests										
both periods	enewrf	maewrf	inewrf	cdewrf	csewrf	heewrf	fiewrf	itewrf		
lags	12	0	12	0	8	0	12	12		
coefficient	-0.789	-0.998	-0.68	-0.891	-0.688	-0.967	-0.617	-0.621		
portmanteau test	39.744	11.293	49.6	16.216	30.842	10.868	82.801	62.001		
p-value	0	0.504	0	0.182	0.002	0.54	0	0		
n-k-1	383	395	383	395	387	395	383	383		
1st period	si1ewrf	si2ewrf	si3ewrf	si4ewrf	si5ewrf	si6ewrf	si7ewrf	si8ewrf	si9ewrf	si10ewrf
lags	12	0	0	12	8	8	0	0	0	8
coefficient	-0.747	-0.83	-0.869	-0.698	-0.757	-0.71	-0.797	-0.787	-0.789	-0.963
portmanteau test	27.372	16.337	19.285	43.474	26.51	29.526	13.17	19.985	25.445	17.479
p-value	0.007	0.176	0.082	0	0.009	0.003	0.357	0.067	0.013	0.132
n-k-1	184	196	196	184	188	188	196	196	196	188
2nd period	si1ewrf	si2ewrf	si3ewrf	si4ewrf	si5ewrf	si6ewrf	si7ewrf	si8ewrf	si9ewrf	si10ewrf
lags	10	8	0	12	0	8	4	8	0	8
coefficient	-0.378	-0.659	-0.916	-0.584	-0.827	-0.668	-0.694	-0.731	-0.852	-0.965
portmanteau test	45.262	35.29	19.651	42.958	20.348	24.757	27.541	24.776	19.67	17.967
p-value	0	0	0.074	0	0.061	0.016	0.007	0.016	0.074	0.117
n-k-1	187	189	197	185	197	189	193	189	197	189
both periods	si1ewrf	si2ewrf	si3ewrf	si4ewrf	si5ewrf	si6ewrf	si7ewrf	si8ewrf	si9ewrf	si10ewrf
lags	12	8	8	10	8	8	12	3	10	12
coefficient	-0.569	-0.689	-0.808	-0.641	-0.728	-0.693	-0.696	-0.731	-0.768	-1.038
portmanteau test	61.527	32.671	26.443	69.966	39.851	51.4	29.907	29.5	36.364	23.478
p-value	0	0.001	0.009	0	0	0	0.003	0.003	0	0.024
n-k-1	383	387	387	385	387	387	383	392	385	383

Appendix 3: Analysis

I perform four tests of the time series properties of the CAPM and real business cycle model.

The ARCH test for conditional heteroscedasticity is performed by estimating:

$$u_t^2 = \gamma_0 + \sum_{i=1}^{q} \gamma_i u_{t-i}^2 + v_t$$

Where q is the ARCH order, $\hat{u}_t^2$ and $\hat{u}_{t-i}^2$ is the squared residuals and their lagged values. The test is conducted by taking an F-test of the joint significance of the lagged squared residuals.

H_0: No significant signs of conditional heteroscedasticity in the error term

H_1: Significant signs of conditional heteroscedasticity in the error term

The normality test is a test of the distribution of the error term. The test observator is chi square distributed:

H_0: Normally distributed error term

H_1: Not normally distributed error term

I also use the White test to test for heteroscedasticity in the explanatory variables.

$$\hat{u}_t^2 = \alpha + \sum_{i=1}^{n} \beta_i x_{it} + \sum_{i=1}^{n} \gamma_i x_{it}^2 + e_t$$

This test is a standard F-test on the joint significance the explanatory variables, x_i, have in explaining the squared values of the residual, u_t^2, in the original regression.

H_0: No significant signs of heteroscedasticity in the error term

H_1: Significant signs of heteroscedasticity in the error term

To test for autocorrelation in the OLS estimations I estimate:

$$u_t = \sum_{i=p}^{r} \alpha_i u_{t-i} + \varepsilon_t \text{ where } 0 \leq p \leq r$$

Where u_t and u_{t-i} are the current and lagged residuals. As suggested by Harvey (1981, 1990) I use an F-test on the joint significance of the lagged residuals.

H_0: No significant signs of autocorrelation in the error term

H_1:Significant sign of autocorrelation in the error term

Furthermore I use information criteria tests for my DCC-GARCH model. The optimal model has the lowest possible value on the information criteria .

Bayesian information criterion (BIC): $-2 * \ln(\mathit{likelihood}) + \ln(N) * k.$

Akaike information criterion (AIC): $-2 * \ln(\mathit{likelihood}) + 2 * k.$

Where k is the number of parameters and n is the number of observations.

