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DETERMINANTS OF THE NORDIC HEDGE FUND PERFORMANCE

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Abstract. Hedge funds have become an important part of the financial sector. The development of the hedge funds in the Nordic countries has been rather robust. Therefore, it is important to identify the determinants of the hedge fund performance and isolate the managerial performance, i.e., the Jensen's alpha. To this end, this paper construct cross sectional and panel model for the Nordic hedge funds over 2005–2018. The Fung-Hsieh 8-factor model and other models are developed to identify the determinants of the Nordic hedge fund performance. The effects of crises of different nature (local to global, hedge funds to banking sector) are also tested. The results indicate that Nordic hedge funds are capable to generate positive alpha during the crisis even exceeding the alpha of the economically stable time periods.

Keywords: hedge funds, Nordic countries, asset pricing, panel models, crisis variable, risk factors.

JEL Classification: G23, C23.

Introduction

Although hedge funds account for less than 5% of all Collective Investment Undertakings (CIU) industry reaching the Assets under Management (AUM) of 3.25 trillion in the end of 2018, hedge funds have received a great deal of coverage by the researchers due to their focus on the high return. The high returns of the hedge funds derive from dealing with higher risk assets often using leverage and derivatives and special management techniques involving the combination of long/short, market neutral, relative value arbitrage strategies. Hedge fund strategies are more contrarian and do not follow the market trend allowing to generate the excess return (alpha) of 2.4%, while mutual funds are more inclined to do the

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opposite (Grinblatt et al., 2020). The analysis of the financial data allows one to identify the underlying trends in the performance of business entities (Zhao et al., 2020). This can be applied to the financial institutions and instruments as well.

Dixon et al. (2012) categorised the higher risk of the hedge fund investment into the following channels:

- Credit channel with the collapse of Long-Term Capital Management (LTCM) in 1998 occurred as a consequence of worldwide crises in Asia and Russia.
- Capital market concentration with tight connection with major investment banks as Bear Stern and Lehman Brothers which collapsed at the peak of financial crisis of 2007–2008.
- Liquidity risk which causes the sudden price fall during the sell-off the assets.

The assessment of the hedge fund performance is determined by balancing the investment instrument-based risk profile and the unique dynamic strategy implemented by the hedge fund manager. CAPM, APT and other conventional methods face challenges when measuring the hedge fund performance (Fung & Hsieh, 2004). The common drawback in trying to apply those methods for hedge fund pricing model is that they both rely on linear risk factors, which hedge funds managers can easily eliminate in their strategies by applying derivatives or option-like strategies.

Considering hedge funds contain financial instruments with linear and non-linear payoffs, they may employ hedging/derivative instruments and they may employ very dynamic trading, Fung and Hsieh (2004), provided a new view on the hedge fund pricing. They identified five major risk components out of the set of the most common ones in the hedge fund universe.

These authors also created five drivers of return within an asset class in relationship to those five components. These drivers were attributed to categories of value, system/trend following, system/opportunity, distressed style factors and global/macro. These portfolios of look back straddles are considered as the trend following risk factors which resemble the returns of trend following hedge funds, providing a key link between hedge fund returns and market assets. Edelman et al. (2012) supplemented the model with emerging market index that is now called Fung and Hsieh 8-factor model initially designed to analyse the surviving hedge funds and their generated positive alpha. Dewaele et al. (2015) and other researchers contributed to hedge funds assets pricing by analysing and proposing other investment-based non-linear factors (or alternative risk premia) summarized by Robertson (2018).

The largest share of the hedge funds is managed by the managers in the United States which were used to develop those hedge fund performance measurement tools. Meanwhile the research of the smaller regions (e.g., the Nordic hedge funds reported AUM of USD 31.52 billion and do not exceed 1% of Global hedge funds) are rather episodic. Do et al. (2005) analyse Australian hedge funds; Van Dyk et al. (2014) compare US, Europe and Asian hedge funds; Oueslati and Hammami (2018) built models for Saudi Arabian and Malaysian hedge funds; Kanuri (2020) analyses Japanese hedge funds performance.

The other special focus of our research is striving to expose whether the performance measurement models are able to figure the main determinants of the performance during the different economic cycle conditions. Researchers globally usually seek the strategies and the actions (e.g., adjusting the strategy, reducing the leverage) leading to the positive results

during the crisis and are interested in identifying the hedge funds outperforming the other investment classes during the crisis. Although Nordic hedge funds indices outperform the global rivals (e.g., NHX Composite index surpasses HFR index in the crisis financial of 2007–2008 by 8%) this phenomenal performance is left overshadowed in the lights of "green economy" or Chinese investors' impact onto the Nordic market. Thus, we set the objective of this paper to develop the pricing models that would reveal the factors determining the performance of the Nordic hedge funds. The special focus shall be accommodated to the selected Nordic hedge fund managers' performance during the crisis time over the period of 2005–2018. We also intentionally did not include the latest Nordic hedge fund performance time series as the Nordic hedge fund market underwent significant transformation: there was a sharp decrease of Nordic hedge fund reported AuM in 2019 and Covid-19 crisis in 2020 with stunning positive results presented by Kolisovas (2021b).

The paper is organized as follows: Section 1 analyses the performance of the NHX hedge funds and the composition of the Nordic hedge fund industry. Section 2 identifies Asset Pricing models and the variables, which would best explain the pricing of the Nordic countries hedge funds. Section 3 presents our empirical Nordic hedge fund pricing modelling results based on the theoretical assumptions. Section 4 examines the robustness of the models. Section 5 discusses the results on the global and wider context. The conclusions summarise the main Nordic hedge fund performance determinants providing the tools to the investors and recommendations for further in-depth research.

