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Riding the Yield Curve: is it Beneficial on a Risk-Adjusted Basis?

Exploration of the Norwegian Fixed Income Market

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NORWEGIAN SCHOOL OF ECONOMICS

Abstract

In this paper, we examine if riding the yield curve strategy in the Norwegian fixed income market is beneficial on a risk-adjusted basis. The strategy is based on purchasing an instrument longer than the investor's holding period and selling it at the end of the holding period. This is done in the pursue of higher returns and to capitalise on the fact that long-term rates are typically higher than short-term rates. It is compared to a buy-and-hold strategy, where the investor buys instruments with maturity equal to their holding period.

Our results show that riding the yield curve does provide excess returns compared to a buy-and-hold strategy, where returns can be enhanced with timing strategies. Excess returns from riding the yield curve, however, comes with increased risk. Nonetheless, a timing strategy based on the slope of the yield curve obtains some positive alphas. This strategy provides, on average, 4.29 percent in annualised excess returns when a ten-year instrument is ridden over a two-year holding period.

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Through courses at NHH, an interest of the fixed income market sparked, which affected our choice in topic. As the Norwegian fixed income market is a growing market, we find it highly interesting to examine the opportunities within it. The process of writing this thesis has given us a deeper insight and knowledge about the Norwegian fixed income market. Moreover, we have learned how to handle large amounts of data by utilising Excel, VBA, and STATA.

We would like to thank our supervisor, Darya Yuferova, for providing guidance and invaluable feedback through the process. Additionally, we would like to express our gratitude to friends and family, who have supported us through a challenging and exciting semester.

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1. Introduction

The name “fixed income” hints to instruments which promise a fixed stream of income, like a debt agreement that states on the entry date a promise of future cash flows. In practice, however, they can be far from fixed, opening for exciting investment opportunities (Bodie et al., 2018). The Norwegian fixed income market is a growing market, where there are such opportunities (Norges Bank, 2020a). With this as a starting point, this thesis will examine whether a simple investment strategy, called “riding the yield curve”, is beneficial on a risk-adjusted basis in the Norwegian fixed income market.

Riding the yield curve is a strategy based on purchasing an instrument longer than the investor’s holding period, and selling it at the end of the holding period (Bieri and Chincarini, 2005). This is done as longer instruments typically have higher rates, providing the investor higher profits (Shiller and McCulloch, 1987). A common alternative is a buy-and-hold strategy, where investors buy instruments with time to maturity equal to their holding period. If riding the yield curve turns out to yield higher returns than a buy-and-hold strategy, it will contradict with the rationale of the expectations hypothesis of the term structure, stating that long-term interest rates are the average of the current and expected future short-term rates (Chua et al., 2006). This further implies that there is a liquidity premium that can be exploited, in accordance with the liquidity preference theory (Bodie et al., 2018).

However, the possibility of gaining excess returns comes with increased risk. If the investor chooses to implement a buy-and-hold strategy, the returns are known when the investment is initiated, given that the issuer can meet his obligations. Implementing a riding strategy implies that, given the same issuer, the investor will not know the realised returns before the end of the investor’s holding period. If interest rates stay at the same level, or fall, riding the yield curve will, all else equal, provide excess returns. An increase in interest rates, however, will incur a loss for the investor.

The largest investors in the Norwegian fixed income market are pension funds, insurance companies, banks and mutual funds (Norges Bank, 2020a). Usually, pension funds and insurance companies implement a buy-and-hold strategy with long-term instruments containing low default risk. Moreover, banks tend to invest in liquid instruments to hedge for liquidity problems. Ultimately, mutual funds invest in line with their customers’ preferences, implying that their risk-profile may vary (Norges Bank, 2020a). Thus, three out of the four largest investors in the Norwegian fixed income market invest here due to their low risk profile. With this thesis, we hope to attract investors with a higher risk profile, by presenting the opportunities within the fixed income market.

This paper concentrates on the corporate bond market from 04.01.2004 to 31.12.2019, where a benchmark is constructed with zero-coupon rates derived from swap rates. Moreover, an unconditional strategy is examined, to see whether riding the yield curve in fact yields excess returns over a buy-and-hold strategy. Furthermore, simple timing strategies are examined, which goal is to predict future movements of the yield curve, hence increase excess returns. The timing strategies are based on utilising the positive cushion and the mean-reversion of the yield curve as filter rules. More precisely, the positive cushion is the difference between the current rate and a calculated break-even rate, stating a riding signal whenever it is higher than a certain percentile of choice. The mean-reverting timing strategies are based on that the current yield level, slope, or curvature mean-reverts to an historical average, asserting a riding signal whenever it is higher than the average. Ultimately, a risk factor regression is performed with a term premium factor, default premium factor and a liquidity factor to analyse how excess returns are exposed to these risk factors, and hence how the strategy performs, on a risk-adjusted basis. Returns from the Norwegian stock market index, OBX, are also included in the model to measure how a riding strategy performs compared to investing in the OBX.

Our results show that riding the yield curve does yield excess returns compared to a buy-and-hold strategy. Furthermore, excess returns increase with longer instruments and stabilise with longer holding periods, in line with the findings of Aspelien and Geving (2016) and Bieri and Chincarini (2005). We find that timing the strategy based on the slope of the yield curve improves excess returns, especially for longer holding periods, disagreeing with the findings of the papers mentioned above. E.g., the strategy obtains on average 1.45 percentage points higher annualised returns than unconditional riding when a ten-year instrument is ridden over two years. Aspelien and Geving (2016), on the other hand, obtain on average 0.03 percentage points lower annualised returns than unconditional riding with the same instrument and holding period in the Norwegian government securities market. However, the condition in our strategy differs from theirs, as we focus on the mean-reversion of the slope. This paper further finds that a timing strategy based on the mean-reversion of curvature is not a good predictor of future changes of the yield curve, disagreeing with the findings of Chua et al. (2006). Ultimately, our findings show that excess returns primarily are due to higher exposure to risk factors, agreeing with the findings of Grieves et al. (1999).

The paper is divided into six parts. Section two presents the theoretical framework of the paper and reviews the existing literature on the topic. Furthermore, section three presents how and from where we have collected relevant data. Section four and five present the empirical methodology of our thesis and our results, respectively. Ultimately, in section six, we conclude the findings of this paper.

2. Theoretical Framework

2.1 The Yield Curve

To understand the reasoning behind riding the yield curve, it is necessary to comprehend the yield curve, also known as the term structure of interest rates. The yield curve is a graphical illustration of the relationship between yield to maturity and time to maturity (Bodie et al., 2018). Hence, it shows how the yields differ between different maturities. The yield curve is both used to value bonds and seen as the market expectations on future interest rates. By comparing the current yield curve and one's future expectations, investors can take bets to gain profits. For instance, riding the yield curve takes such bets by utilising the upwards slope of the yield curve. Furthermore, this paper takes additional bets by implementing different timing strategies to the riding, aiming to take advantage of the yield curve's current shape.

The shape of the yield curve varies. Shiller and McCulloch (1987) show that an upward sloping term structure is the most common form, which means that long-term interest rates are higher than short-term interest rates. However, the yield curve can be inverted, meaning that short-term interest rates exceed long-term interest rates. Furthermore, the yield curve can have a hump shape, which implies that intermediate terms have the highest interest rates. Ultimately, the yield curve can be flat, meaning that all interest rates are equal. In finance literature, these shapes of the yield curve are commonly described by estimates of the level, slope and the curvature of the yield curve (Afonso and Martins, 2010). The level indicates how high the rates are, the slope indicates the difference between long-term and short-term rates, whilst the curvature represents the form of the yield curve. These estimations can be used to estimate variations in the yield curve, which this paper will attempt to exploit (Sundaresan, 2009). The two following subsections elaborate on two theories regarding the term structure, its behaviour and how it can be interpreted, namely the expectations hypothesis and the liquidity preference theory.

2.1.1 The Expectations Hypothesis

The expectations hypothesis is a well-known theory of the yield curve, which states that the forward rates equal the markets expectations of future short interest rates (Bodie et al., 2018). This means that long-term bonds solely reflect the average of expected future short rates. The fact that long-term interest rates typically are higher than short-term is explained by investors' expectations that interest rates will increase, not by a term premium. One should therefore be indifferent between buying long-term bonds and short-term bonds. Hence, this hypothesis contradicts with a riding strategy. If the expectations hypothesis holds, riding the yield curve and a buy-and-hold strategy should yield the same return. Thus, by performing a riding the yield curve strategy, we are also testing if the expectations hypothesis holds.

Previous studies indicate that the expectations hypothesis does not hold. E.g., the findings of Fama and Bliss (1987) indicate that there is a time-varying term premium, which contradicts with the expectations hypothesis. Bieri and Chincarini (2005) obtain the same result by performing riding the yield curve in the U.S. market. Therefore, this paper looks at another yield curve theory, namely the liquidity preference theory. By doing so, we obtain a better understanding of the yield curve, and can more thoroughly explain the motivation behind riding the yield curve.

2.1.2 The Liquidity Preference Theory

The liquidity preference theory states that investors have a preference regarding their holding period and need to be compensated to change it. Thus, short-term investors would need a premium to hold long-term bonds, and vice versa for long-term investors (Bodie et al., 2018). The liquidity preference theory believes the market is dominated by short-term investors, and since interest rates depend on supply and demand, long-term bonds typically have a positive liquidity premium. Thus, the fact that the yield curve is mostly upward sloping is due to long-term bonds obtaining a premium. It also states that issuers of bonds prefer to issue long-term bonds, as higher supply will reduce the price, hence the yields increase as they have an inverted relation.

There is a resemblance with the expectations hypothesis, in the matter that both theories believe that long-term interest rates are an average of future short rates. However, only the liquidity preference theory believes that there is an additional premium compensating for liquidity preferences (Bodie et al., 2018). A riding the yield curve strategy will attempt to exploit this premium, by buying bonds with longer maturities than the investor’s holding period. It is therefore of great importance for our research. In the next section, we will further discuss the yield curve utilised in this paper.

2.2 The Swap Curve

Financial instruments are commonly priced in relation to comparable investment opportunities. When finding the yield on a corporate bond, it can be priced as the yield with the same maturity from the yield curve, with an added premium, reflecting the additional default- and liquidity risk (Rakkestad and Hein, 2004). Hence, finding a decent and reliant yield curve is of great importance in an efficient financial market. To do so, government securities or swap rates can be utilised, where this thesis utilises swap rates.

Swap rates occur from interest rate swaps, which is a mutual agreement between two parties in transferring interest rates from floating to fixed (or vice versa) on an agreed principal over a fixed time space (Haug, 1995). Typically, the floating rate is the three- or six-month NIBOR. The fixed rate is referred to as the swap rate and is set to reflect the present value of expected future floating rates. Hence, the value of the contract under initiation is zero, and no principal is exchanged between the two parties. These rates will be utilised to construct the yield curve in this thesis. In the next section, existing literature on riding the yield curve is presented to provide an overview of various outcomes from the strategy.

2.3 Riding the Yield Curve

There is a significant amount of existing literature on the topic of riding the yield curve, with various outcomes. Some studies, see for example Bieri and Chincarini (2005), say that the strategy is profitable, whilst others, see Pelaez (1997), come with the conclusion that the strategy is not that profitable, taken risk into account. The ambiguous findings of different studies have been the main motivation for us to further dig into if this yield curve trading strategy in fact can yield excess risk-adjusted returns.

Among the studies implying that riding the yield curve is profitable, we first have Grieves and Marcus (1992), who finds that riding the yield curve with six-month bills stochastically dominates a buy-and-hold strategy over a three-month holding period. However, they find that riding longer bills with longer holding periods do not offer enhanced excess returns over a buy-and-hold strategy, after adjusting for risk. Ang et al. (1998) disagree with Grieves and Marcus' (1992) main findings, where they are not able to find that riding the yield curve stochastically dominates a buy-and-hold strategy in their sample period. Hence, their findings state that higher returns from riding primarily come from greater risk.

Furthermore, (Grieves et al., 1999) finds that riding the bill curve over a ten year period, from January 1987 to April 1997, on average enhances returns over a given holding period versus a buy-and-hold strategy. They also find that increased returns come from increased risk, however they state that only the most risk-averse investors would reject such a strategy.

Together with Bieri and Chincarini (2005), Aspelien and Geving (2016) find a clear tendency in that excess returns increase with the maturity of the riding instrument. More specifically, Aspelien and Geving (2016) study the strategy, both conditional and unconditional, in the Norwegian government bonds and bills market. Their findings also state that all conditional and unconditional strategies, on average, yield excess holding period returns. Furthermore, Bieri and Chincarini (2005) finds that riding the yield curve provides excess returns for U.S. Treasuries (data from April 1982 to December 2003) and German government securities (data from January 1973 to December 2003). In addition, they show that riding the yield curve beats a buy-and-hold strategy on a risk-adjusted basis, by introducing the concept of duration-neutral riding.

Chua et al. (2006) examine the profitability of other yield curve trading strategies that are based on the view that the yield curve mean-reverts towards an historical average. Moreover, they find that several yield curve trading strategies are significantly profitable. They find that especially the mean-reversion of yield slopes and curvatures significantly outperformed common benchmark investment strategies, on a risk-adjusted basis.

Pelaez (1997), on the other hand, finds that one-year rides with two-year bonds produce higher average returns, but not excess risk-adjusted returns. According to his research, the excess returns from riding mainly represent term premiums to compensate for excessive risk-taking, instead of pure profits. Therefore, he concludes that riding the yield curve is not a superior investment strategy.