And the log likelihood function: $-\frac{T}{2}\ln 2\pi - \frac{T}{2}\ln(\sigma^2) - \frac{1}{2\sigma^2}\sum_{j=1}^{n}(x_j - \mu)$

(Wooldridge 2006 and Brooks 2008)

The following portfolios have been estimated using a different period length than the usual 2-198 (first period) and 199-396 (second period), where the complete sample length stretches from January 1980 to December 2012 and data is registered at a monthly frequency. These deviations in period length are made to ensure convergence in the log likelihood function is achieved. The sample stretches from January 1980 (1) to December 2012 (396) and is registered at a monthly frequency.

bm3ewrf	1-191	mo1ewrf	197-396
bm5ewrf	26-198	mo2ewrf	223-396
mo4ewrf	15-198	mo7ewrf	199-344
Csewrf	3-198	si6ewrf	196-396
si4ewrf	1-206	si10ewrf	198-396
bm5vwrf	1-199	bm7vwrf	198-396
bm7vwrf	1-197	mo2vwrf	223-396
bm9vwrf	1-197	mo6vwrf	203-396
		envwrf	203-396

The approximate critical values on the F-tests are:

1%=3.48

5%=2.45

10%=1.99

Diagnostic test CAPM

Table 10: Diagnostics: CAPM								
	ARCH test	p-value	AR test	p-value	Normality test	p-value	hetero test	p-value
Book To Market portfolios (value weighted)								
1st period								
1(low)	0.44	0.876	1.04	0.404	72.41	0	8.46	0
2	1.54	0.157	5.78	0	446.86	0	0.31	0.734
3	10.3	0	0.86	0.539	48.3	0	12.28	0
4	0.77	0.614	1.36	0.225	12.4	0.002	1.14	0.323
5	2.84	0.008	0.6	0.757	37.07	0	1.33	0.268
6	0.12	0.997	1.87	0.077	65.73	0	3.23	0.042
7	1.72	0.107	2.2	0.036	26.4	0	7.28	0.001
8	2.45	0.02	0.78	0.605	13.12	0.001	9.56	0
9	1.95	0.064	0.71	0.66	166.37	0	0.56	0.572
10(high)	1.46	0.183	0.95	0.468	27.37	0	1.63	0.198
2nd period								
1(low)	0.28	0.962	2.17	0.039	109.77	0	22.02	0
2	0.04	1	0.78	0.601	541.09	0	0.5	0.609
3	2.16	0.04	0.46	0.864	59.91	0	28.39	0
4	0.42	0.891	1.86	0.078	62.3	0	28.94	0
5	1.12	0.355	0.96	0.459	34.71	0	21.22	0
6	4.63	0	3.22	0.003	77.15	0	1.74	0.178
7	0.06	1	0.7	0.674	19.78	0	15.1	0
8	4.21	0	0.88	0.527	67.81	0	20.1	0
9	0.25	0.972	2.97	0.006	79.9	0	17.83	0
10(high)	1.99	0.059	2.38	0.024	22.27	0	4.55	0.012
Book To Market portfolios (equally weighted)								
1st period								
1(low)	1.1	0.367	2.34	0.026	90.35	0	18.49	0
2	3.42	0.002	1.08	0.38	4.51	0.105	21.53	0
3	3.14	0.004	0.32	0.945	6.38	0.041	9.04	0
4	0.71	0.667	0.73	0.65	13.17	0.001	6.62	0.002
5	0.44	0.873	2.65	0.012	6.68	0.036	8.01	0.001
6	0.06	1	0.46	0.864	139.1	0	5.35	0.006
7	3.18	0.003	1.26	0.275	32.1	0	9.25	0
8	2.61	0.014	0.85	0.548	29.99	0	12.01	0
9	1.44	0.194	0.61	0.747	7.8	0.02	6	0.003
10(high)	5.13	0	1.5	0.17	37.86	0	5.14	0.007
2nd period								
1(low)	2.11	0.045	1.62	0.131	30.72	0	6.34	0.002
2	0.07	0.999	1.4	0.21	98.05	0	4.08	0.019
3	1.64	0.125	3.5	0.002	3.41	0.182	0.43	0.651
4	1.64	0.128	1.34	0.232	112.54	0	0.52	0.594
5	0.79	0.599	0.44	0.879	6.55	0.038	1.43	0.242
6	1.48	0.178	0.72	0.652	18.87	0	9.19	0
7	1.17	0.32	1.75	0.099	12.93	0.002	1.1	0.335
8	0.52	0.815	1.26	0.272	1.95	0.377	1.49	0.228
9	0.69	0.682	0.41	0.893	2.17	0.338	3.14	0.046
10(high)	2.94	0.006	1.11	0.357	12.51	0.002	3.1	0.047