1. Nordic hedge funds

The Nordic countries are extensively represented by Hedge Nordic database collected and published by Nordic Business Media Aktiebolag – a private limited company registered in Stockholm, Sweden. Hedge Nordic provides the main Nordic Hedge Index Composite – NHX Composite – an equally-weighted index tracking the performance of the universe of Nordic hedge fund managers on a monthly basis. To be admitted to the NHX index, the fund, the fund manager, or the investment advisor should be domiciled in one of the Nordic countries (i.e., Finland, Sweden, Norway, Denmark, or Iceland), or the investment theme of the fund should be clearly Nordic or exhibit strong and convincing ties to the Nordic region. Hedge Nordic breaks down the Nordic hedge fund universe into five categories of hedge funds, which are also reflected by NHX strategy equally weighted indices: NHX Equities, NHX Fixed income, NHX CTA, NHX Multi-strategy and NHX Fund of funds. Nordic equities and fixed income hedge funds contain Nordic region equity or debt securities and their derivatives, Nordic CTA may also use the commodity and currency instruments. These specific focus on the Nordic investment instruments impose the assumption Nordic hedge funds returns are affected by Nordic specific systemic risk measures. The distribution of Nordic hedge fund across countries and strategies is presented in Table 1.

Hedge funds with a track record of longer than 100 months from 2005 to March 2018 were analysed making in total 72 funds out of 219 reported in 2018. Estrada (2021) concludes the series of reports claiming, that most hedge funds fail: their average life span is about 5

years. However, out of 72 analysed Nordic hedge funds, 57 survived for over 10 years making Nordic as a long-livers region (Kolisovas, 2021a).

Table 1. Nordic hedge funds distribution

Country / Hedge fund strategy	Sweden	Denmark	Finland	Norway	All selected funds
Nordic Equities	19	1	–	6	26
Nordic Fixed income	2	7	–	1	10
Nordic Multi-strategy	5	5	1	–	11
Nordic CTA	8	1	3	–	12
Nordic Fund of funds	10	–	3	–	13
Total	44	14	7	7	72

Considering the Nordic region factors are significant and following Hespeler and Loiacono (2015) hedge funds were split into two main categories: the funds with returns significantly correlated with the industry / sector and the funds with neutral character. The values ≥ 0.3 and ≤ -0.3 are considered of high or moderate degree correlated and the values in the range between -0.3 and 0.3 are said to be a small correlation close to industry / strategy neutral. Such split into categories shall also reduce the possible effect of heteroscedasticity. Having considered this rule within the same NHX strategies indices the funds can be distributed in the following pools (Table 2).

Table 2. Hedge funds by correlation with corresponding NHX index

Hedge fund strategy	Total number of selected funds	Positive correlation	Low correlation	Negative correlation
Nordic Equities	26	18	8	–
Nordic Fixed income	10	5	5	–
Nordic Multi–strategy	11	9	2	–
Nordic CTA	12	8	4	–
Nordic Fund of funds	13	10	3	–
Total	72	50	22	–

In contradiction to Hespeler and Loiacono (2015) Nordic hedge fund data did not reveal any significant negative correlation which could lead to negative coefficients. However, 22 hedge funds out of 72 are showing signs of neutrality and their strategies may be more contrarian. Ardia and Boudt (2018) and Canepa et al. (2020) also proposed analysing hedge funds data split into quantiles by the performance. However, the preliminary analysis revealed, that splitting the funds into larger and wider quantiles does not make any significant effect on the models. Splitting into four to five quantiles leave smaller groups indivisible. Kolisovas (2021b) analysed Nordic equity hedge funds only splitting the hedge funds into quintiles by the volatility allowing to track the performance of the Nordic equity hedge funds right before and during the pandemic of Covid-19.

Following the performance characterisation by correlation with the index, as well as following Teo (2009) and Kang et al. (2020) there were constructed equally weighted three different portfolios of hedge funds based on their correlation with the index returns. These portfolios are named "Total", "Correlated" (positively) and "Neutral". Table 3 reports the summary statistics of these portfolios constructed for each hedge fund strategy.

Table 3. Summary statistics of NHX hedge fund portfolios (monthly)

Hedge fund strategy	Mean	Std. Dev.	Sharpe	Skew	Kurtosis
Equities hedge funds					
Total	0.51%	1.26%	40.48%	–0.3	4.56
Correlated	0.55%	1.75%	31.59%	–0.49	4.93
Neutral	0.42%	0.71%	58.69%	0.34	5.39
NHX Equities	0.48%	1.50%	32.23%	–0.73	4.62
Fixed income hedge funds					
Total	0.61%	0.91%	66.56%	–0.89	9.33
Correlated	0.77%	1.57%	48.77%	–2.02	1.69
Neutral	0.44%	0.57%	77.52%	0.6	3.51
NHX Fixed income	0.46%	1.35%	34.15%	–3.84	27.05
Multistrategy hedge funds					
Total	0.48%	1.92%	25.07%	–1.64	10.39
Correlated	0.44%	2.25%	19.51%	–1.79	10.49
Neutral	0.69%	1.89%	36.53%	0.34	3.31
NHX Multistrategy	0.41%	1.11%	37.28%	–0.51	3.54
CTA hedge funds					
Total	0.36%	2.45%	14.81%	0.12	2.96
Correlated	0.29%	3.47%	8.26%	–0.12	3.04
Neutral	0.51%	2.26%	22.77%	0.23	3.95
NHX CTA	0.50%	1.95%	25.38%	0.21	3.29
Fund of funds hedge funds					
Total	0.26%	0.69%	37.02%	–0.45	2.96
Correlated	0.26%	0.88%	30.27%	–0.42	2.94
Neutral	0.23%	0.41%	56.90%	0.47	4.36
NHX Fund of funds	0.18%	0.90%	19.76%	–0.92	5.87

For comparison purposes the summary statistics of the corresponding hedge fund indices is also presented next to the hedge fund portfolios statistics. The mean returns of "Total" portfolios of Nordic Equities, Nordic Fixed income, Nordic Multi-strategy and Nordic Fund of funds exceed the NHX index mean return what corresponds to the survivorship bias characteristic to most of hedge fund databases. Fung and Hsieh (2004), Hespeler and Loiacono (2015), Joenväärä et al. (2019) and others who made their analysis on the global scale

choose several or even all five global databases combined data to reduce the bias. Dou et al. (2021) detected the material survivorship bias of small databases similar to Nordic hedge funds which cannot be reduced. Alliance Bernstein's (2012) research noted that alive funds reported 2.5% (or 0.2% monthly) better annual returns comparing with portfolios including the funds discontinued reporting. An example of NHX CTA index, however, is opposite: the mean return is 0.5% monthly, whereas Nordic CTA "Total" portfolio only is 0.36%. Taking in consideration hedge fund return reporting biases, we admit the paper represents the pricing models of the long living funds, not the entire Nordic hedge fund universe.