The indistinct findings on this topic have been the main motivation for us to further scrutinise it. What most research has in common is that riding the yield curve certainly increases returns compared to a buy-and-hold strategy. However, it seems to be a disagreement regarding the excessive risk taken from riding the yield curve, and hence how the strategy performs, on a risk-adjusted basis. Additionally, the research on the topic in the Norwegian market is minimal. Therefore, we found it highly interesting to build on this and provide more research regarding the strategy in the Norwegian fixed income market.

2.4 Riding Strategies

Before the conditional riding strategies are examined, an unconditional riding strategy is scrutinised in our sample period, hence 2004-2019. This is done to see if riding the yield curve yields excess returns over a buy-and-hold strategy. If we find out that it does, this will contradict with the expectations hypothesis, and thereby motivate for further investigation of riding the yield curve.

After riding the yield curve unconditionally, the paper will examine different timing strategies. The timing strategies, which are based on easy-to-implement filter rules, will define whether we should be riding at a given point in time. Furthermore, the performance will be compared to the unconditional riding strategy. This is done to see if they provide good predictions of future changes in the yield curve. Our filter rules are inspired by Bieri and Chincarini (2005) and Chua et al. (2006) and will be reviewed in the following subsections.

2.4.1 Positive Cushion Timing Strategies

Before entering a riding strategy, it can be wise to quantify the risk associated with it (Bieri and Chincarini, 2005). By calculating the break-even rate, the investor can see how much the rate must increase before a loss is incurred. The difference between this break-even rate and the current rate will be referred to as the positive cushion. Hence, the cushion can be utilised to compare the investors' expectations against the markets, evaluating if the investor finds the investment worthwhile. In our thesis, we believe that when the cushion is high, there is a lower risk of incurring a loss, as the rates must increase with a greater magnitude.

For this strategy, three different percentiles of the cushion are examined. The percentile indicates how many percent of the observations that are lower than the current value. For instance, a 70^{th} percentile indicates that 70 percent of the cushions in the dataset are lower than the current cushion. If the current cushion is higher than the percentile condition, it is a riding signal. Aspelien and Geving (2016) have already applied this conditional strategy in the Norwegian government securities market with the 75^{th} percentile constraint. This thesis will strengthen their findings by testing and comparing two additional constraints, namely the 70^{th} and 80^{th} percentile. The idea is that when the cushion lies outside its two-year moving conditional percentile, the risk of incurring a loss will be reduced. In addition, we believe a higher percentile will further lower the risk.

2.4.2 Mean-Reverting Timing Strategies

Mean-reverting trading strategies are based on the theory that the yield curve deviates from an historical average, before it mean-reverts (Chua et al., 2006). Previous research support the theory, see for example Campbell and Shiller (1991). Therefore, deviations can be used to predict changes in the yield curve, hence investment opportunities. Chua et al. (2006) has this theory as their starting point to take strategical positions on the yield curve in their pursue of gaining profits. We are aiming to expand their research by examining the riding strategy based on the yield curve's deviation from its historical average. By comparing the level, slope, and curvature of the current yield curve to the historical average, we believe to find predicting signals that can be exploited.

We are examining three different timing strategies based on the mean-reversion of the yield curve. The first strategy is based on the level of the yield curve. If the level is higher than the historical average, our hypothesis is that yields will fall, implying that investors will benefit from riding the yield curve. On the other hand, when the levels are lower than its average, we believe they will increase, and will therefore not be riding.

Second, the slope of the yield curve is examined. If the slope is higher than its historical average, our hypothesis is that it will fall, signalling that riding the yield curve is beneficial. If the slope is lower than its average, however, we believe the curve will increase, and will therefore not be riding.

The last strategy is based on the curvature of the yield curve. If the curvature is higher than its historical average, we believe that the curvature will fall. Thus, our hypothesis is that it is beneficial to ride when the curvature is higher than its average, and vice versa.

2.5 Risk Factors

Riding the yield curve is a riskier investment strategy than a buy-and-hold strategy. If an investor implements a buy-and-hold strategy, the magnitude and timing of the cash flows are known at the time of investment. The only uncertainty is whether the loan-issuer can meet their obligations or not, hence the risk of default. Riding the yield curve, on the other hand, implies that investors sell the instrument at the end of their holding period, instead of waiting for the face value at the maturity date. Hence, the investor is more exposed to risk factors from the market that influences the price of the bond when it is about to be sold. Such risk factors are the interest rate risk, default risk and liquidity risk, which is further elaborated in the subsequent subsections.

2.5.1 Interest Rate Risk

The price of a bond and its yield has an inverted relationship. If yields fall, the price of the bond increases, and vice versa (Berk and DeMarzo, 2016). If an investor implements a buy-and-hold strategy, this is irrelevant, as the investor holds the bond until maturity. Riding the yield curve, on the other hand, implies that investors buy bonds or bills with longer maturities than their holding period. If yields decrease, the price of the bond will increase and provide an excess return over a buy-and-hold strategy. If yields increase, however, the price of the bond will fall, which can result in a loss. Longer instruments are more sensitive to interest rate risk, meaning that a ten-year instrument will drop more in value than a one-year instrument if yields increase. Thus, investors are exposed to interest rate risk which increases with longer instruments, opposed to the buy-and-hold strategy.

2.5.2 Default Risk

In the market for corporate bonds, investors are compensated for bearing default risk, i.e., the risk related to the likelihood of default for corporate bonds. This is widely referred to as the default risk premium (Asvanunt and Richardson, 2017). Asvanunt and Richardson (2017) emphasise that the default risk premium varies with economic growth and inflation expectations. Intuitively, in times of high economic growth and high inflation expectations, credit spreads fall. Thus, investors will be less compensated for default risk than in times of low economic growth and low inflation.

2.5.3 Liquidity Risk

In an illiquid market, there is a risk that investors cannot sell their instruments at a fair price. Hence, they are forced to lower the price of their instruments to be able to sell. This risk is referred to as liquidity risk (Evjen et al., 2017). For a riding the yield curve strategy, this is an important risk factor to adjust for, since the investor is reliant on selling the instrument, whilst it will not affect a buy-and-hold strategy. Moreover, the liquidity of the market can reflect changes in the economic condition of an economy. In economic crises, investors tend to move from the stock market to high rated fixed income, hence increase the liquidity in the fixed-income market (Goyenko and Ukhov, 2009).

2.5.4 Risk Factor Model

In 1952, Harry Markowitz laid the groundwork of modern portfolio management. Twelve years later, Sharpe (1964), Lintner (1965) and Mossin (1966) introduced the world of finance to the capital asset pricing model (CAPM). This model provides a prediction of how the relationship is between the risk of an asset and its expected return (Bodie et al., 2018). Fama and French have formulated a three-factor model based on the CAPM for the stock market, to obtain a better estimation of how risk premiums are captured. Moreover, Fama and French (1993) have also formulated a risk factor model which scrutinises what risk factors that mainly drive excess returns in bond markets. Inspired by them, this paper attempts to expand their risk factor model on bonds to obtain a broader understanding of the risk related to riding the yield curve.

The fixed income factor model of Fama and French includes two factors: a term premium factor and a default premium factor. Also, it includes a constant term, Jensen's Alpha, hereafter referred to as alpha (Jensen, 1967). The term premium factor is the risk related to unexpected changes in interest rates. Furthermore, the default premium factor is the risk related to shifts in economic conditions that change the likelihood of default for corporate bonds. In line with the above elaboration, Fama and French emphasise that the term- and default premium factors are the main drivers of returns in the fixed income market (Fama and French, 1993). Additionally, two factors are considered. This is done to further build on the model of Fama and French (1993). First, a liquidity factor is added to see whether excess returns from riding can be explained by liquidity risk. This liquidity factor must not be mistaken with the liquidity premium from the liquidity preference theory. Second, returns from the stock market index, OBX, is added to measure the performance of a riding strategy compared to it.

Moreover, Jensen (1967) introduced alpha as an absolute measure, meaning that it measures the performance against an absolute standard. It indicates if the investment is good or bad, not only how it performs against competing alternatives. Going more in depth, alpha represents excess returns based on selection- or timing bets (Dopfel, 2004). Dopfel (2004) further elaborates that selection bets refer to the selection of specific securities based on what the investor believes will yield greater returns than its benchmark. In our case, an investor selects a specific riding instrument based on his belief that it will yield greater returns than a buy-and-hold strategy. Timing bets are based on forecasting the shape of the yield curve. Thus, an active investor will choose when and what to ride in the pursue of risk-adjusted excess returns.

3. Data

The sample period of this paper ranges from 02.01.2004 to 31.12.2019. We utilised Bloomberg to extract daily swap closing rates and NIBOR closing rates for our sample period, including rates back to 04.01.1994 to avoid look-ahead bias for the timing strategies, see table 1. The swap rates are the fixed rates on six-month NIBOR-related interest rate swaps from one to ten years. Furthermore, the rates extracted are single quotes which apply to all corporates. We attained NIBOR rates for one week, one month, two months, three months, and six months, all annualised rates. NIBOR is not traded at holidays, while some of the swaps have observations on holidays. This thesis is testing a trading strategy and the data is therefore sorted for trading days, resulting in 6312 observations.

Furthermore, to calculate the proxies for the risk factor model, we have collected relevant data from the Norwegian Central Bank's web pages (Norges Bank, 2020b). More specifically, we have collected daily ten-year government bond rates and daily three-month government bills rates from 02.01.2004 to 31.12.2019, see table 1. Moreover, we have utilised the liquidity factor, *LIQ*, and OBX daily returns calculated by Bernt Arne Ødegaard, obtained from his home page (Ødegaard, n.d.). Ødegaard is a renowned finance professor in Norway, currently working at the University of Stavanger. His work is frequently utilised and referred to in Norwegian research. Therefore, we find it credible to apply his calculations to our model.

To adjust for outliers in our returns, the winsorization method is performed. This method is based on equalling the returns higher than the 99th percentile to the 99th percentile, likewise for returns lower than the 1st percentile (Ghosh and Vogt, 2012). Our results have also been run prior to winsorizing, obtaining similar results.

In the two following subsections, we discuss a common approach to constructing the yield curve, namely based on government securities, and why this is not the best fit for the Norwegian market. Hence, we elaborate on why we have chosen to construct a benchmark yield curve based on swap data.

Table 1: Descriptive statistics of extracted swap- and NIBOR-data

The first column contains the maturity of different instruments. Mean, standard deviation, min and max are respective values for interest rates in the period 04.01.1994-31.12.2019. They are annualised and presented in percent.

	Extracted Swap- and NIBOR-Data				
Maturities	Mean	S.D.	Min	Max	Obs.
NIBOR					
1 week	3.47	2.24	0.50	10.29	6,339
1 month	3.50	2.21	0.55	14.65	6,343
2 month	3.54	2.18	0.66	10.18	6,342
3 month	3.59	2.15	0.71	10.26	6,343
6 month	3.68	2.10	0.82	9.03	6,343
Swaps					
1 year	3.58	2.07	0.86	8.08	6,040
2 year	3.87	2.04	0.78	8.38	6,420
3 year	4.00	2.00	0.79	8.78	6,437
4 year	4.12	1.97	0.83	9.13	6,469
5 year	4.24	1.95	0.87	9.27	6,455
6 year	4.00	1.82	0.94	7.41	5,558
7 year	4.43	1.92	1.01	9.47	6,446
8 year	4.15	1.77	1.08	7.35	5,549
9 year	4.21	1.74	1.15	7.34	5,549
10 year	4.62	1.88	1.21	9.60	6,381
Government securities					
3 month	1.91	1.35	0.14	6.04	4,010
10 year	2.95	1.19	0.88	5.27	4,018

3.1 Norwegian Government Securities

Government bonds have traditionally been used to construct the yield curve due to the absence of default risk, large volume, and a variety of maturities. On the other hand, not all governments have a big debt program. If governments are in a good fiscal situation, the need of debt-issuance is most likely non-existent (Ron, 2000). For the Norwegian government securities market, this is the case. Furthermore, the Norwegian government securities market is rather small, both in international measures and compared to Norwegian macro factors, and thereby less liquid. Thus, even though the government bonds do not contain default risk, they still have liquidity risk. Therefore, their interest rates strongly depend on supply and demand,

and might not reflect changes in the market situation (Rakkestad and Hein, 2004). Ron (2000) also brings up another problem, called the “flight to quality” phenomenon, where the spread between government bonds and other fixed income securities increase substantially in crises. This raises the question of whether Norwegian government bonds can be utilised as the benchmark for the non-government debt instruments. Hence, this paper turns its focus to how the Norwegian swap market can function as a benchmark.

3.2 The Norwegian Swap Market

Utilising swap data to construct a benchmark offers several advantages. Probably the most important advantage is the liquidity of the swap market. The swap market is highly liquid and offer rates at a variety of maturities. Additionally, swap rates are highly correlated with yields on corporate bonds, solving the “flight to quality” phenomenon, hence providing a better representation of actual interest rates (Ron, 2000). The disadvantage with swaps, however, is that they contain counterparty default risk. I.e., there is a risk that the other party in the agreement defaults on their obligations. This risk is embedded in the swap rate and might provide biased results as a benchmark. In Norway, banks are the biggest participants in both the corporate bonds market and the swap market (Rakkestad and Hein, 2004). The counterparty default risk of the swaps will therefore be closely linked to the default risk of corporate bonds.