Table 10: Diagnostics: CAPM								
	ARCH test	p-value	AR test	p-value	Normality test	p-value	hetero test	p-value
momentum portfolios (value weighted)								
1st period								
1(low return)	0.45	0.869	0.6	0.758	6.86	0.032	3.7	0.027
2	2.36	0.025	1.2	0.304	29.74	0	5.65	0.004
3	6.06	0	2.08	0.048	2.42	0.298	4.58	0.011
4	4.34	0	1.98	0.06	71.61	0	2.97	0.054
5	1.2	0.306	0.51	0.829	7.72	0.021	11.01	0
6	4.1	0	1.93	0.067	1.2	0.549	26.75	0
7	1.12	0.351	0.51	0.826	2.63	0.268	2.52	0.083
8	10.58	0	2.12	0.043	242.04	0	1.33	0.268
9	0.52	0.822	1.03	0.41	85.45	0	9.09	0
10(high return)	10.88	0	5.37	0	140.23	0	0.4	0.669
2nd period								
1(low return)	1.14	0.341	2.47	0.019	25.56	0	4.86	0.009
2	0.01	1	0.22	0.98	8629.8	0	27	0
3	1.92	0.069	1.93	0.067	32.98	0	15.68	0
4	1.04	0.402	0.91	0.502	10.94	0.004	15.88	0
5	4.98	0	0.79	0.595	89.64	0	15.95	0
6	0.53	0.814	0.65	0.715	55.85	0	13.74	0
7	0.34	0.933	1.01	0.426	97.62	0	5.66	0.004
8	8.82	0	2.95	0.006	50.93	0	28.39	0
9	1	0.431	0.55	0.797	64.89	0	12.83	0
10(high return)	0.76	0.621	1.38	0.215	162.43	0	26.12	0
momentum portfolios (equally weighted)								
1st period								
1(low return)	0.51	0.828	1.99	0.059	36.23	0	2.85	0.06
2	3.45	0.002	1.91	0.071	27.9	0	9.26	0
3	1.52	0.163	1.07	0.383	0.34	0.844	5.85	0.003
4	0.37	0.921	0.44	0.874	113.32	0	1.42	0.245
5	0.36	0.924	0.25	0.972	18.69	0	2.73	0.068
6	1.07	0.383	1.04	0.401	4.11	0.128	6.71	0.002
7	1.19	0.313	1.61	0.134	22.26	0	3.46	0.034
8	2.74	0.01	2.35	0.025	11.8	0.003	27.47	0
9	11.72	0	1.59	0.141	36.81	0	21.32	0
10(high return)	3.43	0.002	1.3	0.253	63.94	0	11.25	0
2nd period								
1(low return)	1.61	0.134	1.2	0.306	29.61	0	0.8	0.452
2	0.03	1	0.72	0.651	159.43	0	0.02	0.978
3	0.5	0.831	1.02	0.422	21.07	0	8.46	0
4	3.4	0.002	0.63	0.729	13.15	0.001	11.38	0
5	1.27	0.266	0.89	0.517	32.08	0	4.88	0.009
6	1.42	0.201	0.87	0.534	3.68	0.159	7.57	0.001
7	1.14	0.342	1.5	0.17	9.87	0.007	17.19	0
8	2.64	0.013	1.76	0.099	11.48	0.003	4.92	0.008
9	2.59	0.014	0.86	0.537	71.29	0	1.49	0.227
10(high return)	0.96	0.46	1.11	0.358	30.84	0	15.12	0

Table 10: Diagnostics: CAPM								
	ARCH test	p-value	AR test	p-value	Normality test	p-value	hetero test	p-value
industry portfolios (value weighted)								
1st period								
energy	2.75	0.01	1.12	0.354	8.45	0.015	0.95	0.389
materials	0.91	0.502	1.49	0.174	24.79	0	1.14	0.323
industry	1.13	0.344	0.97	0.456	3.28	0.194	2.93	0.056
Cons. Disc.	1	0.432	1.16	0.326	13.36	0.001	1.73	0.18
Cons. Staples	0.7	0.671	0.67	0.696	15.01	0.001	1.31	0.272
Health	0.44	0.877	1.28	0.261	13.51	0.001	2.69	0.07
Financials	1.37	0.219	2.45	0.02	35.81	0	1.7	0.185
IT	6.93	0	3.98	0	241.33	0	3.01	0.052
2nd period								
energy	3.14	0.004	1.82	0.086	76.94	0	21.68	0
materials	0.31	0.947	2.22	0.035	430.59	0	2.46	0.088
industry	0.17	0.99	1.14	0.339	61.98	0	25.74	0
Cons. Disc.	2.8	0.009	1.98	0.06	69.64	0	2.78	0.064
Cons. Staples	1.72	0.107	1.68	0.117	15.85	0	11.46	0
Health	0	1	0.16	0.992	14718	0	26.88	0
Financials	1.51	0.167	0.52	0.822	19.13	0	17.45	0
industry portfolios (equally weighted)								
1st period								
energy	1.71	0.108	1.17	0.322	77.68	0	10.09	0
materials	0.89	0.515	1.19	0.313	92.62	0	0.55	0.576
industry	2.53	0.016	2.13	0.043	19.34	0	16.13	0
Cons. Disc.	2.29	0.029	1.27	0.266	10.13	0.006	4.1	0.018
Cons. Staples	1.22	0.296	0.92	0.492	14.02	0.001	2.69	0.071
Health	0.59	0.76	0.83	0.56	4.94	0.085	6.2	0
Financials	1.41	0.203	1.65	0.125	33.97	0	10.28	0
IT	11.49	0	3.84	0.001	236.81	0	4.51	0.012
2nd period								
energy	3.04	0.005	1.11	0.361	29.29	0	3.62	0.029
materials	0.29	0.958	3.12	0.004	836.27	0	5.16	0.007
industry	1.12	0.35	2.19	0.037	2.38	0.304	0.53	0.591
Cons. Disc.	2.25	0.032	2.4	0.022	80.04	0	3.81	0.024
Cons. Staples	1.18	0.317	1.04	0.407	4.17	0.125	1.32	0.269
Health	0.01	1	0.23	0.978	3263.5	0	0.07	0.929
Financials	2.07	0.049	1.14	0.338	4.31	0.116	3.31	0.039
IT	1.93	0.068	2.17	0.039	24.14	0	5.42	0.005