2. Methods and data

The development of the hedge fund asset pricing models began from relying on the traditional risks (such as traditional asset value or the size of the company issuing the capital market instrument). These traditional risks are gathered in Conventional CAPM, APT or Fama-French three-factor model. Agarwal et al. (2018) noted that investors also started to recognise the exotic risks (such as momentum and option-like investments) usually used by hedge fund managers. Besides Fung and Hsieh 7-factor model initiated in 1997 and developed through 2004, Carhart (1997), Agarwal and Naik (2004), Capocci et al. (2005) and other worked on developing exotic risk factors, which would allow calculating more accurate hedge fund alpha. Agarwal et al. (2018) as well Robertson (2018) linked the risk factors with their relative price, considering exotic factors are more difficult and expensive to achieve. The factors were grouped by the cost and the difficulty from asset-based beta and increasing to smart beta, alternative beta and alpha factor on the top. Such an approach distinguishes alpha as the most contributing to the top results of the hedge funds and therefore need to be adequately rewarded. Agarwal et al. (2018) also argue, that CAPM model explains alpha better than more sophisticated models. Duanmu et al. (2020) analysed the contribution of various factors and found both beta dominant and alpha dominant hedge funds.

Fung and Hsieh 8-factor model enhanced by Edelman et al. (2012) was used as the basis in our research. Fung and Hsieh 8-factor model covers a broad range of the factors including: equity risks consisting of equity market, size spread and emerging market factors; bond risk that consists of bond market and credit spread factors, and trend following risk that consists of bond trend-following, currency trend-following, and commodity trend-following factors. Following the arguments of Agarwal et al. (2018) these factors were diluted with other exotic risk factors of Fama and French 3-factor model Dewaele et al. (2015). The special attention was paid to commodity factors, which are more common in the hedge funds during the difficult conditions (Stafylas et al., 2018).

The above-mentioned researchers were analysing global hedge fund databases (Barclay Hedge; Eureka Hedge; HFR; Morningstar and TASS) which altogether gather over 25 thousand single funds on aggregate. As the vast majority of hedge funds are registered or related to USA, global risk factors were dominant in those researches. Our research focuses on Nordic hedge funds investing into Nordic assets, therefore stock index related factor SPRF, stock size related factor RLSP and 10 years yield related bond factor TYRF were replaced with the corresponding Nordic national factors (Table 4).

Table 4. Substituted risk factors

Risk factor	Descriptions	Substituted factor
OMXSRF	Monthly OMX[1] Stockholm 30 Index (SE0000337842) minus monthly[2] Sweden 3-Month Bond Yield	SPRF
OMXCRF	Monthly OMX Copenhagen Ex OMXC20 (DK0060487064) minus monthly Denmark 3-Months Bond Yield	
OMXHRF	Monthly OMX Helsinki 25 (FI0008900212) minus monthly Finland 2-Years[3] Bond Yield	
OSEBXRF	Monthly Oslo Børs[4] Benchmark Index minus monthly Norway 3-Months Bond Yield	
OMXN40FR	Monthly OMX Nordic 40 Index (SE0001809476) minus Risk-free rate	
SizeSprS	Monthly OMX Stockholm Small Cap minus monthly OMX Stockholm 30 Index (SE0000337842)	RLSP
SizeSprC	Monthly OMX Copenhagen Small Cap minus monthly OMX Helsinki 25 (FI0008900212)	
SizeSprH	Monthly OMX Helsinki Small Cap minus OMX Helsinki 25 (FI0008900212)	
SizeSprO	Monthly Oslo GICS Small Caps minus monthly Oslo Børs Benchmark Index	
10YSwed	Sweden 10Y Bond Yield[5] minus Sweden 3-Month Bond Yield	TYRF
10YDen	Denmark 10Y Bond Yield minus Denmark 3-Months Bond Yield	
10YFin	Finland 10Y Bond Yield minus Finland 2-Years Bond Yield	
10YNor	Norway 10Y Bond Yield minus Norway 3-Months Bond Yield	

Notes: [1] OMX indexes are uploaded from www.nasdaqomxnordic.com/indexes website.
[2] Here and where other yield (or rate) is reported annual, monthly rate is computed by division by 12.
[3] 3-Months Yield is not available in Finland, however 2-Year bonds are not much different in other Nordic countries, therefore 3-Month yield was not extrapolated.
[4] Oslo Børs indexes were uploaded from https://www.oslobors.no/ob_eng/markedsaktivitet website.
[5] All yield information was uploaded from https://www.investing.com/rates-bonds website.

Most of the Nordic hedge funds and risk factors presented in Table 4 are accounted in the local currency (i.e., Sweden – SEK; Finland – EUR; Denmark – DKK and Norway – NOK). To eliminate the possible distortion of the models deriving from the currency exchange, hedge fund returns, and national factors were recalculated (discounted) using the local currency and USD spot market exchange rate deviation.

Almeida et al. (2020) benefited from using panel data models when splitting the hedge funds into narrower pools by performance or interaction with the benchmark what we are also aiming in this research. The ultimate panel data models based on Fung and Hsieh 8-factor model with replaced local variables were also supplemented with commodity and other variables as suggested by Stafylas et al. (2018), Racicot and Theoret (2019), Bohl et al. (2020), Mensi et al. (2021). The list of risk factors is presented in Table 5. The table also presents the summary statistics and the augmented Dickey-Fuller (ADF) test to assure the values in the regression models are stationary. If the variables in the regression model are not stationary, then it can be proved that the standard assumptions for asymptotic analysis will not be valid.