Since the swap market offers more liquidity, a greater variety of maturities and a closer variation to the Norwegian corporate bond market, we see it as the best fit for constructing a reliable yield curve. Therefore, it is applied as the benchmark for valuating bonds in our research. Table 2 presents the zero-coupon rates derived from extracted swap rates and interpolated with the Svensson method, further elaborated in section 4.3.

Table 2: Descriptive statistics for zero-coupon rates

The first column contains the maturity of the different instruments. Mean, standard deviation, min and max are respective values for zero-coupon interest rates from the Svensson method in the period 04.01.1994-31.12.2019. They are annualised and presented in percent.

		Zero-Coupon Rates				
		Mean	S.D.	Min	Max	Obs.
Maturities	*3 Month*	3.58	2.17	0.68	9.85	6,312
	6 Month	3.64	2.13	0.74	8.68	6,312
	1 Year	3.73	2.08	0.83	7.97	6,312
	2 Year	3.89	2.03	0.82	8.38	6,312
	3 Year	4.04	2.00	0.84	8.88	6,312
	4 Year	4.17	1.98	0.86	9.09	6,312
	5 Year	4.29	1.97	0.89	9.28	6,312
	6 Year	4.39	1.95	0.93	9.42	6,312
	7 Year	4.48	1.94	0.99	9.55	6,312
	8 Year	4.56	1.92	1.06	9.65	6,312
	9 Year	4.63	1.91	1.15	9.73	6,312
	10 Year	4.70	1.90	1.20	9.79	6,312

4. Empirical Methodology

This section elaborates and presents the methodology utilised in this thesis. More specifically, the first three subsections present the technical application behind constructing the yield curve. Furthermore, we present how returns are calculated and how we adjust for risk. Then calculations of the riding strategies are carried out, before we elaborate on how this paper tests for significance.

4.1 Deriving Zero-Coupon Rates

The swap rates extracted from Bloomberg are annually received fixed rates and can be treated as coupons (Bjerksund, 2020). When constructing a yield curve, zero-coupon rates are needed, as the rates from coupon bonds are affected by the coupon and would therefore provide incorrect estimations of the yield curve (Kloster, 2000). Hence, zero-coupon rates must be estimated. This is done following a bootstrapping procedure (Sundaresan, 2009). The equations below take us through such a procedure. After doing so, the only difference between the swap rates is the maturity and the yields. This will lead to a more precise comparison of the different riding strategies and a buy-and-hold strategy.

Thus, we have estimated the discount factors and the zero-coupon rates from the obtained swap rates, as the NIBOR rates already are zero-coupon rates. The discount factor, d_1, can be interpreted as what investor would pay today to get 1 NOK in one year. Thus,

$$d_1 = \left(\frac{1}{1 + s_1}\right), \tag{1}$$

where s_1 is the one-year swap rate extracted from the market. The rest of the discount factors are calculated based on previous discount factors. Hence, the following formula is utilised:

$$d_t = \frac{1 - s_t * \sum_{i=1}^{i=t-1} d_t}{1 + s_t}, \tag{2}$$

where s_t is the corresponding swap rate. This provides the appropriate discount factor and will be used to calculate the zero-coupon rates, $y_{t,}$. To do so, the following formula is utilised:

$$y_t = \left(\frac{1}{d_t}\right)^{\left(\frac{1}{t}\right)} - 1. \quad (3)$$

4.2 Continuously Compounded Rates

The derived zero-coupon rates are annually compounded rates, whilst we need continuously compounded rates to construct the yield curve with the Svensson method, further explained in section 4.3. To obtain the continuously compounded spot rates, we follow the calculations from Svensson (1994) and use the following formula:

$$y^* = 100\ ln\left(1 + \frac{y}{100}\right), \quad (4)$$

where $y*$ is the continuously compounded rate and y is the annually compounded zero-coupon rate. After interpolating the yield curve with the Svensson method, we convert the rates back to annually compounded rates as follows:

$$y = 100\left(\exp\left[\frac{y^*}{100}\right] - 1\right). \quad (5)$$

4.3 Construction of the Yield Curve

To construct our benchmark yield curve, we choose to interpolate with the Svensson method (Svensson, 1994). The method estimates the yield curve based on zero-coupon rates derived from the market. Furthermore, it allows for estimating yields for maturities not stated in our data, e.g., the nine-month yield. Alternatively, linear interpolation could have been done, however it would not capture the curvature in the yield curve. Moreover, the Svensson method is an expansion of the original Nelson-Siegel method (Nelson and Siegel, 1987). It adds a fourth term to the model, which captures a second hump-shape. This is added to obtain a better estimation if the term structure is complex. Thus, the method is based on estimating four parameters that can describe the yield curve. To do so, we minimise the error between estimated yields and actual yields obtained from the market. The parameters will then be used to find spot rates of desired maturities. For calculations of the Svensson method, see section 7.1 in the appendix.

4.4 Return

In the following, we look at how to calculate the excess returns from riding. Our calculations are done in line with Sundaresan (2009) and Bieri and Chincarini (2005). First, we calculate the price of a zero-coupon bond in which the bond is bought for:

$$P_{m,t} = \frac{100}{(1 + y_{m,t})^{\frac{m}{z}}}. \tag{6}$$

In the equation, $y_{m,t}$ is the annualised zero-coupon rate extracted from the yield curve, m is the days to maturity, t is the time the bond is bought, while z represents the instrument's day count basis. $P_{m,t}$ is the price at time t, where the price will be 100 at maturity. In the following, the price of the zero-coupon bond at the end of the holding period, h, i.e., when the bond is sold, is calculated:

$$P_{m-h,t+h} = \frac{100}{(1 + y_{m-h,t+h})^{\frac{m-h}{z}}}. \tag{7}$$

Where m-h is the time left to maturity for the bond, and t+h is the end of the holding period. Moreover, $y_{m-h,t+h}$ is the annualised rate of an instrument with m-h days left to maturity. Next, we calculate the holding period return, $H_{m,h}$, for the ride:

$$H_{m,h} = \frac{P_{m-h,t+h}}{P_{m,t}} - 1 = \frac{\left(1 + y_{m,t}\right)^{\frac{m}{z}}}{\left(1 + y_{m-h,t+h}\right)^{\frac{m-h}{z}}} - 1. \tag{8}$$

Furthermore, the returns are annualised, which makes it easier to compare between the different riding instruments. Thus,

$$H^{A}{}_{m,h} = (1 + H_{m,h})^{\frac{z}{h}} - 1. \tag{9}$$

To see the annualised excess return from riding the yield curve compared to the buy-and-hold strategy, the annualised return from a bond with maturity equal the holding period, $y^{A}{}_{h,t}$, is subtracted:

$$XH_{m,h} = H^A_{m,h} - y^A{}_{h,t}. \tag{10}$$

It is important to remember that all these calculations are done by using zero-coupon rates and must be modified if used with a coupon bond.

4.5 Risk

In the following, we examine two ways of adjusting for risk and explaining the risk of riding the yield curve. First, the Sharpe ratio is considered. Second, a risk factor model based on Fama-French is carried out.

4.5.1 Sharpe Ratio

To compare the different riding strategies, we calculate the well-known Sharpe ratio of the strategies (Sharpe, 1994). The Sharpe ratio tells how much return the investor receives per unit of risk, where the standard deviations of returns represent risk. As calculated in equation (10), $XH_{m,h}$ represents the difference between our riding strategy and the benchmark buy-and-hold strategy. First, the mean excess returns are calculated:

$$\overline{XH_{m,h}} = \frac{1}{n}\sum_{i=1}^{n} XH_{m,h}, \tag{11}$$

where n represents the number of returns, and i represents each return 1,2,…,i. The next step is to calculate the standard deviation of the excess returns:

$$\sigma_{XH_{m,h}} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(XH_{m,h} - \overline{XH_{m,h}})^2}\ . \tag{12}$$

Then the Sharpe ratio is calculated:

$$SH = \frac{\overline{XH_{m,h}}}{\sigma_{XH^A_{m,h}}}. \tag{13}$$

When comparing the different strategy’s Sharpe ratio, the higher the better. It is important to be aware that Sharpe ratio only compares the different strategies, and not whether riding the yield curve is superior compared to a buy-and-hold strategy.

4.5.2 Risk Factor Model

By regressing excess returns of riding the yield curve on a term premium factor, default premium factor and a liquidity factor, we can see the returns' exposure to these risk factors. Additionally, OBX returns are utilised in the model to examine whether the performance of riding can be measured against OBX. After calculating $XH_{m,h}$ from equation (10), the regression is as follows:

$$XH_{m,h} = \alpha + \beta_1 TERM + \beta_2 DEF + \beta_3 LIQ + \beta_4 OBX + \varepsilon_t \quad (14)$$

In line with Fama and French (1993), we make proxies for the default premium factor, *DEF*, and the term premium factor, *TERM.* We define the default premium factor as the difference between the ten-year swap rate and the ten-year government bond rate, i.e., the swap spread. As mentioned in subsection 3.2, Rakkestad and Hein (2004) state that the default risk element embedded in the swap curve highly correlates with the default risk of corporate bonds. Furthermore, the Norwegian fixed income market, especially long-term, is rather small, meaning that there are not many decent long-term indices to utilise. Hence, we believe that the swap spread provides the most accurate proxy for the default premium factor. For the term premium factor, we define it as the difference between the ten-year government bond rate and the three-month government bill rate.

Moreover, for the liquidity factor, we utilise the *LIQ* factor constructed by Bernt Arne Ødegaard (Ødegaard, n.d.). This is a liquidity factor for the stock market which is based on the relative spread between returns on the least liquid portfolios and the most liquid portfolios in the market (Næs et al., 2009). As Goyenko and Ukhov (2009) elaborate, there is a strong negative correlation between the liquidity of the stock market and high rated bond markets. Hence, by adding this liquidity factor, we hope to account for the liquidity risk related to a riding strategy. Ultimately, for the stock market returns, daily returns from the Norwegian stock market index, *OBX*, is utilised. If the riding strategy is exposed to the OBX returns, and positive alphas are obtained, this would imply that it is preferable for investors to add the riding strategy to their portfolio.

The aim of the regression is to see how riding the yield curve is exposed to the different risk factors, and whether the returns obtained is higher than the risk exposure dictates. This is expressed in the alpha, α, where a positive alpha indicates that the excess returns are higher than market expectations, after the risk factors are taken into consideration.

4.6 Calculations of the Riding Strategies

This thesis examines four different holding periods. More specifically, a three-month, six-month, one-year and two-year holding period. Riding instruments have maturities ranging from six months to ten years. These are examined for both the unconditional strategy and the timing strategies. In the following, the calculations for the timing strategies in this thesis are presented.

4.6.1 Positive Cushion Timing Strategies

The break-even rate, $y^*_{m-h,t}$, can be expressed as the rate at time $t+h$ for an instrument maturing at m-h days where $m > h$, which makes the investor indifferent between riding the yield curve and a buy-and-hold strategy. This is calculated as follows:

$$y^*_{m-h,t} = \left[\frac{\left(1+y_{m,t}\right)^{\frac{m}{z}}}{\left(1+y_{h,t}\right)^{\frac{h}{z}}}\right]^{\frac{z}{m-h}} - 1. \tag{15}$$

By subtracting the actual m-h rates at time t, $y_{m-h,t}$, we find how much the m-h rates have to change from time t to time $t+h$ in order to equate riding returns with returns from a buy-and-hold strategy. This is defined as the positive cushion, $PC_{m,h}$, of riding the yield curve with an m-day security over the holding period h. Hence, the positive cushion is:

$$PC_{m,h} = \left[\frac{\left(1+y_{m,t}\right)^{\frac{m}{z}}}{\left(1+y_{h,t}\right)^{\frac{h}{z}}}\right]^{\frac{z}{m-h}} - \left(1+y_{m-h,t}\right) = y^*_{m-h,t} - y_{m-h,t}. \tag{16}$$

By knowing this, the positive cushion can now be used to define simple filter rules for determining whether to ride or not.

To reduce the risk of incurring a loss when selling the riding instrument with maturity m-h at time $t+h$, our hypothesis states that market participants should condition their riding to when the positive cushion is higher than the percentile of choice, c. It will be compared with the cushions two years back to avoid look-ahead bias (Iyer and Prakash, 2019). In our case, the percentiles of choice are the 70th, 75th and 80th percentile. Thus,

$$PC_{m,h} = y^*_{m-h,t} - y_{m-h,t} > c. \quad (17)$$

4.6.2 Mean-Reverting Timing Strategies

For the historical average of the slope and curvature, we calculate the average from 04.01.1994 until the day we are evaluating whether to ride or not. This is done to avoid look-ahead bias (Iyer and Prakash, 2019). For the yield levels, however, this has not been an appropriate fit as yield levels mainly have been falling, leading to approximately zero rides in our sample period. The five-year average of the level is therefore utilised to obtain a better comparison with corresponding rates. Thus, we ride when the rate of the riding instrument is higher than its five-year average:

$$y_m > y_H, \quad (18)$$

where y_m is the current rate on the riding instrument, and y_H is the five-year average rate of the instrument.

For the slope and curvature, relevant instruments are compared, inspired by Chua et al. (2006). Usually, the slope of the yield curve is calculated as the ten-year rate minus the two-year rate (or three-month rate). In our case, we will compare the slope between the holding period and the riding instrument. This is done instead of calculating a proxy for the slope of the entire yield curve, since we believe it provides a better prediction of changes relevant for the riding instruments. Hence, for the slope we will ride when

$$y_m - y_h > y_{mH} - y_{hH}, \quad (19)$$

where y_m is the current rate on the riding instrument, y_h is the current rate on the holding period, y_{mH} is the historical average rate on the riding instrument and y_{hH} is the historical average rate of the holding period.