Table 10: Diagnostics: CAPM								
	ARCH test	p-value	AR test	p-value	Normality test	p-value	hetero test	p-value
Size portfolios (Equally weighted)								
1st period								
1(small)	0.29	0.958	1.09	0.369	22.27	0	5.5	0.005
2	1.8	0.089	0.34	0.934	15.63	0	9.18	0
3	2.61	0.014	1.47	0.179	18.27	0	17.62	0
4	2.86	0.007	3.41	0.002	37.32	0	3.35	0.037
5	0.25	0.972	0.66	0.707	122.43	0	6.7	0.002
6	3.23	0.003	1.85	0.079	17.7	0	10.51	0
7	0.23	0.978	0.93	0.484	102.13	0	9.37	0
8	3.36	0.002	1.72	0.107	38.96	0	0.04	0.964
9	2.52	0.017	0.88	0.524	32.3	0	3.79	0.024
10(large)	1.84	0.082	0.94	0.473	25.76	0	4.17	0.017
2nd period								
1(small)	0.92	0.49	0.57	0.781	5.75	0.056	1.98	0.14
2	1.65	0.123	1.72	0.106	12.73	0.002	6.5	0.002
3	1.04	0.404	3.61	0.001	22.74	0	1.25	0.288
4	3.64	0.001	0.84	0.558	18.8	0	1	0.37
5	0.91	0.496	0.93	0.485	42.58	0	11.42	0
6	4.47	0	3.45	0.002	19.84	0	0.07	0.935
7	1.15	0.332	2.93	0.006	3.45	0.178	3.73	0.026
8	1.04	0.404	0.76	0.622	84.26	0	1.07	0.344
9	1.1	0.367	1.5	0.169	11.97	0.003	1.37	0.256
10(large)	0.49	0.843	2.7	0.011	336.61	0	0.04	0.957

Diagnostic test real businesss cycle model

Table 11: Diagnostics: Real business cycle model

	ARCH test	p-value	AR test	p-value	Normality test	p-value	hetero test	p-value
Book To Market portfolios (value weighted)								
1st period								
1(low)	0.59	0.761	1.06	0.395	7.60	0.022	0.35	0.963
2	2.71	0.012	0.42	0.885	14.93	0.001	8.50	0.000
3	2.44	0.023	1.24	0.285	6.42	0.040	1.75	0.078
4	0.40	0.899	1.23	0.292	13.98	0.001	0.70	0.722
5	1.51	0.171	1.16	0.333	20.68	0.000	3.05	0.002
6	0.06	1.000	1.36	0.229	67.89	0.000	1.06	0.397
7	3.18	0.004	3.79	0.001	20.60	0.000	1.53	0.136
8	2.18	0.041	1.20	0.308	3.22	0.200	1.47	0.159
9	1.55	0.159	0.89	0.516	9.53	0.009	4.05	0.000
10(high)	0.54	0.804	0.82	0.569	15.56	0.000	1.44	0.171
2nd period								
1(low)	0.32	0.945	2.71	0.011	121.82	0.000	5.80	0.000
2	0.06	1.000	0.77	0.610	437.03	0.000	0.90	0.531
3	1.67	0.120	0.45	0.867	56.96	0.000	9.20	0.000
4	0.37	0.920	1.79	0.092	67.25	0.000	6.54	0.000
5	0.99	0.443	1.15	0.331	27.31	0.000	4.67	0.000
6	4.61	0.000	3.39	0.002	74.50	0.000	2.16	0.022
7	0.06	1.000	0.75	0.628	18.39	0.000	3.52	0.000
8	3.96	0.001	0.95	0.470	53.18	0.000	6.43	0.000
9	0.64	0.721	2.54	0.016	42.00	0.000	6.14	0.000
10(high)	1.34	0.232	1.17	0.323	25.18	0.000	0.93	0.510
Book To Market portfolios (equally weighted)								
1st period								
1(low)	0.40	0.903	1.04	0.409	13.69	0.001	0.57	0.836
2	0.97	0.454	1.04	0.410	5.80	0.055	2.10	0.030
3	2.84	0.009	1.09	0.375	17.49	0.000	1.10	0.365
4	0.33	0.937	0.91	0.500	5.74	0.057	1.76	0.075
5	0.79	0.594	1.43	0.201	5.29	0.071	1.56	0.127
6	0.04	1.000	0.44	0.875	215.26	0.000	1.60	0.115
7	3.16	0.004	0.77	0.614	6.24	0.044	1.22	0.286
8	3.62	0.002	1.47	0.187	16.30	0.000	5.45	0.000
9	1.08	0.383	0.33	0.941	7.64	0.022	2.47	0.010
10(high)	2.86	0.009	1.97	0.066	38.21	0.000	2.95	0.002
2nd period								
1(low)	2.20	0.037	1.45	0.188	24.25	0.000	3.23	0.001
2	0.11	0.998	1.32	0.243	82.84	0.000	1.51	0.140
3	0.79	0.598	2.29	0.030	3.85	0.146	2.45	0.009
4	2.01	0.056	1.15	0.334	117.55	0.000	0.99	0.454
5	0.67	0.698	0.95	0.467	4.56	0.102	1.53	0.132
6	1.33	0.240	0.80	0.586	19.46	0.000	4.98	0.000
7	1.44	0.192	2.16	0.040	13.12	0.001	1.01	0.434
8	0.35	0.929	1.21	0.297	3.59	0.166	1.46	0.156
9	1.25	0.278	0.71	0.665	2.25	0.325	2.36	0.012
10(high)	2.20	0.036	0.46	0.863	13.19	0.001	0.91	0.529