Table 5. Final model risk factors with corresponding summary statistics

Risk factor	Mean	Std. Dev.	Shapre	Skew	Kurtosis	ADF-p
OMXSRF	0.37%	4.63%	7.90%	–0.89	5.89	0.0000
OMXCRF	0.66%	5.25%	12.63%	–1.29	5.91	0.0000
OMXHRF	0.40%	5.35%	7.39%	–0.31	5.36	0.0000
OSEBXRF	0.64%	5.87%	10.81%	–1.74	9.61	0.0000
SizeSprS	0.53%	3.71%	14.26%	0.56	5.80	0.0003
SizeSprC	–0.54%	2.57%	–21.12%	0.30	4.24	0.0000
SizeSprH	0.10%	3.63%	2.77%	0.64	5.30	0.0000
SizeSprO	–0.14%	3.36%	–4.25%	0.33	3.69	0.0000
10YSwed	0.11%	0.07%	159.73%	0.53	3.45	0.1758*
10YDen	0.08%	0.07%	120.03%	–1.00	4.02	0.0834*
10YFin	0.10%	0.06%	176.45%	0.16	2.19	0.4776*
10YNor	0.07%	0.07%	101.47%	–0.83	4.60	0.0216
BAATY	2.66%	0.85%	311.15%	1.59	6.89	0.0526*
MSEMKFRF	0.59%	6.33%	9.34%	–0.55	5.11	0.0000
PTFSBDRF	–3.45%	14.48%	–23.85%	1.30	4.86	0.0000
PTFSFXRF	–1.46%	19.59%	–7.46%	1.38	5.06	0.0000
PTFSCOMRF	–0.68%	15.08%	–4.48%	0.88	3.34	0.0000
PTFSIRRF	–3.08%	29.54%	–10.43%	4.34	29.02	0.0000
PTFSSTKRF	–4.62%	14.41%	–32.04%	1.72	8.66	0.0000
SMB[1]	0.08%	2.27%	3.43%	0.24	2.68	0.0000
HML	–0.03%	2.55%	–1.02%	0.00	5.66	0.0000
LIQ[2]	0.12%	3.55%	3.46%	–0.39	4.52	0.0000
OCMDRWT[3]	0.33%	3.93%	8.41%	–0.86	5.90	0.0000
GOLD[4]	0.70%	4.07%	17.27%	0.06	3.37	0.0000
COPPER	0.68%	8.03%	8.44%	–0.16	6.91	0.0000
SILVER	0.90%	9.49%	9.46%	0.09	3.27	0.0000
BROIL	0.71%	9.64%	7.40%	–0.16	4.49	0.0000
NGAS	0.26%	13.38%	1.91%	0.76	5.98	0.0000
COCOA	0.64%	7.48%	8.58%	0.03	3.14	0.0000
VIX[5]	0.33%	3.93%	8.41%	–0.86	5.90	0.0000

Notes: [1] SMB and HML – Fama and French (1993) factors also used by Dewaele et al. (2015).

[2] Liquidity factor of Pástor and Stambaugh is presented in https://faculty.chicagobooth.edu/-/media/faculty/lubos-pastor/data/liq_data_1962_2019.txt.

[3] Risk Weighted Enhanced Commodity Ex grains Index tracked by Ossiam ETF, includes 20 out of 24 components from the S&P GSCI TR. This strategy aims to offer volatility reduction and a better participation from all commodity sectors, especially by avoiding the concentration in the energy markets (weighting approximatively 70% of the S&P GSCI allocation). Source https://www.next-finance.net/Ossiam-ETF-on-the-Risk-Weighted.

[4] Commodity (Gold, Copper, Silver, Brent oil – BROIL, Natural gas – NGAS and Cocoa are represented by corresponding monthly spot price change less risk-free rate of return).

[5] 30-day expected volatility of the U.S. stock market, derived from real-time, mid-quote prices of S&P 500® Index (SPXSM) call and put options. On a global basis, it is one of the most recognized measures of volatility – widely reported by financial media and closely followed by a variety of market participants as a daily market indicator http://www.cboe.com/vix.

*For the risk factors, with ADF-p value above 0,05 we cannot reject the null Hypothesis (variable has a unit root), therefore, these variables are not stationary. We replaced these factors with the 1st difference resulting in ADF-p value to fall below 0.05 – all above mentioned variables are stationary and can be used in the regression analysis.

Other macroeconomic indicators, such as GDP, unemployment rate, public debt, etc. are exogenous to hedge fund return. They are excluded from the research even though they are commonly used for the forecasting purposes, macro strategy is not present in the research, therefore based on APT theory variables with focus on the stock market, fixed-income market and the commodity market are used.

The crisis factors are the factors that attract our attention the most. Various researchers look at the crisis from different perspective: Cao et al. (2018), Liang and Qiu (2019), Gregoriou et al. (2021) and others differentiate between the strategies which struggle the most during the crisis and those with positive results, usually adjusting their strategies or reducing the leverage just before the crisis occurs. While Sung et al. (2020), Denk et al. (2020) looked rather specifically on the hedge funds which showed better performance during the crisis than the benchmarks or mutual funds. Our calculations show that Nordic hedge funds outperformed global hedge funds performance by as much as 8 percent during the harsh drawdown in 2009 connected with the financial crisis of 2007–2008.

Racicot and Théoret (2016) found VIX index embeds the macroeconomic conditions into the performance of the hedge funds and focused their attention to the hedge fund strategies (e.g., distressed securities, short-sellers and futures' strategies) which allow the diversification of the portfolio during the distressed market conditions. The later view of Racicot et al. (2021) focused on the indicators of co-skewness and co-kurtosis and how they reflect the hedge fund response to the shocks especially related with illiquidity issues. In this research we seek to encounter different crisis condition determining indicators and see whether hedge funds have long-term fundamental "successful crisis survival" features not related to individual instant and frequent strategy adjustment.

To assess the impact of the crisis on the performance of the Nordic hedge funds we analysed the crisis definitions first. Babecký et al. (2014) defined the banking crisis which impacts the credit supply process and consequently result in the production and housing markets. There were the following banking crises identified in Nordic countries: Sweden 2008 January – 2008 December and Denmark 2008 January – 2010 December. Banking crisis should restrain Hedge Fund abilities to borrow money in the financial markets and limit the leverage possibilities.

Hespeler and Loiacono (2015) also sought for coherence of hedge fund returns with periods of financial distress and covered the following crisis periods: The Asian crisis, the Russian default crisis (also LTCM), the "dotcom" crisis of 2000, the crisis following September 11, the great recession starting in 2007, the EU debt crisis starting in 2009 and its continuation in 2012. Other and the latest crisis periods related to Brexit vote, Brexit execution, negative interest rates and Covid-19 1st wave (this research does not cover any Covid-19 related crisis,

as the research horizon is limited to March 2018). The periods of the Global crisis are general and valid in all Nordic countries: global financial crisis (2007-08 to 2009-03); European debt crisis (2009-10 – 2011-12 and 2012-07 – 2013-05); the Brexit-related crisis (2016-06 to 2018-03). However, due to arguments about the severity of the Brexit impact on the financial markets "Global crisis excluding the Brexit" factor is also analysed.