Furthermore, the curvature indicates the shape of the yield curve, and is calculated as follows:

$$c_{h,m,v} = \frac{y_m - y_h}{m - h} - \frac{y_v - y_m}{v - m}. \tag{20}$$

Here, h is the holding period, m is the time to maturity of the riding instrument and v is the time to maturity of the long-term instrument, in our case ten years. Furthermore, y_h is the current rate on the holding period, y_m is the rate on the riding instrument, and y_v is the rate on the long-term instrument. This will be compared with the historical average of the curvature, and if the current curvature is higher than the historical average, we will ride the instrument with maturity m.

4.7 Test of Significance

To examine whether the excess returns from riding the yield curve are statistically significant different from zero, a t-test is performed. For the analysis of the risk exposure, the risk factor model elaborated above is utilised. However, if our data contains autocorrelation or heteroscedasticity, biased standard errors are obtained. Autocorrelation may occur as the data depends on the same fundamental factors, meaning that the error term will correlate over time. Furthermore, heteroscedasticity may occur as the financial market is very volatile and will experience shocks, meaning that the variance of the error term will not stay the same over time. Hence, a Breusch-Godfrey test and Breusch-Pagan test are performed to test for autocorrelation and heteroscedasticity, respectively (Wooldridge, 2013). These tests prove that the data significantly contains both in the standard errors. Thus, the Newey West method is implemented to deal with these issues. More precisely, the method calculates Heteroscedasticity and Autocorrelation corrected (HAC) standard errors, offering more robust and correct results (Newey and West, 1987, Newey and West, 1994).

5. Results

Our results show that riding the yield curve provides excess returns compared to a buy-and-hold strategy. This contradicts with the expectations hypothesis, implying there is a liquidity premium that can be captured, supporting further examination of the timing strategies. In the following, our results are examined by dividing the analysis into three parts. First, excess returns are presented and compared between the different strategies. Second, the results from our risk factor model are examined. Third, a discussion is carried out regarding the overall performance of the different strategies. Additionally, a discussion of the limitations of this thesis is provided. Our findings state that riding the yield curve provides mixed results, where we find some attractive opportunities. Since there are clear trends in the results, the tables in the subsequent subsections only present some of the instruments. For complete tables, see table 9-16 in the appendix.

5.1 Excess Returns

Generally, our strategies provide increasing excess returns with longer instruments. According to the liquidity preference theory, such a pattern is expected, as longer instruments have a higher liquidity premium. For unconditional riding, longer holding periods obtain lower and more stable returns, also shown in the standard deviations elaborated in the next subsection. The timing strategies, however, provide better predictions with longer time horizons, and therefore enhance excess returns with longer holding periods. This is in line with the research of Fama and Bliss (1987), hence that interest rates process mean-reverting gradually over time. Thus, it makes it harder to forecast short-term movements compared to long-term movements. The level timing strategy stands out, as it yields negative excess returns which further decrease with both longer instruments and holding periods. Hence, implying that rates tend to further increase when rates are higher than their five-year average. This is the only strategy that consistently yields negative excess returns, hence it does not seem beneficial.

With a three-month holding period, unconditional riding yields the highest returns of all the strategies, as the timing strategies need a longer horizon for their yield curve predictions. The six-month holding period follows the same pattern, where unconditional riding generally provides the highest excess returns. However, medium- and long-term instruments with the positive cushion timing strategy yields higher returns, increasing with higher percentiles.

Moreover, with the two longest holding periods, both the positive cushion timing strategies and the slope timing strategy yield higher excess returns than unconditional riding. The positive cushion strategies generally provide the highest returns, where excess returns increase with higher percentiles. This is in line with our expectations, namely that higher cushions signal better riding opportunities. The highest excess return is 5.42 percent and is obtained by the 80^{th} percentile, with a ten-year instrument ridden over one year, see table 3. Excess returns from the curvature timing strategy follow the returns from unconditional riding closely.

Overall, the excess returns show that riding the yield curve yields higher returns than a buy-and-hold strategy. Additionally, with longer holding periods, these excess returns can further be improved with easy-to-implement timing strategies based on the positive cushion and the mean-reversion of the slope. In the following subsection, related standard deviations are presented before a comparison of the different strategies' Sharpe ratio is carried out.

Table 3: Excess returns from the riding strategies

The first column contains riding instruments, where the investor's holding period is in bold. The subsequent columns show annualised mean excess returns for all the riding strategies. These are presented in percent. The stars indicate at which level the annualised mean excess returns are statistically significant different from zero, where * p < 0.10, ** p < 0.05 and *** p < 0.01. These calculations are corrected for autocorrelation and heteroskedasticity by utilising the Newey-West standard error. For full results, see table 9 in the appendix.

			$XH_{m,h}$					
			Positive Cushion			*Mean-Reverting*		
	Instrument	Unconditional	70th	75th	80th	Level	Slope	Curvature
Maturities	**3-month holding period**							
	6 month	0.19***	0.15***	0.15***	0.14***	0.04	0.16***	0.15***
	5 year	2.14***	1.41*	1.20*	0.96	-0.73	0.44	-0.05
	9 year	3.94***	3.11***	2.43*	1.46	-2.18*	2.39***	0.55
	10 year	4.39***	3.14***	2.33*	1.03	-2.78*	2.90***	
	6-month holding period							
	1 year	0.23***	0.12***	0.12***	0.13***	-0.24***	0.17***	0.12***
	5 year	1.93***	2.13***	2.30***	2.57***	-1.14***	1.26***	0.14
	9 year	3.61***	4.35***	4.17***	4.33***	-2.10***	3.42***	1.58*
	10 year	4.00***	4.80***	4.89***	5.11***	-2.67***	3.75***	
	1-year holding period							
	2 year	0.40***	0.82***	0.89***	0.90***	-0.47***	0.55***	0.45***
	5 year	1.61***	2.38***	2.54***	2.66***	-1.02***	2.11***	1.33***
	9 year	3.11***	4.23***	4.68***	4.81***	-2.06***	3.77***	3.07***
	10 year	3.46***	4.84***	5.19***	5.42***	-2.47***	4.24***	
	2-year holding period							
	3 year	0.39***	0.67***	0.67***	0.67***	-0.44***	0.75***	0.55***
	5 year	1.14***	1.64***	1.66***	1.72***	-1.08***	1.86***	1.43***
	9 year	2.50***	3.94***	4.08***	4.18***	-2.31***	3.84***	2.34***
	10 year	2.84***	4.46***	4.54***	4.58***	-2.69***	4.29***	

5.1.1 Standard Deviation

Overall, standard deviations increase with longer instruments, indicating that they are more volatile. E.g., we obtain the highest standard deviation of 12.80 when a ten-year instrument is ridden over three months with the 80th percentile cushion strategy, shown in table 4. This is in line with their sensitivity to interest rate risk, where long-term instruments are more affected by changes in the interest rate level. However, the general level of volatility decreases with longer holding periods, implying that returns become more stable. An explanation to this can be that longer holding periods have more time to stabilise shocks and will therefore be less volatile than short-term holding periods. This pattern is shared for all strategies.

The standard deviation from a positive cushion timing strategy varies between holding periods. More specifically, the shortest holding periods provide lower standard deviations than unconditional riding for short-term instruments, and vice versa for long-term instruments. For the two-year holding period, and the long-term instruments with a one-year holding period, positive cushion generally provides lower standard deviations than unconditional riding, implying more stable returns. Moreover, when the percentile increases, the standard deviation generally increases, whilst the volatility with a two-year holding period is stable.

The volatility in returns from the mean-reverting timing strategies varies compared to riding unconditionally. Level as a timing strategy provides returns that are less volatile for every holding period. Moreover, both the slope and curvature timing strategies generally provide lower standard deviations. The exception is for short- and medium-term instruments over a one-year holding period, where the returns are more volatile.

Table 4: Standard deviations from the riding strategies

The first column contains riding instruments, where the investor's holding period is in bold. The subsequent columns show standard deviations for all the riding strategies. These are presented in percent. For full results, see table 10 in the appendix.

		Standard Deviation					
		Positive Cushion			*Mean-Reverting*		
Instrument	Unconditional	70th	75th	80th	Level	Slope	Curvature
3-month holding period							
6 month	0.36	0.22	0.22	0.23	0.35	0.24	0.24
5 year	7.27	7.46	7.67	7.79	6.96	6.09	6.27
9 year	11.67	11.54	11.79	11.84	10.73	9.88	10.84
10 year	12.69	12.33	12.59	12.80	11.75	10.88	
6-month holding period							
1 year	0.66	0.34	0.35	0.36	0.39	0.40	0.41
5 year	5.15	6.65	6.99	7.29	3.31	4.54	4.22
9 year	8.14	8.51	8.79	9.29	5.86	7.89	7.63
10 year	8.84	8.96	9.29	9.63	6.48	8.41	
1-year holding period							
2 year	0.94	1.32	1.37	1.41	0.45	1.14	1.16
5 year	2.95	3.39	3.50	3.63	1.81	2.97	3.26
9 year	5.06	4.20	3.93	3.88	3.25	4.33	4.71
10 year	5.56	4.15	3.91	3.81	3.63	4.62	
2-year holding period							
3 year	0.66	0.60	0.61	0.62	0.38	0.54	0.65
5 year	1.70	1.53	1.52	1.52	0.92	1.29	1.41
9 year	3.28	2.18	2.17	2.14	1.64	2.19	2.33
10 year	3.64	2.29	2.35	2.34	1.83	2.36	

Maturities

5.1.2 Sharpe Ratio

Generally, Sharpe ratios increase with longer instruments and longer holding periods. The exception is for a three-month holding period, where the Sharpe ratio decreases until the medium-term instruments before they increase for the long-term instruments. In our findings, the Sharpe ratios from the level timing strategy stand out, as all but one is negative. The lowest Sharpe ratio of -1.47 is obtained with this strategy, when a ten-year instrument is ridden over a two-year holding period, see table 5. This strategy also follows a different trend, where the Sharpe ratio generally decreases with longer instruments.

For the shortest holding periods, riding unconditionally primarily obtains a higher Sharpe ratio than the timing strategies, implying that the timing bets are not worthwhile. The exception is when long-term instruments are ridden over six months with a positive cushion strategy, which generate higher Sharpe ratios.

With the longest holding periods, however, the slope and positive cushion timing strategies provide greater Sharpe ratios, where positive cushion generally performs somewhat better. Moreover, the performance of the positive cushion timing strategy increases with higher percentiles. The highest Sharpe ratio of 1.96 is obtained by riding a ten-year instrument over two years with the 80th percentile cushion strategy, shown in table 5. A curvature timing strategy mainly provides Sharpe ratios in line with unconditional riding with a one-year holding period, whilst they are higher for the longest holding period. By solely looking at Sharpe ratios, positive cushion with a high percentile and long-term instruments seems to be the best strategy for longer holding periods. For the shortest holding period, however, unconditional riding is preferable.

Table 5: Sharpe ratios from the riding strategies

The first column contains riding instruments, where the investor's holding period is in bold. The subsequent columns show the Sharpe ratios for all the riding strategies. For full results, see table 11 in the appendix.

			Sharpe Ratio					
			Positive Cushion			*Mean-Reverting*		
	Instrument	Unconditional	70th	75th	80th	Level	Slope	Curvature
Maturities	**3-month holding period**							
	6 month	0.53	0.69	0.67	0.62	0.12	0.65	0.63
	5 year	0.29	0.19	0.16	0.12	-0.11	0.07	-0.01
	9 year	0.34	0.27	0.21	0.12	-0.20	0.24	0.05
	10 year	0.35	0.25	0.19	0.08	-0.24	0.27	
	6-month holding period							
	1 year	0.35	0.35	0.34	0.35	-0.62	0.41	0.30
	5 year	0.37	0.32	0.33	0.35	-0.35	0.28	0.03
	9 year	0.44	0.51	0.48	0.47	-0.36	0.43	0.21
	10 year	0.45	0.54	0.53	0.53	-0.41	0.45	
	1-year holding period							
	2 year	0.42	0.62	0.65	0.64	-1.06	0.48	0.39
	5 year	0.55	0.70	0.72	0.73	-0.56	0.71	0.41
	9 year	0.62	1.01	1.19	1.24	-0.63	0.87	0.65
	10 year	0.62	1.17	1.33	1.42	-0.68	0.92	
	2-year holding period							
	3 year	0.59	1.11	1.10	1.09	-1.16	1.40	0.85
	5 year	0.67	1.07	1.09	1.13	-1.17	1.44	1.02
	9 year	0.76	1.80	1.88	1.95	-1.41	1.75	1.00
	10 year	0.78	1.95	1.93	1.96	-1.47	1.82	

5.2 Risk Factor Regression

Riding the yield curve is based on utilising relatively risk-free instruments and expose them to risk factors in the pursue of excess returns. In the following, an analysis is provided of how the factors can be interpreted and how the strategy has been exposed to the risk factors elaborated in this thesis, in addition to its performance against OBX. The subsequent section will more thoroughly discuss how the different riding strategies have performed, after adjusting for risk factors.