Table 11: Diagnostics: Real business cycle model

	ARCH test	p-value	AR test	p-value	Normality test	p-value	hetero test	p-value
momentum portfolios (value weighted)								
1st period								
1(low return)	0.29	0.956	0.35	0.930	6.65	0.036	1.79	0.069
2	3.03	0.006	1.21	0.305	17.06	0.000	3.99	0.000
3	4.22	0.000	0.73	0.645	3.53	0.171	1.33	0.225
4	5.47	0.000	1.04	0.407	19.04	0.000	7.95	0.000
5	1.14	0.344	2.29	0.032	0.66	0.718	2.30	0.017
6	0.69	0.684	1.79	0.097	1.98	0.371	1.13	0.344
7	1.85	0.084	0.27	0.966	0.82	0.663	2.12	0.028
8	1.00	0.433	0.45	0.869	5.75	0.057	1.19	0.303
9	1.17	0.326	0.14	0.995	50.64	0.000	3.11	0.002
10(high return)	1.10	0.368	1.08	0.379	5.41	0.067	2.04	0.036
2nd period								
1(low return)	1.08	0.380	2.58	0.015	26.05	0.000	2.02	0.033
2	0.01	1.000	0.38	0.912	7530.90	0.000	6.15	0.000
3	2.12	0.043	3.19	0.003	23.37	0.000	6.10	0.000
4	0.85	0.547	0.72	0.652	6.61	0.037	5.10	0.000
5	4.73	0.000	0.74	0.637	73.27	0.000	8.42	0.000
6	0.98	0.444	0.75	0.626	37.40	0.000	2.45	0.009
7	0.40	0.901	0.81	0.581	103.31	0.000	1.86	0.053
8	8.79	0.000	2.85	0.008	49.80	0.000	8.29	0.000
9	0.97	0.452	0.57	0.783	54.84	0.000	3.20	0.001
10(high return)	0.61	0.744	1.46	0.186	164.34	0.000	7.33	0.000
momentum portfolios (equally weighted)								
1st period								
1(low return)	0.40	0.901	1.35	0.232	36.18	0.000	0.81	0.617
2	3.87	0.001	1.52	0.166	20.99	0.000	4.28	0.000
3	2.11	0.048	1.27	0.269	1.95	0.378	1.64	0.105
4	0.29	0.956	0.71	0.660	50.80	0.000	2.24	0.020
5	0.61	0.747	0.18	0.989	3.06	0.217	3.64	0.000
6	0.89	0.515	0.63	0.733	3.92	0.141	0.49	0.893
7	2.01	0.060	1.42	0.205	5.27	0.072	2.19	0.023
8	2.45	0.023	1.08	0.383	0.28	0.869	4.79	0.000
9	0.55	0.799	1.17	0.325	0.29	0.865	0.95	0.489
10(high return)	0.86	0.541	0.56	0.789	16.34	0.000	1.12	0.352
2nd period								
1(low return)	1.52	0.163	1.12	0.349	28.46	0.000	4.02	0.000
2	0.03	1.000	0.80	0.587	153.46	0.000	0.43	0.933
3	0.40	0.901	1.78	0.094	19.64	0.000	1.89	0.049
4	2.57	0.015	0.78	0.603	7.58	0.023	4.23	0.000
5	1.27	0.270	1.10	0.365	30.08	0.000	7.03	0.000
6	1.69	0.114	1.15	0.336	2.47	0.291	2.35	0.013
7	0.60	0.754	1.42	0.198	2.70	0.260	3.68	0.000
8	2.56	0.015	1.58	0.142	10.49	0.005	3.24	0.001
9	2.46	0.019	0.91	0.499	65.71	0.000	1.40	0.183
10(high return)	0.51	0.823	0.75	0.634	23.26	0.000	3.30	0.001