Hedge Fund Exposure & Tail Risk Industry Report published by Evestment (2018) presented the historical scenarios that have made the highest impact on the 30 largest reporting hedge funds. Global Hedge Funds' Industry Drawdown is presented in Table 6.

Table 6. Global Hedge Fund Industry Drawdown periods

Historical scenario	Drawdown period	Drawdown variable period
2008 January Crisis	12/11/07 – 1/22/08	2007 December – 2008 January
2008 Lehman Bankruptcy	9/2/08 – 11/20/08	2008 September – 2008 November
2010 Greece Downgrade	4/27/10 – 6/14/10	2010 May – 2010 June
2014 Russia/ Crimea	2/21/14 – 3/18/14	2014 February – 2014 March
2014 WTI Drop	9/26/14 – 12/29/14	2014 October – 2014 December
2015 Chinese Market Crash	6/12/15 – 9/4/15	2015 June – 2015 September
2015 Fed Rate Hike	12/16/15 – 1/22/16	2015 December – 2016 January
2016 Brexit & Sterling Drop	6/23/16 – 6/27/16	2016 June

All above mentioned crisis are called accordingly: Banking Crisis, Global crisis and Global Drawdown. Crisis periods take value 1 and the value 0 when no crisis occurred. The cross section and panel econometric models are estimated by treating the Nordic hedge fund returns as a dependent variable. The time series are not split into smaller periods; therefore, the results reflect long-term models and long-term performance measures covering the whole research horizon from January 2005 till March 2018. It is also important to note, that such long duration time series model diminishes smart and alternative beta factors, which according Racicot and Théoret (2019) fund managers can variate depending on the market situation, and they can be frequently adjusted depending on the market situation. A series of statistical tests[1] is applied to check the relevance of the models proposed. The backward procedure is applied to isolate the significant factors which achieve at least 95% of significance level.

3. Results

A series of Fung and Hsieh 8-factor panel data models have been compiled to assess the contribution of risk factors listed in Table 5. Models based on the traditional Fung and Hsieh 8-factor model factors are compared with models using additional risk factors, which are split into two groups: National factors (Stock index, Size spread and 10-year bond yield) and other researchers hedge fund specific factors or Other specific factors (Fama-French factors, Commodities, Liquidity premium, VIX index). For comparison purposes the impact of National

[1] The tests are applied in the following order seeking to construct a fixed-effect cross-section models: Breusch-Pagan LM random effect, if pass – Hausman fixed effect, if pass – Breusch-Pagan LM cross-section dependence tests.

factors replacing the Global equivalents and adding other specific factors were also tested using multiple linear regression Fung and Hsieh 8-factor models. However, due to limitations of the NHX indices no models combining National factors and adding other specific factors can be compiled using NHX indices. While replacing of the Global risk factors with National is only possible using NHX country indices, adding the other specific factors may be strategy specific and therefore can only give conclusive results when using NHX strategy index. The comparison of models based on Global factors and models with National factors replacing the Global is best presented analysing adjusted R^2 of the models presented in Table 7.

Table 7. NHX country index model comparison

NHX country index	NHX Sweden	NHX Denmark	NHX Finland	NHX Norway	Composite
Adj. R^2 Global factors	0.5437	0.6770	0.3316	0.5260	0.6353
Adj. R^2 National factors	0.7307	0.7421	0.5656	0.7820	0.7824

The increase of adjusted R^2 on average by 20% is due to the construction of panel data models using pooled hedge fund return data with individually linked country-specific risk factors cross-sectionally connected by the NHX strategy. Fung and Hsieh 8-factor panel data models with hedge funds cross-sectionally connected by the strategies are compiled using Global factors and National factors connected to each hedge fund based on the NHX index country allocation. The adjusted R^2 of those models are presented in Table 8.

Table 8. Nordic hedge fund panel data global and national model comparison

Nordic hedge fund strategy	Equity	Fixed income	CTA	Multi-strategy	Fund of funds
Adj. R^2 Global factors	0.4353	0.4570	0.1370	0.5088	0.4782
Adj. R^2 National factors	0.5323	0.6532	0.1708	0.5567	0.6263

The changes of adjusted R^2 presented in Table 8 are comparatively lower than in Table 7 where multiple linear regression models were used. As Tables 7 and 8 present models based on different dimension (i.e., Table 7 present models based on Nordic countries and Table 8 – on strategies), no direct comparison is possible. However, the trends persist and National factors (Stock index, Size spread and 10-year bond yield) outperform the Global factors in equity hedge funds nearly 10% and fixed income hedge funds – almost 20% (similar to changes in models presented in Table 7). The further and more in-depth analysis of the degree of the improvement of R^2 are presented with further in-depth analysis of the other specific factor determination.

The models in Table 8 represent the "Total" models involving all selected hedge funds regardless their correlation effect. The correlation factor with the NHX index was selected as the grouping factor following Teo (2009), Edelman et al. (2012) and Hespeler and Loiacono (2015). When analysis the skewness of "Correlated" and "Neutral" pools of hedge funds with the corresponding NHX strategy (Table 3), "Correlated" funds in all strategies except CTA

have negative skewness as well as the corresponding index and opposite skewness with the Neutral strategies. The CTA strategy present the opposite result providing CTA to be more contrarian to other strategies. Taking the co-skewness of Equity, Fixed income, Multi-strategy and Fund of funds into consideration, the models built on "Correlated" pools of hedge funds shall also better represent the entire Nordic hedge fund market.

"Correlated" and "Neutral" models in Table 9 provide the following R^2 confirming the observation of the "Total" models presented in Table 8 – National factors generate more accurate models with higher adjusted R^2 than Global factors for the Nordic equity hedge funds and Nordic fixed income hedge funds than the models.