5.2.1 *TERM*

Interestingly, the exposure to the *TERM* factor shifts between being negative and positive between holding periods. The mixed exposure is probably due to the short end of the yield curve. *TERM* will increase either if long-term rates increase more than short-term rates, or if short-term rates decrease more than long-term rates. The short end of the yield curve is more volatile than the long end, implying that *TERM* fluctuates mainly due to movements in short-term rates. For riding the yield curve, returns benefit from stable or falling rates. More precisely, when positive excess returns are obtained, the rates on riding instruments have been stable or falling. By comparing the excess returns and the exposure to *TERM*, we can see how the factor affects the strategies. For most strategies, the exposure is positive to *TERM*, indicating that our excess returns increase as *TERM* increases. This implies that the strategies tend to ride when the rates are falling, where short-term rates fall more than long-term rates. However, we also find that positive excess returns are negatively exposed to *TERM*, e.g., the shorter holding periods with the positive cushion timing strategy. After further examination, this strategy tends to ride at the end of crises, where rates generally fall in the beginning, and short-term rates falls more than long-term. However, the strategy tends to keep riding as market conditions improve, where long-term rates start to increase and short-term further decreases. Hence, excess returns reduce as *TERM* increases, resulting in the negative exposure.

As elaborated above, the returns from the strategies are overall highly positive exposed to the term premium factor, *TERM*, see table 5. For the two shortest holding periods, however, the exposure to this factor is mixed. The curvature timing strategy seems to be highly positive exposed, whilst an unconditional strategy and the slope timing strategy provide fewer significant coefficients. Furthermore, the positive cushion timing strategies are significantly negative exposed to *TERM* with shorter holding periods, where the number of significant coefficients increase with higher percentiles. Ultimately, the level timing strategy proves to be the major exception, where the exposure is generally insignificant for the three-month holding period and negatively significant for the rest.

Table 6: TERM-coefficients from the risk factor regressions

The first column contains riding instruments, where the investor's holding period is in bold. The subsequent columns show *TERM*-coefficients for all the riding strategies. The coefficients are obtained from equation (14). The stars indicate at which level the coefficients are statistically significant, where * p < 0.10, ** p < 0.05 and *** p < 0.01. They are corrected for autocorrelation and heteroskedasticity by utilising the Newey-West standard error. For full results, see table 13 in the appendix.

		TERM					
		Positive Cushion			*Mean-Reverting*		
Instrument	Unconditional	70th	75th	80th	Level	Slope	Curvature
3-month holding period							
6 month	0.14***	0.12***	0.12***	0.12***	-0.14*	0.16***	0.16***
5 year	-0.18	-1.91*	-2.43**	-2.96***	-2.07	1.26	1.65**
9 year	-0.86	-1.99	-3.54**	-4.80***	-0.40	-0.61	2.68*
10 year	-1.10	-2.79	-4.42***	-6.01***	0.29	-0.70	
6-month holding period							
1 year	0.40***	0.39***	0.40***	0.43***	0.00	0.44***	0.41***
5 year	0.89**	-1.47*	-1.93**	-1.98**	-2.03***	1.56**	2.54***
9 year	0.50	-1.80*	-2.17**	-2.83**	-4.40***	0.35	3.45***
10 year	0.32	-2.23*	-2.34*	-3.47**	-4.41***	0.28	
1-year holding period							
2 year	0.84***	1.72***	1.81***	1.93***	-0.09	1.66***	1.62***
5 year	1.53***	2.60***	2.80***	3.03***	-1.78***	3.17***	4.44***
9 year	1.53***	2.61**	2.34**	2.42**	-3.19**	2.56***	4.61***
10 year	1.47***	2.19**	2.08**	2.35**	-2.21	1.85***	
2-year holding period							
3 year	0.67***	0.64***	0.61***	0.60***	0.03	0.63***	0.93***
5 year	1.35***	0.94***	0.94***	0.93***	-0.43**	0.82***	1.31***
9 year	1.84***	1.04***	1.08***	1.07***	-1.05*	-0.51	1.51***

Maturities

5.2.2 *DEF*

The *DEF* factor indicates a default premium in the market, where our strategies are mainly positive exposed and yield positive excess returns. As riding the yield curve depends on the interest rates to stay stable or fall to obtain a profit, the exposure can be interpreted in a way that *DEF* tends to increase in times where interest rates generally decrease. This is typically in times of uncertainty, where the risk in the market increases. As corporate bonds contain default risk, their rates obtain a premium to compensate for this risk. Therefore, these rates fall less than the risk-free government bonds, increasing the *DEF* factor. However, we also find negative exposure to *DEF*, i.e., over a six-month holding period with the curvature timing strategy. This indicates that the strategy tends to ride and yield excess returns as *DEF* falls, which can occur when rates fall rapidly, and corporate rates decrease more than government rates. As the excess returns are approximately zero, this also indicates that the strategy rides as rates increase, and *DEF* decreases. After crises, for example, when market conditions improve, government rates increase more than corporate rates, as the default risk in the market decreases.

In line with *TERM*, the exposure to this factor is mixed for the two shortest holding periods, see table 6. For the three-month holding period, the unconditional strategy is the only strategy to provide positive significant coefficients, whilst the rest is mainly insignificant. Furthermore, returns from an unconditional strategy and the positive cushion strategies over a six-month holding period are overall significantly positive exposed to *DEF*. The curvature timing strategy is negatively exposed, whilst slope as a timing strategy is insignificantly exposed to this factor. Again, level as a timing strategy stands out, as *DEF* is generally insignificant over a three-month holding period, whilst returns from the other holding periods are negatively exposed to *DEF*.

Table 7: DEF-coefficients from the risk factor regressions

The first column contains riding instruments, where the investor's holding period is in bold. The subsequent columns show *DEF*-coefficients for all the riding strategies. The coefficients are obtained from equation (14). The stars indicate at which level the coefficients are statistically significant, where * p < 0.10, ** p < 0.05 and *** p < 0.01. They are corrected for autocorrelation and heteroskedasticity by utilising the Newey-West standard error. For full results, see table 14 in the appendix.

			DEF				
		Positive Cushion			*Mean-Reverting*		
Instrument	Unconditional	70th	75th	80th	Level	Slope	Curvature
3-month holding period							
6 month	0.35***	0.37***	0.38***	0.41***	-0.72***	0.35***	0.34***
5 year	3.08***	6.24	7.40	10.01*	-6.53	-0.33	-1.28
9 year	2.30	1.88	0.40	0.62	4.33	0.56	-2.94
10 year	1.55	0.29	0.65	1.29	11.22	0.80	
6-month holding period							
1 year	0.59***	-0.07	-0.20	-0.23*	-1.06***	0.33***	0.26***
5 year	3.24***	9.65***	11.39***	12.88***	-9.77***	0.43	-3.17
9 year	2.96**	3.53*	3.71*	2.48	-16.59***	2.68	-5.79
10 year	2.51	1.39	0.93	-0.93	-14.98**	2.41	
1-year holding period							
2 year	1.06***	2.13***	2.13***	1.76***	-1.70***	1.63***	1.19***
5 year	3.02***	9.12***	9.60***	10.56***	-8.23***	5.73***	2.71***
9 year	3.37***	10.03***	8.85***	8.60***	-12.23**	7.91***	3.86**
10 year	3.17***	9.30***	8.30***	8.28***	-7.91	6.82***	
2-year holding period							
3 year	0.67***	2.11***	2.19***	2.26***	-1.43***	1.36***	0.91***
5 year	1.59***	5.48***	5.59***	5.76***	-4.32***	3.15***	3.33***
9 year	2.03***	5.26***	5.43***	5.43***	-7.44***	1.88***	5.96***
10 year	1.93***	5.25***	5.53***	5.70***	-5.85**	1.60***	

Maturities

5.2.3 *LIQ* and *OBX*

Both the liquidity factor, *LIQ*, and *OBX* provide very few significant results, see table 15 and 16 in the appendix. Additionally, they are only significant at the ten- or five percent level. As the regression analysis in this thesis is of great magnitude, one must be cautious about the error-margin of the ten- and five percent level. To illustrate, we are performing 262 regressions in our thesis, where the ten percent level would statistically provide 26 significant coefficients merely by random chance (Jensen, 1967). Neither *LIQ* nor *OBX* have more significant results than the expected number of false significant coefficients, hence, we cannot interpret them with certainty.

5.2.4 Alpha

The risk factor model utilised in this paper obtains many significant alphas, see table 7. When it is positive, it implies that excess returns are higher than market expectations after adjusting for risk factors, and vice versa when alpha is negative. For the two longest holding periods, we obtain a similar pattern in obtained alphas, where they are primarily high and negative. Most long-term instruments, however, provide insignificant alphas, indicating that their returns are in line with market expectations. Nonetheless, the slope timing strategy obtains some high positive alphas with the longest instruments.

Moreover, the two shortest holding periods provide mixed results, where there are generally less significant alphas. The unconditional-, slope- and curvature strategy obtains some negative alphas for shorter instruments. Additionally, the unconditional strategy finds positive alphas with the longest instruments over a three-month holding period. Positive cushion timing strategies, on the other hand, provide increasingly higher positive alphas with longer instruments, where more alphas are obtained with higher percentiles. The level timing strategy differs from the others as it provides no alphas for the shortest holding period. Nevertheless, the other holding periods obtain positive alphas which are increasing with longer instruments and decreasing with longer holding periods.

Our analysis has returned varied results, where the two shortest holding periods stand out. More precisely, the timing strategies generally yield lower excess returns, and the risk factor regression has less significant coefficients and alphas. Additionally, we obtain significant alphas corresponding with insignificant coefficients. Campbell and Shiller (1991) discovered that the forecast power is low for horizons below one year, which is in line with the excess returns from the timing strategies. Moreover, it can help explain our mixed results from the regression, in the way that there might be other factors affecting short-term returns. Therefore, a clear conclusion regarding their risk-adjusted performance cannot be made, as the model is not sufficient. Long-term returns, however, provide stable results and are exposed to our risk factors. The discussion in the subsequent section regarding the risk-adjusted performance of the strategies will therefore solely focus on the two longest holding periods.

Table 8: Alphas from the risk factor regressions

The first column contains riding instruments, where the investor's holding period is in bold. The subsequent columns show alphas for all the riding strategies. The alphas are obtained from equation (14) and are presented in percent. The stars indicate at which level the alphas are statistically significant, where * $p < 0.10$, ** $p < 0.05$ and *** $p < 0.01$. They are corrected for autocorrelation and heteroskedasticity by utilising the Newey-West standard error. For full results, see table 12 in the appendix.

Alpha							
		Positive Cushion			*Mean-Reverting*		
Instrument	Unconditional	70th	75th	80th	Level	Slope	Curvature
3-month holding period							
6 month	-0.15***	-0.17***	-0.18***	-0.21***	0.48***	-0.22***	-0.22***
5 year	0.61	1.86	2.09	1.72	3.49	-1.32	-1.98
9 year	3.55*	5.38	8.18**	9.22**	-4.73	3.02	-2.30
10 year	4.66**	7.55**	9.41**	10.38**	-9.96	3.54	
6-month holding period							
1 year	-0.49***	-0.40***	-0.37***	-0.38***	0.37**	-0.60***	-0.52***
5 year	-0.77	0.04	0.14	-0.18	4.90***	-1.38	-2.20*
9 year	1.46	5.02*	5.31*	7.07**	8.84**	1.41	-1.28
10 year	2.28	7.34**	7.78**	10.77**	7.41*	1.99	
1-year holding period							
2 year	-1.00***	-2.78***	-2.88***	-2.93***	0.51***	-2.72***	-2.48***
5 year	-1.54***	-5.80***	-6.14***	-6.85***	4.09***	-5.77***	-6.91***
9 year	-0.25	-5.58**	-4.20	-4.11	5.99	-4.41***	-6.32***
10 year	0.28	-4.31	-3.27	-3.47	2.83	-2.25	
2-year holding period							
3 year	-0.59***	-1.24***	-1.23***	-1.24***	0.36***	-0.93***	-1.33***
5 year	-0.98***	-2.31***	-2.35***	-2.40***	1.48***	-1.14***	-2.37***
9 year	-0.31	-0.91	-1.01	-0.94	2.41	3.27***	-3.15***
10 year	0.03	-0.52	-0.76	-0.86	1.08	4.25***	

Maturities

5.3 Risk-Adjusted Performance

Unconditional riding yields excess returns for all instruments and holding periods, while the risk factor regression illustrates an increase in risk. The short- and medium-term instruments provide negative alphas, indicating that the excess returns are lower than market expectations compared to these risk factors. The long-term instruments, on the other hand, obtain insignificant alphas, meaning they provide returns that are in line with the risk taken.

The positive cushion timing strategy achieves the highest excess return of all the strategies, where returns increase with higher instruments and holding periods. By comparing Sharpe ratios, positive cushion seemed to be the best strategy, providing high and stable returns. After adjusting for risk factors, however, we see that returns from longer instruments merely compensate for the increased risk exposure. As the percentile condition increases, more negative alphas become insignificant for longer instruments, implying fair returns. The short- and medium-term instruments obtain negative alphas and is therefore not worthwhile on a risk-adjusted basis.

The level timing strategy provides mixed results in our analysis. Mainly significant positive alphas are obtained from the risk factor regressions, whilst excess returns are negative. After further inspection, this timing strategy tends to ride when long-term rates are high and short-term rates increase rapidly. Moreover, level as a timing strategy even rides as the yield curve inverts, which is an indication of high uncertainty in the market. This corresponds well with the coefficients from the risk factor regression, which are highly negative. Therefore, this timing strategy provides a high amount of systematic risk. The positive alphas indicate that the model is not sufficient to explain these returns, hence more factors are needed. Nevertheless, excess returns are solely negative, i.e., the strategy is not beneficial.