Table 11: Diagnostics: Real business cycle model								
	ARCH test	p-value	AR test	p-value	Normality test	p-value	hetero test	p-value
				industry portfolios (value weighted)				
1st period								
energy	1.14	0.346	0.85	0.545	2.75	0.253	1.89	0.053
materials	1.79	0.096	0.37	0.919	24.71	0.000	6.18	0.000
industry	4.26	0.000	0.92	0.493	8.53	0.014	4.01	0.000
Cons. Disc.	0.77	0.610	2.02	0.058	11.21	0.004	2.29	0.017
Cons. Staples	2.21	0.038	1.43	0.201	1.18	0.554	3.84	0.000
Health	1.23	0.291	0.72	0.658	4.77	0.092	0.75	0.675
Financials	0.33	0.941	1.04	0.410	25.96	0.000	0.52	0.873
IT	0.71	0.662	0.29	0.957	21.56	0.000	0.86	0.572
2nd period								
energy	3.01	0.005	1.74	0.103	75.56	0.000	5.93	0.000
materials	0.55	0.798	2.82	0.008	242.63	0.000	5.66	0.000
industry	0.19	0.988	1.20	0.304	54.58	0.000	5.28	0.000
Cons. Disc.	4.15	0.000	2.14	0.042	82.72	0.000	8.96	0.000
Cons. Staples	1.37	0.222	1.75	0.100	21.72	0.000	4.32	0.000
Health	0.00	1.000	0.35	0.927	12464.00	0.000	6.15	0.000
Financials	1.48	0.177	0.68	0.690	10.34	0.006	6.30	0.000
IT	0.05	1.000	1.76	0.097	180.63	0.000	4.33	0.000
				industry portfolios (equally weighted)				
1st period								
energy	0.55	0.795	1.07	0.387	2.68	0.262	1.15	0.329
materials	0.76	0.619	1.74	0.106	53.41	0.000	0.84	0.594
industry	0.93	0.483	0.73	0.643	0.46	0.793	1.74	0.079
Cons. Disc.	1.56	0.153	1.11	0.364	12.25	0.002	2.28	0.018
Cons. Staples	0.52	0.815	0.86	0.537	2.85	0.240	2.36	0.014
Health	0.58	0.770	0.63	0.732	6.28	0.043	2.11	0.029
Financials	1.59	0.146	2.51	0.019	17.98	0.000	1.45	0.166
IT	2.80	0.010	0.70	0.675	9.20	0.010	0.67	0.751
2nd period								
energy	3.07	0.004	1.01	0.429	28.91	0.000	4.19	0.000
materials	0.41	0.898	3.52	0.001	552.50	0.000	6.18	0.000
industry	0.72	0.658	2.05	0.051	1.88	0.392	2.34	0.013
Cons. Disc.	3.16	0.004	2.67	0.012	134.59	0.000	6.84	0.000
Cons. Staples	1.73	0.105	1.04	0.407	3.91	0.142	2.09	0.027
Health	0.01	1.000	0.36	0.922	2877.50	0.000	0.60	0.812
Financials	1.00	0.436	1.10	0.367	5.28	0.072	2.16	0.022
IT	2.30	0.028	1.66	0.122	23.72	0.000	1.97	0.039

Table 11: Diagnostics: Real business cycle model								
	ARCH test	p-value	AR test	p-value	Normality test	p-value	hetero test	p-value
Size portfolios (Equally weighted)								
1st period								
1(small)	0.75	0.628	1.77	0.099	23.89	0.000	0.35	0.966
2	0.90	0.512	1.16	0.329	15.44	0.000	2.29	0.018
3	5.73	0.000	1.30	0.259	19.09	0.000	5.49	0.000
4	4.75	0.000	1.60	0.143	17.62	0.000	5.25	0.000
5	0.49	0.841	1.44	0.196	2.03	0.362	1.97	0.043
6	5.51	0.000	1.34	0.240	7.33	0.026	3.34	0.001
7	0.07	0.999	0.89	0.513	63.14	0.000	2.41	0.012
8	1.99	0.062	1.63	0.134	28.83	0.000	4.47	0.000
9	3.39	0.003	0.87	0.534	8.78	0.012	2.98	0.002
10(large)	1.95	0.068	0.66	0.708	14.44	0.001	0.83	0.604
2nd period								
1(small)	0.73	0.647	0.33	0.937	7.68	0.022	0.74	0.684
2	1.05	0.400	1.84	0.081	13.95	0.001	4.77	0.000
3	1.14	0.341	3.55	0.001	22.25	0.000	1.39	0.186
4	4.67	0.000	0.52	0.821	19.85	0.000	2.28	0.015
5	0.84	0.552	1.11	0.361	32.48	0.000	4.77	0.000
6	5.06	0.000	3.78	0.001	12.65	0.002	4.40	0.000
7	1.08	0.379	3.08	0.004	4.71	0.095	1.37	0.198
8	0.96	0.459	0.89	0.516	83.26	0.000	1.68	0.088
9	0.98	0.444	2.27	0.031	10.73	0.005	5.56	0.000
10(large)	0.43	0.880	2.46	0.020	330.92	0.000	0.52	0.873

F-test of joint significance of the real business cycle variables (December 1985 - June 1996 and July 1996 - December 2012)