Table 9. Nordic hedge fund panel data global and national "Correlated" and "Neutral" model comparison

Nordic hedge fund strategy	Equity	Fixed income	CTA	Multi-strategy	Fund of funds
Adj. R^2 Global factors (Correlated)	0.4940	0.5053	0.2062	0.5750	0.5000
Adj. R^2 National factors (Correlated)	0.5768	0.6988	0.2365	0.5982	0.6670
Adj. R^2 Global factors (Neutral)	0.3015	0.4163	0.0519	0.2903	0.3131
Adj. R^2 National factors (Neutral)	0.4821	0.6567	0.1020	0.5321	0.3972

National stock index, size spread, and 10-year yield factors are regular through all Nordic hedge fund strategies and through all three panel data model pools (i.e., Total, Correlated and Neutral). This regularity is also reflected in significant increase of the adjusted R^2 in all strategies through all tree models ranging from 3–5% in CTA strategy funds which are concentrating their strategies on the global Commodity market. Equities strategy hedge funds' adjusted R^2 increased in the range of 8–18% presuming higher concentration into local stock. Fixed income strategy hedge funds' adjusted R^2 increased even more in the range of 19–24% presenting even higher concentration of fixed income hedge funds into Nordic market financial instruments. Adjusted R^2 of Multi-strategy and Fund or funds strategies also increased when replacing global factors with national ones, however these strategies represent a mixture of equities, fixed income and CTA, therefore there is difficult to determine the proportion of contribution to those increase.

Although the use of National factors in the performance measurement of the hedge funds is a rarity, Do et al. (2005) compared Fama and French three-factor model with additional factors discovered by Capocci et al. (2005). This research also showed that the Australian hedge fund returns are rather independent of local indexes, which were obtained from the Australian ASX indexes. A research of rather specific Chinese stock market by Chen et al. (2019) using CAPM model and as a market benchmark using National SSE 180 Index despite the limitations of Chinese stock market compiled models with adjusted R^2 of 0.4728. However, Nordic hedge fund pricing models presented in this paper are rather conclusive in favour of using National stock and bond market factors.

The other specific factors contribution to the Nordic hedge fund performance measurement models is analysed by using the stepwise regression model with applied forward and backward procedure. Fung and Hsieh 8-factor NHX strategy index-based linear regression models were compiled to see which of the other specific factors impact the performance of the entire NHX strategy indices. As NHX strategy indices are only available on the Nordic level (and no sub-indices are available on the National level), the models only use Global factors (SPRF, RLSP, TYRF). Table 10 presents the models with all significant factors and for comparison purposes with adjusted R^2 of Fung and Hsieh 8-factor model without any other specific factors.

Table 10. NHX strategy index returns models based on Fung-Hsieh 8-factor with other specific factors

Factors / Strategy	NHX equity	NHX fixed income	NHX CTA	NHX multi-strategy	NHX fund of funds
α (monthly)	**0.0074** (0.0019)	**0.0040** (0.0007)	**0.0050** (0.0013)	**0.0033** (0.0006)	**0.0039** (0.0014)
SPRF	**0.1202** (0.0306)	–	–	**0.0960** (0.0246)	–
RLSP	–0.2620 (0.1111)	–	–	–	–
D(TYRF)	–	**–8.0416** (2.6051)	–	–	–
D(BAATY)	**–1.0187** (0.3812)	**–2.7780** (0.4017)	–	–	–
MSEMKFRF	**0.0820** (0.0183)	**0.0471** (0.0138)	–	**0.0778** (0.0153)	**0.0485** (0.0100)
PTFSBDRF	–	–	–	–	–
PTFSFXRF	–	–0.0080 (0.0039)	**0.0432** (0.0066)	0.0063 (0.0033)	**0.0074** (0.0027)
PTFSCOMRF	–	–	–	–	–
PTFSIRRF	–	–0.0069 (0.0027)	–	–	**–0.0083** (0.0020)
PTFSSTKRF	–	–	–	–	–
Other specific factors:					
SMB	**0.3671** (0.1186)	–	–0.1448 (0.0572)	–	–
HML	–	–	–	–	–
LIQ	–	–	–	–	**0.0424** (0.0149)
OCMDRWT	–	–	–	–	–
GOLD	–	–	–	–	–
COPPER	–	–	–	–	–
SILVER	–	–	**0.0745** (0.0137)	–	**0.0168** (0.0060)
BROIL	–	–	–	–	–

End of Table 10

Factors / Strategy	NHX equity	NHX fixed income	NHX CTA	NHX multi-strategy	NHX fund of funds
NGAS	–	–	–	–	–
COCOA	–	–	–	–	**0.0183** (0.0069)
VIX	–0.0195 (0.0091)	–	–	–	–0.0151 (0.0066)
Adj. R^2	0.6506	0.5692	0.3096	0.5130	0.5092
Adj. R2 before other specific factors	0.6332	0.5692	0.2236	0.5130	0.4404

Note: Standard errors in parentheses. Coefficients in **bold** indicate statistical significance at the 99% one-tailed level (the other – 95%).

Adding the other specific factors into Fung and Hsieh 8-factor model resulted in relatively lower increase of adjusted R^2 in NHX equity and NHX fixed income index-based models in comparison to replacing the Global stock and bond factors with National factors. No other specific factors were identified as significant in NHX Fixed income and NHX Multi-strategy indices models. SMB factor of Fama and French is significant in NHX equity and NHC CTA models. SMB variable amounts 0.3671 and is two times bigger comparing with models of Stafylas et al. (2018), who used the other Fama and French factors in their models. The coefficient of volatility index VIX index, however, is of the same range of Stafylas et al. (2018) – where VIX coefficient ranges from –0.021 to –0.034. However, it is important to note, that these observations lack support from other Nordic region research and are also conclusive to NHX strategy indices, whereas this paper seek determinants in 72 selected long living Nordic hedge funds.

Combination of National factors and the other specific factors may provide synergy, which can be achieved compiling panel data models using pooled hedge fund return data with individually linked country-specific National risk factors cross-sectionally connected by the NHX strategy and added the other specific factors. Following Bernard et al. (2019) and Almeida et al. (2020) panel data also allows compiling narrower models allocating hedge funds by correlation with the corresponding strategy index (i.e., "Total", "Correlated" and "Neural"). Detailed description of the models and their results are available from the corresponding author upon request.

"Total", "Correlated" and "Neutral" models in Table 11 provide the pairs of adjusted R^2 prior adding the other specific factors and with them.