Moreover, slope as a timing strategy provides excess returns that are high and stable, implying a profitable strategy. After adjusting for risk factors, nonetheless, we obtain mainly insignificant or negative alphas, indicating either fair returns or that returns are too low to compensate for excess risk exposure. Nevertheless, the long-term instruments with a two-year holding period do obtain positive alphas, indicating that it is preferable. This is in line with the excess returns, where these ridings provided the highest and most stable returns from the strategy.

Ultimately, the curvature timing strategy yields excess returns close to riding unconditionally. Our regression model solely returns significant negative alphas, indicating that excess returns cannot compensate for increased exposure to risk. Hence, riding the yield curve by utilising the curvature timing strategy is not preferable.

5.4 Limitations

Before concluding this paper, there are some limitations to our study one must be aware of. First, our calculations are based on a benchmark constructed with swap rates. This is done to make sure we have the appropriate rates, and isolate other factors than maturity. In the market, nonetheless, each bond has its own characteristics, which in a real world will affect its price. Moreover, there may well not be any bonds with the right time to maturity available in the market at any given point in time, or the bonds available might not have suitable characteristics for the investors, such as too high default risk. Hence, the strategy may not be as easy to implement in the Norwegian fixed income market as our theoretical framework implies.

Furthermore, our sample period offers an advantage to a riding the yield curve strategy. As elaborated earlier, riding the yield curve will yield a profit if market rates stay put or fall, whilst it might incur a loss if rates increase. From 2004 to 2019, rates have generally been falling, implying that riding the yield curve has been advantageous. Nevertheless, rates have been volatile, experiencing upward spikes. Timing strategies were therefore implemented intended to predict when riding the yield curve can be beneficial. Hence, it implied that riding the yield curve also might be advantageous in a market where interest rates generally increase.

Moreover, transaction costs are not considered. As our benchmark rates are derived from swap rates, we neither have actual transactions, bid nor ask prices in the market. However, they have an impact as riding the yield curve contains an additional transaction compared to a buy-and-hold strategy. I.e., the instrument is sold at the end of an investor's holding period, affecting excess returns. Therefore, actual returns would be somewhat lower in the market than in our analysis. We attempted to somewhat adjust for transaction costs by adding the *LIQ* factor to the risk factor model, however it turned out not to be significant.

Ultimately, zero-coupon rates have been utilised in our calculations. In the Norwegian bond market, however, coupon bonds are more common (Norges Bank, 2020a). Hence, to obtain our returns, one would need to reinvest the coupons. This would again meet the problems of finding a bond in accordance to an investor's preferences, having enough to invest in the bond, and transaction costs that occur.

As an investor should be aware of the obstacles elaborated above before implementing a riding the yield curve strategy, the theoretical framework still stands. It provides knowledge of how an investor should assess a riding strategy compared to a buy-and-hold strategy.

6. Conclusion

This paper has examined whether riding the yield curve is a beneficial strategy compared to a buy-and-hold strategy in the Norwegian fixed income market. An unconditional riding strategy yields excess returns for all instruments and holding periods, contradicting the expectations hypothesis. The excess returns increase with longer instruments, supporting that there is an increasing liquidity premium that can be exploited.

Moreover, the paper tested whether simple timing strategies can be utilised to predict changes in the yield curve and thereby increase excess returns. The obtained results are mixed. Overall, unconditional riding seemed to outperform the timing strategies with shorter holding periods. This supports the research of Fama and Bliss (1987), hence that short-term movements are harder to predict. With the longer holding periods, a timing strategy based on the mean-reversion of the slope of the yield curve and the positive cushion timing strategies stand out as the best. In general, they enhance excess returns compared to unconditional riding. The curvature and level timing strategy, on the other hand, do not enhance returns, where the level strategy seems to pick riding dates that provide negative excess returns.

On a risk-adjusted basis, we obtain inconclusive results for the two shortest holding periods, where the returns do not seem to be explained by our model. For the longer holding periods, however, excess returns are highly positive exposed to the term premium factor and the default premium factor. Short- and medium-term instruments obtain negative alphas, implying that excess returns cannot compensate for the excess risk taken. Moreover, long-term instruments primarily obtain insignificant alphas, suggesting that their excess returns are in line with their increased risk exposure. Furthermore, the mean-reverting timing strategies stand out. More precisely, curvature as a timing strategy obtains solely negative alphas, implying that returns cannot compensate for increased risk exposure. Level as a timing strategy is very exposed to systematic risk, yielding solely negative excess returns, hence not beneficial. Ultimately, the slope timing strategy obtains positive alphas when longer instruments are ridden over a two-year holding period. Hence, it is beneficial on a risk-adjusted basis compared to a buy-and-hold strategy.

This thesis attempted to expand the model of Fama and French (1993) by adding a liquidity risk factor. However, the new factor proved insufficient to explain the returns, whilst the original factors were highly significant, especially long-term. For shorter holding periods, however, the model seemed to be missing factors, supporting further research on the topic.

All in all, riding the yield curve can provide higher returns than a buy-and-hold strategy. However, it is a strategy that is based on pursuing excess returns by exposing instruments to more risk. The excess returns from short- and medium-term instruments cannot compensate for the excess risk taken, whilst long-term instruments generally do. Hence, investors should utilise long-term instruments when riding the yield curve. Returns can further be increased by forecasting the future change of the yield curve with simple-to-implement methods based on the current shape of the yield curve. Slope as a timing strategy proved to be favourable, where investors can obtain returns higher than the increased risk exposure suggests.

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7. Appendix

7.1 The Svensson Method

This section follows closely the article of Svensson (1994). In the following calculations, we use continuously compounded rates. The Svensson method is, as mentioned in section 5.2, an expansion of the Nelson-Siegel method (Nelson and Siegel, 1987). Therefore, we start with explaining the original model. Nelson and Siegel created a model to interpolate the instantaneous forward rates as following:

$$f_{m;b} = \beta_0 + \beta_1 \exp\left(-\frac{m}{\tau_1}\right) + \beta_2 \frac{m}{\tau_1} \exp\left(-\frac{m}{\tau_1}\right). \qquad (21)$$

Here, b = (β_0, β_1, β_2, τ_1) is a vector of parameters, where both β_0 and τ_1 must be positive, and *m* represents time to settlement. The first term, β_0, is a constant, which the forward rate approaches when *m* reaches infinity. When *m* reaches zero, however, the forward rate reaches $\beta_0 + \beta_1$. The second term, $\beta_1 \exp\left(-\frac{m}{\tau_1}\right)$, will decrease towards zero as *m* increases, or conversely increase if β_1 is negative. The third term generates the hump-shape (or U-shape if β_2 is negative) (Svensson, 1994). Svensson added a fourth term with two new parameters, generating a second hump-shape (or U-shape), to better explain complex yield curves (Svensson, 1994). With his addition, the formula to calculate instantaneous forward rates is:

$$f_{m;b} = \beta_0 + \beta_1 \exp\left(-\frac{m}{\tau_1}\right) + \beta_2 \frac{m}{\tau_1} \exp\left(-\frac{m}{\tau_1}\right) + \beta_3 \frac{m}{\tau_2} \exp\left(-\frac{m}{\tau_2}\right), \qquad (22)$$

where we can see the two new parameters β_3 and τ_2. Subsequently, we integrate the formula in equation (22) to obtain the formula for spot rates:

$$i_{m;b} = \beta_0 + \beta_1 \frac{1-\exp\left(-\frac{m}{\tau_1}\right)}{\frac{m}{\tau_1}} + \beta_2 \left(\frac{1-exp\left(-\frac{m}{\tau_1}\right)}{\frac{m}{\tau_1}} - \exp\left(-\frac{m}{\tau_1}\right)\right) + \beta_3 \left(\frac{1-\exp\left(\frac{m}{\tau_2}\right)}{\frac{m}{\tau_2}} - \exp\left(-\frac{m}{\tau_2}\right)\right). \qquad (23)$$

We estimate the parameters for each trading date by minimizing yield error between the estimation and actual rates in the market. The pricing error can also be minimized, however

Svensson (1994) points out that this can lead to very large yields errors for short maturities since the price is very insensitive to short yields. The estimated parameters will then be used to calculate the appropriate spot rates, which we transform to annually compounded rates, seen in equation (5).

7.2 Tables

Table 9: Excess returns for all riding strategies and instruments

The first column contains riding instruments, where the investor's holding period is in bold. The subsequent columns show annualised mean excess returns for all the riding strategies. These are presented in percent. The stars indicate at which level the annualised mean excess returns are statistically significant different from zero, where * p < 0.10, ** p < 0.05 and *** p < 0.01. These calculations are corrected for autocorrelation and heteroscedasticity by utilising the Newey-West standard error.

		$XH_{m,h}$					
		Positive Cushion			*Mean-Reverting*		
Instrument	Unconditional	70^{th}	75^{th}	80^{th}	Level	Slope	Curvature
3-month holding period							
6 month	0.19***	0.15***	0.15***	0.14***	0.04	0.16***	0.15***
1 year	0.36***	0.15***	0.14***	0.13*	-0.17	0.16***	0.11*
2 year	0.74***	0.08	0.03	0.03	-0.59*	0.16	-0.01
3 year	1.20***	0.25	-0.21	-0.37*	-0.71*	0.10	-0.02
4 year	1.67***	0.97*	0.84	0.45	-0.64	0.10	-0.07
5 year	2.14***	1.41*	1.20*	0.96	-0.73	0.44	-0.05
6 year	2.61***	1.61*	1.38	1.07	-0.91	0.85	-0.01
7 year	3.08***	1.93*	1.68*	1.02	-1.22	1.34*	0.11
8 year	3.52***	2.38*	1.99*	1.03	-1.56	2.03***	0.27
9 year	3.94***	3.11***	2.43*	1.46	-2.18*	2.39***	0.55
10 year	4.39***	3.14***	2.33*	1.03	-2.78*	2.90***	
6-month holding period							
1 year	0.23***	0.12***	0.12***	0.13***	-0.24***	0.17***	0.12***
2 year	0.60***	0.63***	0.63***	0.39***	-0.79***	0.22*	0.07
3 year	1.04***	1.27***	1.10***	0.98*	-1.02***	0.31	0.02
4 year	1.48***	1.86***	2.02***	2.17***	-1.07***	0.72***	0.02
5 year	1.93***	2.13***	2.30***	2.57***	-1.14***	1.26***	0.14
6 year	2.36***	2.38***	2.69***	3.15***	-1.24***	1.90***	0.42
7 year	2.79***	2.88***	3.07***	3.50***	-1.44***	2.53***	0.78
8 year	3.20***	3.48***	3.47***	3.65***	-1.72***	3.02***	1.15*
9 year	3.61***	4.35***	4.17***	4.33***	-2.10***	3.42***	1.58*
10 year	4.00***	4.80***	4.89***	5.11***	-2.67***	3.75***	
1-year holding period							
2 year	0.40***	0.82***	0.89***	0.90***	-0.47***	0.55***	0.45***
3 year	0.80***	1.49***	1.58***	1.71***	-0.76***	1.02***	0.69***
4 year	1.22***	1.94***	2.07***	2.14***	-0.90***	1.64***	1.01***
5 year	1.61***	2.38***	2.54***	2.66***	-1.02***	2.11***	1.33***
6 year	2,00***	2.94***	3.10***	3.24***	-1.15***	2.53***	1.78***
7 year	2.39***	3.43***	3.66***	3.75***	-1.40***	2.96***	2.26***
8 year	2.76***	3.81***	4.15***	4.47***	-1.67***	3.37***	2.71***
9 year	3.11***	4.23***	4.68***	4.81***	-2.06***	3.77***	3.07***
10 year	3.46***	4.84***	5.19***	5.42***	-2.47***	4.24***	
2-year holding period							
3 year	0.39***	0.67***	0.67***	0.67***	-0.44***	0.75***	0.55***
4 year	0.76***	1.15***	1.15***	1.16***	-0.80***	1.31***	1.06***
5 year	1.14***	1.64***	1.66***	1.72***	-1.08***	1.86***	1.43***
6 year	1.50***	2.26***	2.32***	2.39***	-1.33***	2.34***	1.71***
7 year	1.88***	2.82***	3.00***	3.17***	-1.59***	2.91***	1.96***
8 year	2.22***	3.42***	3.62***	3.70***	-1.91***	3.41***	2.18***
9 year	2.50***	3.94***	4.08***	4.18***	-2.31***	3.84***	2.34***
10 year	2.84***	4.46***	4.54***	4.58***	-2.69***	4.29***	

Maturities

Table 10: Standard deviations for all riding strategies and instruments

The first column contains riding instruments, where the investor's holding period is in bold. The subsequent columns show standard deviations for all the riding strategies. These are presented in percent.