Table 12: F-tests

1st period	SSRur (real)	SSRr (CAPM)	q	n-k-1	F-value	2nd period	SSRur (real)	SSRr (CAPM)	q	n-k-1	F-value
bm1vwrf	0.356	0.371	4	121	1.275	bm1vwrf	0.625	0.646	4	192	1.647
bm2vwrf	0.318	0.377	4	121	5.567	bm2vwrf	1.398	1.418	4	192	0.690
bm3vwrf	0.224	0.225	4	121	0.155	bm3vwrf	0.455	0.469	4	192	1.483
bm4vwrf	0.298	0.301	4	121	0.262	bm4vwrf	0.380	0.393	4	192	1.711
bm5vwrf	0.325	0.337	4	121	1.064	bm5vwrf	0.367	0.378	4	192	1.416
bm6vwrf	0.377	0.396	4	121	1.513	bm6vwrf	0.512	0.517	4	192	0.452
bm7vwrf	0.443	0.467	4	121	1.611	bm7vwrf	0.534	0.545	4	192	0.995
bm8vwrf	0.402	0.437	4	121	2.593	bm8vwrf	0.592	0.634	4	192	3.374
bm9vwrf	0.478	0.494	4	121	1.021	bm9vwrf	0.492	0.560	4	192	6.730
bm10vwrf	0.557	0.594	4	121	2.020	bm10vwrf	0.712	0.807	4	192	6.372
bm1ewrf	0.276	0.285	4	121	1.039	bm1ewrf	0.393	0.408	4	192	1.840
bm2ewrf	0.160	0.167	4	121	1.281	bm2ewrf	0.420	0.432	4	192	1.483
bm3ewrf	0.139	0.150	4	121	2.424	bm3ewrf	0.207	0.217	4	192	2.230
bm4ewrf	0.279	0.288	4	121	1.035	bm4ewrf	0.244	0.247	4	192	0.661
bm5ewrf	0.271	0.285	4	121	1.647	bm5ewrf	0.136	0.146	4	192	3.313
bm6ewrf	0.447	0.462	4	121	1.038	bm6ewrf	0.202	0.202	4	192	0.086
bm7ewrf	0.214	0.220	4	121	0.788	bm7ewrf	0.236	0.244	4	192	1.588
bm8ewrf	0.314	0.335	4	121	2.047	bm8ewrf	0.161	0.166	4	192	1.563
bm9ewrf	0.256	0.261	4	121	0.591	bm9ewrf	0.175	0.186	4	192	3.118
bm10ewrf	0.708	0.714	4	121	0.261	bm10ewrf	0.215	0.229	4	192	3.150
envwrf	0.234	0.252	4	121	2.253	envwrf	0.389	0.394	4	192	0.662
mavwrf	0.334	0.348	4	121	1.266	mavwrf	3.424	3.471	4	192	0.656
invwrf	0.089	0.091	4	121	0.625	invwrf	0.282	0.287	4	192	0.924
cdvwrf	0.713	0.733	4	121	0.842	cdvwrf	1.691	1.724	4	192	0.944
csvwrf	0.285	0.312	4	121	2.901	csvwrf	0.540	0.561	4	192	1.890
hevwrf	0.643	0.688	4	121	2.098	hevwrf	16.236	16.698	4	192	1.365
fivwrf	0.269	0.289	4	121	2.233	fivwrf	0.440	0.451	4	192	1.187
itvwrf	0.663	0.701	4	121	1.755	itvwrf	2.030	2.067	4	192	0.873
enewrf	0.189	0.205	4	121	2.520	enewrf	0.308	0.310	4	192	0.255
maewrf	0.609	0.641	4	121	1.587	maewrf	2.953	2.971	4	192	0.291
inewrf	0.061	0.063	4	121	1.136	inewrf	0.101	0.104	4	192	1.291