When analysing how other specific factors impact the pricing models the increase in adjusted R^2 differs between the strategies and is not coherent with aforementioned increases. On the contrary to National factors, the impact of other specific factors, mostly related with commodities had the highest increase of adjusted R^2 in CTA strategy in the range of 3–8%. Equity hedge funds and fixed income hedge funds models have comparatively modest increase in the range of 2–5% of adjusted R^2 from adding the other specific factors. Equity and

Table 11. Nordic hedge fund panel data global and national models' comparison

Nordic hedge fund strategy	Equity	Fixed income	CTA	Multi-strategy	Fund of funds
Adj. R^2 Global factors (Total)	0.4353	0.4570	0.1370	0.5088	0.4782
Adj. R^2 Other factors (Total)	0.4584	0.4938	0.1768	0.5214	0.5269
Adj. R^2 Global factors (Correlated)	0.4940	0.5053	0.2062	0.5750	0.5000
Adj. R^2 Other factors (Correlated)	0.5126	0.5295	0.2829	0.5812	0.5505
Adj. R^2 Global factors (Neutral)	0.3015	0.4163	0.0519	0.2903	0.3131
Adj. R^2 Other factors (Neutral)	0.3497	0.4696	0.0811	0.3652	0.3602

fixed income hedge funds are less focusing on commodities, however, the increase of adjusted R^2 originates from the other specific factors except commodities spot prices. Adjusted R^2 of Stafylas et al. (2018) models range from 0.76 to 0.89. The models of Swartz and Emami-Langroodi (2018) and Racicot and Theoret (2019), which both sought connection with VIX volatility index and commodities spot prices adjusted R^2 vary from 0.2 to 0.7. They proved commodity related factors usually have positive expression, however, did not analyse CTA strategy hedge funds. Based on the regularity of the other specific factors between three panel data models (i.e., Total, Correlated and Neutral), the following regular significant factors shall be used in addition to Fung and Hsieh 8-factor model factors with national stock and bond factors, when pricing the Nordic hedge funds' performance.

Nordic **equity** hedge funds performance is additionally determined by:

1. HML is present in all three equity hedge fund models ranging from 0.0521 to 0.0692. HML factor was also significant in Stafylas et al. (2018) with values ranging between 0.069 and 0.10 during the growth or bull market times, while negative in the recession and bear market (ranging between –0.131 and –0.253). Swartz and Emami-Langroodi (2018) did not find significant connection between equity hedge funds and HML.
2. LIQ is present in "Total" and "Correlated" models. The factor is negative and range from –0.0412 to –0.0604. Liquidity factor impact on the equity portfolios was widely analysed by Pástor and Stambaugh (2003) who called it liquidity beta and in most of the analysed portfolios it was also negative with similar proportion.

Although VIX volatility index is present in "Total" and "Correlated" models and the coefficient value range from –1.3060 to –1.5888, they are significantly different from the results of other studies. VIX index coefficients range from –0.021 to –0.034 in research of Stafylas et al. (2018) and range from –0.0149 to –0.0179 in the research of Swartz and Emami-Langroodi (2018) who only found significant connection of VIX volatility index with related value Volatility funds. These VIX coefficients of Stafylas et al. (2018) and Swartz and Emami-Langroodi

(2018) are of the same range when comparing with VIX coefficient of –0.0195 presented in the multiple linear regression models compiled for NHX equity index (Table 10). Other factors selected by the NHX equity hedge funds' models are random in nature, therefore will not be included in further analysis of crisis impact on the pricing models either.

Nordic **fixed income** hedge funds performance is additionally determined by LIQ factor, which is present in all three hedge fund models. The factor is negative and range from –0.0896 to –0.1260, which is two times higher than is Nordic hedge fund models providing Nordic fixed income hedge funds are more dependent on the changes in liquidity premiums. Other factors selected by the NHX fixed income hedge funds' models are random in nature, therefore will not be included in further analysis of crisis impact on the pricing models.

Nordic **CTA** hedge funds performance is additionally determined by:

1. SMB is present in "Total" and "Correlated" models ranging from –0.2407 to –0.3878. SMB factor was also significant equities in hedge funds models of Stafylas et al. (2018) ranging from 0.127 for small funds to 0.173 for funds with lockups. Swartz and Emami-Langroodi (2018) analysed various hedge funds strategies and the closest to CTA would be Energy Infrastructure funds (both are related with energy commodities) which present SMB coefficient of –0.0209, whereas other strategies present SMB coefficients in the positive ranges similar to Stafylas et al. (2018). SMB factor of –0.1448 present in the multiple linear regression models compiled for NHX CTA index (Table 10).
2. GOLD is present in "Total" and "Correlated" models. GOLD ranging from 0.0091 to 0.0900 comparing with models of Billio et al. (2012), where GOLD coefficient takes a negative value of –0.09 for Short bias strategy and ranges from 0.03 in equity neutral to 0.16 in Emerging strategy hedge funds. Swartz and Emami-Langroodi (2018) only found significant connection of GOLD with Volatility portfolio with negative value of –0.06. Although none of aforementioned researchers analysed CTA strategy in particular, based on APT theory of Ross (1976) the presence of GOLD in CTA hedge funds pricing model raises the presumption there is actual investment into GOLD or XAU[2] index in these funds.
3. SILVER is present in "Total" and "Correlated" models. SILVER is ranging from 0.0551 to 0.0975. Using of SILVER in hedge fund pricing models is rather uncommon by other researchers, however it shall not be discarded from the model, as in some interim calculations SILVER even prevailed the GOLD factor. SILVER factor also presented in the multiple linear regression models compiled for NHX CTA index (Table 10) and amount 0.0745, which is close to the values of the panel data models.

As with equities strategy, VIX volatility index is present in all models and the coefficient equal –2.8468, –6.0041 and 2.5290. Such values are significantly different from the results of other studies mentioned above and therefore shall not be included in the models. Other factors selected by the NHX CTA hedge funds' models are random in nature, therefore will not be included in further analysis of crisis impact on the pricing models.

All Nordic hedge fund pricing models with National factors and with aforementioned other specific factors were tested for cross-section Fixed effect presence. Breusch-Pagan LM

[2] XAU index – Gold Bullion index monthly rate of return.

random effect, Hausman fixed effect and Breusch-Pagan LM cross-section dependence tests were applied for all models. Equities and fixed income all panel data models (i.e., "Total", "Correlated" and "Neutral") proved to be able to apply cross-sectional Fixed Effect after successful Cross Section Dependence diagnostic test of Breusch-Pagan (1980) Lagrange Multiplier (LM). This led to further increase for the adjusted R^2 as presented in Table 12.