		Standard Deviation					
		Positive Cushion			*Mean-Reverting*		
Instrument	Unconditional	70th	75th	80th	Level	Slope	Curvature
3-month holding period							
6 month	0.36	0.22	0.22	0.23	0.35	0.24	0.24
1 year	1.06	0.67	0.67	0.68	1.18	0.69	0.73
2 year	2.90	1.36	1.31	1.29	2.92	1.89	2.03
3 year	4.50	2.96	2.22	2.18	4.26	3.32	3.38
4 year	5.94	5.81	5.94	5.77	5.71	4.74	4.85
5 year	7.27	7.46	7.67	7.79	6.96	6.09	6.27
6 year	8.50	8.70	8.87	9.09	7.95	7.22	7.58
7 year	9.66	9.79	10.07	10.20	8.79	8.19	8.77
8 year	10.71	10.78	11.08	11.21	9.69	8.98	9.85
9 year	11.67	11.54	11.79	11.84	10.73	9.88	10.84
10 year	12.69	12.33	12.59	12.80	11.75	10.88	
6-month holding period							
1 year	0.66	0.34	0.35	0.36	0.39	0.40	0.41
2 year	2.06	2.02	1.98	1.20	1.27	1.27	1.25
3 year	3.26	4.14	3.87	3.72	1.94	2.45	2.20
4 year	4.26	5.81	6.07	6.33	2.65	3.58	3.24
5 year	5.15	6.65	6.99	7.29	3.31	4.54	4.22
6 year	5.95	7.27	7.63	8.11	3.94	5.49	5.11
7 year	6.71	7.68	8.08	8.66	4.55	6.60	5.94
8 year	7.44	7.97	8.45	8.95	5.18	7.34	6.84
9 year	8.14	8.51	8.79	9.29	5.86	7.89	7.63
10 year	8.84	8.96	9.29	9.63	6.48	8.41	
1-year holding period							
2 year	0.94	1.32	1.37	1.41	0.45	1.14	1.16
3 year	1.72	2.24	2.31	2.42	0.91	1.93	2.07
4 year	2.37	2.92	3.00	3.11	1.37	2.48	2.74
5 year	2.95	3.39	3.50	3.63	1.81	2.97	3.26
6 year	3.49	3.68	3.79	3.88	2.23	3.32	3.72
7 year	4.03	3.91	3.98	4.02	2.57	3.64	4.08
8 year	4.55	4.11	4.01	3.91	2.90	3.99	4.43
9 year	5.06	4.20	3.93	3.88	3.25	4.33	4.71
10 year	5.56	4.15	3.91	3.81	3.63	4.62	
2-year holding period							
3 year	0.66	0.60	0.61	0.62	0.38	0.54	0.65
4 year	1.22	1.07	1.08	1.10	0.68	0.95	1.07
5 year	1.70	1.53	1.52	1.52	0.92	1.29	1.41
6 year	2.13	1.85	1.84	1.80	1.13	1.55	1.68
7 year	2.53	2.03	2.01	1.96	1.31	1.76	1.93
8 year	2.91	2.11	2.06	2.04	1.48	1.99	2.14
9 year	3.28	2.18	2.17	2.14	1.64	2.19	2.33
10 year	3.64	2.29	2.35	2.34	1.83	2.36	

Maturities

Table 11: Sharpe ratios from all riding strategies and instruments

The first column contains riding instruments, where the investor's holding period is in bold. The subsequent columns show the Sharpe ratios for all the riding strategies.

		Sharpe Ratio					
		Positive Cushion			*Mean-Reverting*		
Instrument	Unconditional	70^{th}	75^{th}	80^{th}	Level	Slope	Curvature
3-month holding period							
6 month	0.53	0.69	0.67	0.62	0.12	0.65	0.63
1 year	0.34	0.23	0.21	0.19	-0.14	0.23	0.15
2 year	0.26	0.06	0.02	0.02	-0.20	0.08	0.00
3 year	0.27	0.08	-0.10	-0.17	-0.17	0.03	-0.01
4 year	0.28	0.17	0.14	0.08	-0.11	0.02	-0.01
5 year	0.29	0.19	0.16	0.12	-0.11	0.07	-0.01
6 year	0.31	0.18	0.16	0.12	-0.11	0.12	0.00
7 year	0.32	0.20	0.17	0.10	-0.14	0.16	0.01
8 year	0.33	0.22	0.18	0.09	-0.16	0.23	0.03
9 year	0.34	0.27	0.21	0.12	-0.20	0.24	0.05
10 year	0.35	0.25	0.19	0.08	-0.24	0.27	
6-month holding period							
1 year	0.35	0.35	0.34	0.35	-0.62	0.41	0.30
2 year	0.29	0.31	0.32	0.32	-0.63	0.17	0.06
3 year	0.32	0.31	0.28	0.26	-0.53	0.13	0.01
4 year	0.35	0.32	0.33	0.34	-0.41	0.20	0.01
5 year	0.37	0.32	0.33	0.35	-0.35	0.28	0.03
6 year	0.40	0.33	0.35	0.39	-0.31	0.35	0.08
7 year	0.42	0.37	0.38	0.40	-0.32	0.38	0.13
8 year	0.43	0.44	0.41	0.41	-0.33	0.41	0.17
9 year	0.44	0.51	0.48	0.47	-0.36	0.43	0.21
10 year	0.45	0.54	0.53	0.53	-0.41	0.45	
1-year holding period							
2 year	0.42	0.62	0.65	0.64	-1.06	0.48	0.39
3 year	0.47	0.67	0.68	0.71	-0.84	0.53	0.33
4 year	0.51	0.66	0.69	0.69	-0.65	0.66	0.37
5 year	0.55	0.70	0.72	0.73	-0.56	0.71	0.41
6 year	0.57	0.80	0.82	0.83	-0.52	0.76	0.48
7 year	0.59	0.88	0.92	0.93	-0.54	0.81	0.55
8 year	0.61	0.93	1.04	1.14	-0.58	0.85	0.61
9 year	0.62	1.01	1.19	1.24	-0.63	0.87	0.65
10 year	0.62	1.17	1.33	1.42	-0.68	0.92	
2-year holding period							
3 year	0.59	1.11	1.10	1.09	-1.16	1.40	0.85
4 year	0.63	1.08	1.06	1.06	-1.17	1.38	0.99
5 year	0.67	1.07	1.09	1.13	-1.17	1.44	1.02
6 year	0.71	1.23	1.26	1.33	-1.18	1.51	1.01
7 year	0.74	1.39	1.49	1.61	-1.21	1.65	1.01
8 year	0.76	1.62	1.76	1.82	-1.29	1.72	1.02
9 year	0.76	1.80	1.88	1.95	-1.41	1.75	1.00
10 year	0.78	1.95	1.93	1.96	-1.47	1.82	

Maturities

Table 12: Alphas from the risk factor regressions

The first column contains riding instruments, where the investor's holding period is in bold. The subsequent columns show alphas for all the riding strategies. These are presented in percent and are obtained from equation (14). The stars indicate at which level the alphas are statistically significant different from zero, where * p < 0.10, ** p < 0.05 and *** p < 0.01. They are corrected for autocorrelation and heteroskedasticity by utilising the Newey-West standard error.

Maturities

Alpha							
		Positive Cushion			*Mean-Reverting*		
Instrument	Unconditional	70th	75th	80th	Level	Slope	Curvature
3-month holding period							
6 month	-0.15***	-0.17***	-0.18***	-0.21***	0.48***	-0.22***	-0.22***
1 year	-0.43**	-0.44***	-0.41**	-0.41**	1.14	-0.75***	-0.80***
2 year	-0.43	0.03	0.20	0.42	0.29	-1.62***	-1.77***
3 year	-0.15	1.60**	1.33**	1.33**	0.90	-2.01**	-1.36
4 year	0.19	1.54	1.19	0.48	2.69	-2.22	-1.69
5 year	0.61	1.86	2.09	1.72	3.49	-1.32	-1.98
6 year	1.16	2.69	3.53*	3.60*	3.21	-0.36	-2.32
7 year	1.86	3.11	5.17**	5.59**	2.17	0.92	-2.47
8 year	2.67	3.68	6.32**	7.52**	-1.73	2.73	-2.56
9 year	3.55*	5.38	8.18**	9.22**	-4.73	3.02	-2.30
10 year	4.66**	7.55**	9.41**	10.38**	-9.96	3.54	
6-month holding period							
1 year	-0.49***	-0.40***	-0.37***	-0.38***	0.37**	-0.60***	-0.52***
2 year	-0.98***	-0.63	-0.58	-0.24	0.58	-1.34***	-0.85***
3 year	-1.08**	-0.24	-0.40	-0.88	1.62**	-2.04***	-1.19*
4 year	-0.99	-0.23	-0.32	-0.59	3.30***	-1.94*	-1.84*
5 year	-0.77	0.04	0.14	-0.18	4.90***	-1.38	-2.20*
6 year	-0.40	0.46	1.75	1.87	6.42***	-0.40	-2.05
7 year	0.10	1.86	3.58*	4.02*	7.60***	0.40	-1.68
8 year	0.72	3.58	4.94**	5.14*	8.36**	0.69	-1.54
9 year	1.46	5.02*	5.31*	7.07**	8.84**	1.41	-1.28
10 year	2.28	7.34**	7.78**	10.77**	7.41*	1.99	
1-year holding period							
2 year	-1.00***	-2.78***	-2.88***	-2.93***	0.51***	-2.72***	-2.48***
3 year	-1.44***	-4.59***	-4.81***	-5.23***	1.49***	-4.72***	-4.52***
4 year	-1.59***	-5.91***	-5.99***	-6.70***	2.79***	-5.52***	-5.99***
5 year	-1.54***	-5.80***	-6.14***	-6.85***	4.09***	-5.77***	-6.91***
6 year	-1.35**	-5.58***	-6.02***	-5.94***	5.34***	-5.68***	-7.40***
7 year	-1.06	-5.67***	-5.72***	-5.60**	6.04**	-5.45***	-7.35***
8 year	-0.70	-5.69**	-5.03**	-4.04	6.27*	-5.05***	-6.98***
9 year	-0.25	-5.58**	-4.20	-4.11	5.99	-4.41***	-6.32***
10 year	0.28	-4.31	-3.27	-3.47	2.83	-2.25	
2-year holding period							
3 year	-0.59***	-1.24***	-1.23***	-1.24***	0.36***	-0.93***	-1.33***
4 year	-0.88***	-1.70***	-1.77***	-1.82***	0.91***	-1.23***	-1.96***
5 year	-0.98***	-2.31***	-2.35***	-2.40***	1.48***	-1.14***	-2.37***
6 year	-0.93***	-2.33***	-2.65***	-2.64***	2.00***	-0.82*	-2.68***
7 year	-0.78**	-2.10***	-2.28***	-2.38***	2.37**	0.70	-2.99***
8 year	-0.55	-1.44***	-1.51***	-1.54**	2.56*	2.08***	-3.08***
9 year	-0.31	-0.91	-1.01	-0.94	2.41	3.27***	-3.15***
10 year	0.03	-0.52	-0.76	-0.86	1.08	4.25***	

Table 13: TERM-coefficients from the risk factor regressions

The first column contains riding instruments, where the investor’s holding period is in bold. The subsequent columns show *TERM*-coefficients for all the riding strategies. The coefficients are obtained from equation (14). The stars indicate at which level the coefficients are statistically significant different from zero, where * p < 0.10, ** p < 0.05 and *** p < 0.01. They are corrected for autocorrelation and heteroskedasticity by utilising the Newey-West standard error.

		TERM					
		Positive Cushion			*Mean-Reverting*		
Instrument	Unconditional	70th	75th	80th	Level	Slope	Curvature
3-month holding period							
6 month	0.14***	0.12***	0.12***	0.12***	-0.14*	0.16***	0.16***
1 year	0.34***	0.50***	0.49***	0.48***	-0.38	0.52***	0.54***
2 year	0.33	-0.01	-0.13	-0.26	-0.05	0.98***	1.16***
3 year	0.13	-0.98**	-0.89**	-1.01**	-0.58	1.15**	1.17***
4 year	-0.04	-1.88**	-2.13**	-2.65***	-1.54	1.36**	1.39**
5 year	-0.18	-1.91*	-2.43**	-2.96***	-2.07	1.26	1.65**
6 year	-0.33	-1.97*	-2.79**	-3.24***	-2.13	0.92	2.01**
7 year	-0.50	-2.07*	-3.02**	-3.82***	-1.91	0.40	2.34**
8 year	-0.69	-2.02	-3.49**	-4.54***	-0.62	-0.55	2.60**
9 year	-0.86	-1.99	-3.54**	-4.80***	-0.40	-0.61	2.68*
10 year	-1.10	-2.79	-4.42***	-6.01***	0.29	-0.70	
6-month holding period							
1 year	0.40***	0.39***	0.40***	0.43***	0.00	0.44***	0.41***
2 year	0.77***	0.18	0.05	-0.20	0.00	1.04***	1.00***
3 year	0.87***	-0.75	-0.65	-1.12*	-0.50	1.58***	1.45***
4 year	0.90**	-1.44*	-1.81**	-2.48**	-1.28**	1.75***	2.04***
5 year	0.89**	-1.47*	-1.93**	-1.98**	-2.03***	1.56**	2.54***
6 year	0.85*	-1.38	-2.02**	-2.23**	-2.75***	0.98	2.86***
7 year	0.77	-1.66*	-2.29**	-2.60**	-3.35***	0.61	3.07***
8 year	0.65	-2.00**	-2.60***	-2.66**	-3.83***	0.47	3.31***
9 year	0.50	-1.80*	-2.17**	-2.83**	-4.40***	0.35	3.45***
10 year	0.32	-2.23*	-2.34*	-3.47**	-4.41***	0.28	
1-year holding period							
2 year	0.84***	1.72***	1.81***	1.93***	-0.09	1.66***	1.62***
3 year	1.24***	2.42***	2.50***	2.62***	-0.54**	2.80***	2.84***
4 year	1.43***	2.83***	2.80***	3.04***	-1.16***	3.14***	3.78***
5 year	1.53***	2.60***	2.80***	3.03***	-1.78***	3.17***	4.44***
6 year	1.57***	2.58***	2.76***	2.65***	-2.38***	3.07***	4.82***
7 year	1.58***	2.73***	2.64***	2.62**	-2.77***	2.92***	4.88***
8 year	1.58***	2.76***	2.57**	2.34**	-2.99**	2.78***	4.80***
9 year	1.53***	2.61**	2.34**	2.42**	-3.19**	2.56***	4.61***
10 year	1.47***	2.19**	2.08**	2.35**	-2.21	1.85***	
2-year holding period							
3 year	0.67***	0.64***	0.61***	0.60***	0.03	0.63***	0.93***
4 year	1.08***	0.75***	0.71***	0.71***	-0.17	0.85***	1.21***
5 year	1.35***	0.94***	0.94***	0.93***	-0.43**	0.82***	1.31***
6 year	1.53***	1.04***	1.05***	1.05***	-0.70**	0.73***	1.34***
7 year	1.68***	1.13***	1.13***	1.12***	-0.90**	0.30	1.42***
8 year	1.78***	1.09***	1.13***	1.12***	-1.04**	-0.12	1.47***
9 year	1.84***	1.04***	1.08***	1.07***	-1.05*	-0.51	1.51***
10 year	1.91***	1.00***	1.07***	1.07***	-0.51	-0.81**	

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Table 14: DEF-coefficients from the risk factor regressions

The first column contains riding instruments, where the investor's holding period is in bold. The subsequent columns show *DEF*-coefficients for all the riding strategies. The coefficients are obtained from equation (14). The stars indicate at which level the coefficients are statistically significant different from zero, where * p < 0.10, ** p < 0.05 and *** p < 0.01. They are corrected for autocorrelation and heteroskedasticity by utilising the Newey-West standard error.