Table 12: F-tests											
1st period	SSRur (real)	SSRr (CAPM)	q	n-k-1	F-value	2nd period	SSRur (real)	SSRr (CAPM)	q	n-k-1	F-value
cdewrf	0.254	0.277	4	121	2.755	cdewrf	0.499	0.510	4	192	1.050
csewrf	0.243	0.266	4	121	2.856	csewrf	0.370	0.397	4	192	3.433
heewrf	0.661	0.673	4	121	0.526	heewrf	3.172	3.256	4	192	1.261
fiewrf	0.130	0.141	4	121	2.607	fiewrf	0.078	0.081	4	192	2.034
itewrf	0.365	0.389	4	121	2.028	itewrf	0.565	0.589	4	192	2.024
mo1vwrf	0.358	0.393	4	121	2.955	mo1vwrf	1.085	1.088	4	192	0.111
mo2vwrf	0.834	0.890	4	121	2.019	mo2vwrf	7.721	7.805	4	192	0.522
mo3vwrf	0.362	0.404	4	121	3.497	mo3vwrf	0.590	0.621	4	192	2.515
mo4vwrf	0.378	0.410	4	121	2.597	mo4vwrf	0.498	0.510	4	192	1.183
mo5vwrf	0.201	0.203	4	121	0.337	mo5vwrf	0.429	0.434	4	192	0.586
mo6vwrf	0.217	0.224	4	121	0.861	mo6vwrf	0.359	0.376	4	192	2.260
mo7vwrf	0.188	0.190	4	121	0.360	mo7vwrf	0.527	0.539	4	192	1.068
mo8vwrf	0.164	0.165	4	121	0.172	mo8vwrf	0.353	0.354	4	192	0.105
mo9vwrf	0.216	0.225	4	121	1.261	mo9vwrf	0.473	0.483	4	192	0.986
mo10vwrf	0.231	0.245	4	121	1.881	mo10vwrf	0.699	0.712	4	192	0.887
mo1ewrf	0.248	0.268	4	121	2.376	mo1ewrf	0.381	0.400	4	192	2.401
mo2ewrf	0.515	0.522	4	121	0.409	mo2ewrf	0.535	0.546	4	192	0.955
mo3ewrf	0.224	0.243	4	121	2.644	mo3ewrf	0.224	0.232	4	192	1.800
mo4ewrf	0.240	0.257	4	121	2.154	mo4ewrf	0.154	0.163	4	192	2.649
mo5ewrf	0.124	0.135	4	121	2.458	mo5ewrf	0.176	0.180	4	192	0.964
mo6ewrf	0.123	0.128	4	121	1.254	mo6ewrf	0.108	0.109	4	192	0.390
mo7ewrf	0.125	0.128	4	121	0.687	mo7ewrf	0.144	0.149	4	192	1.683
mo8ewrf	0.121	0.122	4	121	0.175	mo8ewrf	0.149	0.152	4	192	0.952
mo9ewrf	0.123	0.125	4	121	0.530	mo9ewrf	0.245	0.256	4	192	2.212
mo10ewrf	0.266	0.271	4	121	0.577	mo10ewrf	0.317	0.335	4	192	2.819
si1ewrf	0.535	0.561	4	121	1.493	si1ewrf	0.138	0.147	4	192	2.918
si2ewrf	0.262	0.276	4	121	1.659	si2ewrf	0.250	0.255	4	192	0.944
si3ewrf	0.185	0.195	4	121	1.535	si3ewrf	0.190	0.191	4	192	0.066
si4ewrf	0.177	0.188	4	121	1.809	si4ewrf	0.250	0.260	4	192	2.002
si5ewrf	0.139	0.145	4	121	1.458	si5ewrf	0.210	0.216	4	192	1.204
si6ewrf	0.187	0.206	4	121	3.157	si6ewrf	0.172	0.177	4	192	1.622
si7ewrf	0.263	0.272	4	121	0.968	si7ewrf	0.143	0.150	4	192	2.389
si8ewrf	0.213	0.225	4	121	1.716	si8ewrf	0.207	0.209	4	192	0.463
si9ewrf	0.214	0.255	4	121	5.829	si9ewrf	0.199	0.211	4	192	2.757
si10ewrf	0.257	0.292	4	121	4.100	si10ewrf	0.677	0.708	4	192	2.215

Information criteria

I have performed information criteria tests on a few selected portfolios. All the selected portfolios are sorted by the Carhart factors and were found to have an abnormal return in the unconditional model. These portfolios have been selected as it makes it easier to test whether a conditional model removes all abnormal return.

Table 13: Information criteria

	1st period	B/M 4 ew	B/M 9 ew	B/M 10 vw	MOM 2 vw	MOM 10 vw	Size 1 ew	Size 2 ew
ARCH(1)	Log L	295.484	298.117	249.576	206.969	277.980	248.591	293.371
	AIC	-582.969	-588.234	-491.152	-405.939	-547.960	-489.182	-578.741
	BIC	-570.066	-575.331	-478.249	-392.806	-534.828	-476.050	-565.608
GARCH(1,1)	Log L	295.520	299.426	255.539	209.892	278.800	248.089	296.117
	AIC	-581.040	-588.853	-501.078	-409.783	-547.601	-486.178	-582.234
	BIC	-564.911	-572.724	-484.949	-393.367	-531.185	-469.762	-565.818
GARCH (1,2)	Log L	295.556	299.483	256.292	210.450	convergence not achieved	249.166	295.959
	AIC	-579.112	-586.966	-500.585	-408.901		-486.332	-579.918
	BIC	-559.757	-567.612	-481.230	-389.202		-466.632	-560.218
GARCH(2,1)	Log L	convergence not achieved	299.437	259.614	210.975	279.661	249.479	296.156
	AIC		-586.873	-507.228	-409.950	-547.321	-486.959	-580.311
	BIC		-567.519	-487.873	-390.251	-527.622	-467.260	-560.612

	2nd period	MOM 4 ew	size 1 ew	size 9 ew
ARCH(1)	Log L	427.409	432.926	396.679
	AIC	-846.818	-857.852	-785.357
	BIC	-833.665	-844.699	-772.204
GARCH(1,1)	Log L	427.836	434.19	403.657
	AIC	-845.671	-858.379	-797.313
	BIC	-829.23	-841.938	-780.872
GARCH(1,2)	Log L	convergence not achieved	436.041	405.792
	AIC		-860.082	-799.584
	BIC		-840.352	-779.855
GARCH (2,1)	Log L	convergence not achieved	435.884	405.708
	AIC		-859.768	-799.416
	BIC		-840.038	-779.686