		DEF					
		Positive Cushion			*Mean-Reverting*		
Instrument	Unconditional	70^{th}	75^{th}	80^{th}	Level	Slope	Curvature
3-month holding period							
6 month	0.35***	0.37***	0.38***	0.41***	-0.72***	0.35***	0.34***
1 year	0.79***	-0.30	-0.40	-0.43	-2.17*	0.52***	0.53***
2 year	1.52***	0.19	0.14	0.10	-1.53	0.70	0.41
3 year	2.19***	0.62	-0.21	-0.08	-2.59	0.75	-0.75
4 year	2.73***	5.94	7.59*	10.96*	-5.21	0.47	-1.00
5 year	3.08***	6.24	7.40	10.01*	-6.53	-0.33	-1.28
6 year	3.22**	4.89	5.68	6.48	-6.26	-0.38	-1.69
7 year	3.13*	4.69	3.31	3.90	-5.00	-0.35	-2.29
8 year	2.81	4.05	2.96	2.36	0.57	0.28	-2.68
9 year	2.30	1.88	0.40	0.62	4.33	0.56	-2.94
10 year	1.55	0.29	0.65	1.29	11.22	0.80	
6-month holding period							
1 year	0.59***	-0.07	-0.20	-0.23*	-1.06***	0.33***	0.26***
2 year	1.47***	2.28***	2.62***	2.32***	-2.44***	0.02	-1.02**
3 year	2.24***	6.10***	5.88***	8.87***	-4.46***	-0.05	-1.97**
4 year	2.84***	9.66***	11.61***	15.25***	-7.20***	-0.10	-2.52*
5 year	3.24***	9.65***	11.39***	12.88***	-9.77***	0.43	-3.17
6 year	3.43***	8.37***	8.50***	9.86***	-12.20***	1.48	-4.13*
7 year	3.44***	6.86***	5.91**	6.88**	-14.15***	2.23	-5.02*
8 year	3.27**	5.28***	4.64**	4.62*	-15.5***	2.94	-5.46*
9 year	2.96**	3.53*	3.71*	2.48	-16.59***	2.68	-5.79
10 year	2.51	1.39	0.93	-0.93	-14.98**	2.41	
1-year holding period							
2 year	1.06***	2.13***	2.13***	1.76***	-1.70***	1.63***	1.19***
3 year	1.91***	5.41***	5.80***	6.64***	-3.76***	2.93***	2.06***
4 year	2.56***	7.99***	8.51***	9.43***	-6.02***	4.45***	2.51***
5 year	3.02***	9.12***	9.60***	10.56***	-8.23***	5.73***	2.71***
6 year	3.30***	9.34***	10.00***	10.36***	-10.32***	6.62***	3.09**
7 year	3.44***	9.54***	10.18***	10.14***	-11.63***	7.36***	3.54**
8 year	3.47***	9.71***	9.40***	8.65***	-12.23**	7.79***	3.88**
9 year	3.37***	10.03***	8.85***	8.60***	-12.23**	7.91***	3.86**
10 year	3.17***	9.30***	8.30***	8.28***	-7.91	6.82***	
2-year holding period							
3 year	0.67***	2.11***	2.19***	2.26***	-1.43***	1.36***	0.91***
4 year	1.20***	3.88***	4.23***	4.36***	-2.97***	2.32***	2.13***
5 year	1.59***	5.48***	5.59***	5.76***	-4.32***	3.15***	3.33***
6 year	1.86***	6.00***	6.66***	6.70***	-5.54***	3.55***	4.33***
7 year	2.02***	5.94***	6.43***	6.76***	-6.47***	2.93***	5.20***
8 year	2.07***	5.56***	5.66***	5.82***	-7.17***	2.37***	5.64***
9 year	2.03***	5.26***	5.43***	5.43***	-7.44***	1.88***	5.96***
10 year	1.93***	5.25***	5.53***	5.70***	-5.85**	1.60***	

Maturities

Table 15: LIQ-coefficients from the risk factor regressions

The first column contains riding instruments, where the investor's holding period is in bold. The subsequent columns show *LIQ*-coefficients for all the riding strategies. The coefficients are obtained from equation (14). The stars indicate at which level the coefficients are statistically significant different from zero, where * p < 0.10, ** p < 0.05 and *** p < 0.01. They are corrected for autocorrelation and heteroskedasticity by utilising the Newey-West standard error.

LIQ							
		Positive Cushion			*Mean-Reverting*		
Instrument	Unconditional	70^{th}	75^{th}	80^{th}	Level	Slope	Curvature
3-month holding period							
6 month	-0.01	0.00	0.00	0.00	-0.03	-0.01	0.00
1 year	-0.03	-0.02	-0.02	-0.02	-0.03	-0.01	-0.01
2 year	-0.09	-0.03	-0.07	-0.04	-0.15	-0.04	-0.02
3 year	-0.14	0.04	0.04	0.02	-0.32	-0.09	-0.08
4 year	-0.17	0.07	0.10	0.23	-0.11	-0.08	-0.07
5 year	-0.20	-0.02	-0.02	-0.09	0.01	-0.14	-0.10
6 year	-0.22	0.01	0.08	0.02	0.22	-0.10	-0.10
7 year	-0.24	-0.05	-0.15	-0.06	0.08	-0.17	-0.14
8 year	-0.26	-0.08	-0.14	-0.05	-0.04	-0.16	-0.19
9 year	-0.28	-0.26	-0.31	-0.33	0.14	-0.13	-0.20
10 year	-0.30	-0.51	-0.57	-0.43	0.07	-0.33	
6-month holding period							
1 year	-0.01	0.02	0.01	0.01	0.00	0.02*	0.02**
2 year	-0.04	-0.19	-0.13	0.00	-0.02	0.02	0.03
3 year	-0.07	-0.17	-0.31	-0.33*	-0.06	0.01	0.02
4 year	-0.09	-0.13	-0.20	-0.21	0.03	-0.14	0.00
5 year	-0.10	-0.24	-0.24	-0.23	0.08	-0.20	-0.02
6 year	-0.10	-0.23	-0.25	-0.26	0.13	-0.16	-0.12
7 year	-0.10	-0.21	-0.25	-0.26	0.12	-0.02	-0.22
8 year	-0.10	-0.35	-0.23	-0.24	0.05	-0.06	-0.23
9 year	-0.11	-0.32	-0.25	-0.24	0.13	-0.11	-0.34
10 year	-0.12	-0.26	-0.23	-0.20	0.04	-0.16	
1-year holding period							
2 year	0.00	-0.03	-0.01	0.00	-0.02	0.03	0.03
3 year	-0.01	0.01	-0.01	-0.01	-0.05	0.02	0.04
4 year	-0.02	-0.06	-0.05	-0.05	-0.02	0.05	0.02
5 year	-0.02	0.10	-0.12	-0.10	-0.02	0.04	-0.03
6 year	-0.02	-0.04	-0.03	-0.02	-0.02	0.01	-0.01
7 year	-0.03	-0.01	-0.10	-0.12	-0.05	0.00	0.09
8 year	-0.03	0.03	-0.08	-0.09	-0.09	-0.01	-0.01
9 year	-0.04	-0.03	-0.11	-0.19	-0.09	-0.01	-0.01
10 year	-0.04	-0.06	-0.08	-0.19	-0.17	-0.03	
2-year holding period							
3 year	0.00	0.00	0.00	0.00	-0.01	0.01	-0.01
4 year	0.00	0.02	0.01	0.00	-0.01	0.03	0.01
5 year	0.00	0.00	0.02	0.01	0.00	0.02	0.04
6 year	0.01	0.00	0.03	0.04	-0.01	0.04	0.04
7 year	0.01	0.03	0.02	0.03	-0.01	0.03	0.05
8 year	0.02	0.04	0.02	0.03	-0.02	0.03	0.07*
9 year	0.03	0.04	0.10	0.10	-0.02	0.02	0.08*
10 year	0.03	0.02	0.10	0.12	-0.07	0.02	

Maturities

Table 16: OBX-coefficients from the risk factor regressions

The first column contains riding instruments, where the investor's holding period is in bold. The subsequent columns show *OBX*-coefficients for all the riding strategies. The coefficients are obtained from equation (14). The stars indicate at which level the coefficients are statistically significant different from zero, where * $p < 0.10$, ** $p < 0.05$ and *** $p < 0.01$. They are corrected for autocorrelation and heteroskedasticity by utilising the Newey-West standard error.

Maturities

		OBX					
		Positive Cushion			*Mean-Reverting*		
Instrument	Unconditional	70th	75th	80th	Level	Slope	Curvature
3-month holding period							
6 month	-0.01	0.00	-0.01	-0.01**	-0.02*	-0.01	-0.01
1 year	-0.03	-0.02	-0.03	-0.03	-0.07	0.00	-0.02
2 year	-0.10	-0.09*	-0.11**	-0.09	-0.17	-0.03	-0.01
3 year	-0.15	-0.13	0.00	-0.04	-0.24	-0.09	-0.05
4 year	-0.19	-0.04	0.01	0.06	-0.13	-0.06	-0.05
5 year	-0.22	-0.12	-0.14	-0.16	-0.18	-0.15	-0.06
6 year	-0.24	-0.05	-0.01	0.01	-0.04	-0.13	-0.04
7 year	-0.26	-0.10	-0.03	-0.02	0.00	-0.18	-0.04
8 year	-0.29	-0.13	-0.03	-0.04	-0.22	-0.13	-0.03
9 year	-0.31	-0.26	-0.23	-0.35	-0.10	-0.09	-0.07
10 year	-0.34	-0.26	-0.41	-0.26	-0.37	-0.36	
6-month holding period							
1 year	0.00	0.01	0.01	0.01	-0.01	0.01	0.01
2 year	-0.01	-0.05	0.01	0.01	-0.02	0.02	0.02
3 year	-0.02	-0.06	-0.12	-0.09	-0.03	0.01	0.03
4 year	-0.03	-0.01	-0.04	-0.04	0.01	0.01	0.05
5 year	-0.04	-0.03	0.06	0.01	0.00	-0.08	0.06
6 year	-0.04	0.12	0.00	0.10	0.03	-0.04	-0.04
7 year	-0.04	0.14	0.02	0.02	0.04	0.10	0.02
8 year	-0.04	0.01	0.04	0.14	-0.02	0.08	0.01
9 year	-0.04	0.02	0.01	0.04	0.01	-0.03	-0.10
10 year	-0.05	0.06	-0.03	0.05	-0.09	-0.02	
1-year holding period							
2 year	0.01	-0.01	-0.01	0.00	-0.02**	0.04*	0.04
3 year	0.01	0.00	-0.02	-0.02	-0.05*	0.07*	0.07*
4 year	0.00	0.05	0.00	0.00	-0.05	0.12*	0.06
5 year	0.00	0.07	-0.05	0.02	-0.08	0.09	0.07
6 year	0.00	-0.01	0.02	0.04	-0.10	0.05	0.10
7 year	-0.01	-0.01	-0.07	-0.07	-0.12	0.05	0.20*
8 year	-0.01	0.00	-0.04	-0.05	-0.17	0.04	0.14
9 year	-0.02	-0.06	-0.07	-0.04	-0.18	0.05	0.12
10 year	-0.02	-0.06	-0.03	-0.13	-0.26**	-0.01	
2-year holding period							
3 year	0.00	0.00	0.00	0.00	-0.01*	0.01	0.00
4 year	0.00	0.02	0.00	0.00	-0.02	0.02	0.02
5 year	0.00	-0.01	0.01	0.01	-0.02	0.02	0.03
6 year	0.01	-0.01	0.02	0.02	-0.03	0.03	0.05
7 year	0.01	0.02	0.00	0.01	-0.03	0.02	0.05
8 year	0.01	0.02	0.02	0.02	-0.04	0.00	0.07
9 year	0.02	0.02	0.09	0.08	-0.05	-0.02	0.07
10 year	0.02	0.01	0.09	0.10	-0.10*	-0.02	