Table 12. Nordic panel data models with applied cross-sectional Fixed Effect

	Total	Correlated	Neutral
Adj. R^2 Equity Panel Least Squares	0.5373	0.5846	0.4892
Adj. R^2 Equity Panel EGLS (Cross-section weights)	0.6887	0.7353	0.5387
Adj. R^2 Fixed income Panel Least Squares	0.6603	0.7053	0.6702
Adj. R^2 Fixed income Panel EGLS (Cross-section weights)	0.6622	0.7162	0.6884

The high level of adjusted R^2 of the models with applied cross-sectional Fixed Effect provides the opportunity to analyse alpha of every single hedge fund within the pool.

Adding the crisis dummy variables in all models (i.e., "Total", "Correlated" and "Neutral") for all Nordic hedge fund strategies yielded the following results:

1. Banking Crisis variable was significant in most of the models of fixed income, CTA, multi-strategy and fund of funds models, and was rejected by all equity models.
2. Global Drawdown variable was significant only for all CTA models and rejected in all other hedge fund strategies.
3. Global Crisis including Brexit period as a crisis was significant in all fixed income, most multi-strategy and most fund of funds models, and was rejected by equity and CTA models.
4. Global Crisis which does not include Brexit as a crisis period was also significant in all equity hedge fund models.

All crisis related factor coefficients and their standard errors are presented in Table 13.

Table 13. Nordic hedge fund panel data crisis alpha

Crisis	Strategy / Models	Equity	Fixed income	CTA	Multi-strategy	Fund of funds
Banking Crisis	"Total"	–	**0.0133** (0.0017)	**0.0127** (0.0048)	**0.0106** (0.0027)	**0.0149** (0.0029)
	"Correlated"	–	**0.0104** (0.0021)	–	**0.0076** (0.0028)	**0.0160** (0.0029)
	"Neutral"	–	**0.0113** (0.0031)	**0.0209** (0.0057)	**0.0198** (0.0070)	–
Global Drawdown	"Total"	–	–	**0.0167** (0.0037)	–	–
	"Correlated"	–	–	**0.0112** (0.0046)	–	–
	"Neutral"	–	–	**0.0180** (0.0047)	0.0119 (0.0058)	–

End of Table 13

Crisis	Strategy / Models	Equity	Fixed income	CTA	Multi-strategy	Fund of funds
Global Crisis including Brexit	"Total"	–	**0.0077** (0.0012)	–	**0.0048** (0.0017)	0.0026 (0.0011)
	"Correlated"	–	**0.0077** (0.0017)	–	–	**0.0034** (0.0012)
	"Neutral"	**0.0044** (0.0017)	**0.0064** (0.0017)	–	0.0068 (0.0034)	–
Global Crisis excluding Brexit	"Total"	**0.0051** (0.0011)	**0.0109** (0.0013)	–	**0.0078** (0.0018)	**0.0043** (0.0012)
	"Correlated"	**0.0045** (0.0013)	**0.0126** (0.0017)	–	**0.0062** (0.0020)	**0.0053** (0.0013)
	"Neutral"	**0.0051** (0.0017)	**0.0076** (0.0018)	–	**0.0110** (0.0035)	–

Note: Standard errors in parentheses. Coefficients in **boldface** indicate statistical significance at the 99% one-tailed level (otherwise – 95%).

All crisis alpha coefficients presented in Table 13 are positive meaning the crisis alpha is greater than alfa in the quiet times. This can be explained by the hedge fund managers' experience to prevent the value of the hedge fund from dropping to the level of market declines. Carhart (1997) found the connection between the good returns of the current years and the negative returns in the past. Berglund et al. (2018) relate the increasing in the events when the crisis erupts with monetary policy actions in times of crisis, and then possibly lose alpha as unconventional policies restrain volatility. Cao et al. (2018) analysed the alpha during the liquidity crisis including bankruptcy of Lehman Brothers on September 15, 2008 and discovered, hedge funds what used the leverage provided by Lehman Brothers were reduced opportunities to borrow. However other (non-Lehman Brothers related funds) outperformed the other financial institutions. Liang and Qiu (2019) made an in-depth analysis of leverage prior, during and after the crisis concluding, that among the other, the stronger fund governance is associated with higher hedge fund leverage. The long living Nordic hedge funds analysed in this paper are rather experienced and generate robust returns. Nordic region had not faced a major banking crisis in the research horizon, the borrowing possibility had not been extinct. This also imposes the explanation why all models generated positive crisis alpha.

Increased alpha during the crisis times can also be explained by hedge fund managers' skills in finding the opportunities and employing short strategies, which may not be the case with Bull markets widely discussed by Siegel (2005), who concluded that this additional alpha could be considered as additional liquidity premia or opacity of other risk factors.

The positive crisis alpha, however, contradicts the alpha yielded by the models with split time series into crisis and non-crisis period. Research of Metzger and Shenai (2019) compiled separate models using financial crisis of 06/2007 – 03/2009 and non-crisis period after the crisis until 01/2017. While alpha of the 9 500 hedge funds collected in Credit Suisse's Hedge Index database calculated using Carhart's Four factor model (Carhart, 1997) is dominantly negative during the crisis, it remains negative in some strategies even after the crisis. Al-

though such approach of splitting the time-series into crisis and non-crisis periods enables adjusting the hedge fund long / short strategy, the Long / Short strategy of models of Metzger and Shenai (2019) generate alpha of –0.0004 during the crisis and –0.0008 after the crisis.

However, regardless some controversy between the models' estimated alpha, there is a consensus between researchers (e.g., Sung et al., 2020; and Denk et al., 2020 among the latest) who agree the hedge funds have better results than other types of investment during the crisis period. This exceptional performance during the crisis suggests the skills of the hedge fund managers are well executed and are fairly reflected on the crisis alpha factors.

4. Robustness analysis

The robustness of the main results is examined in this section. The models and selected factors, determining the Nordic hedge fund performance are selected using the stepwise regression technique and were mostly consistent through the different hedge fund pools within the same strategy (i.e., "Total", "Correlated" and "Neutral"). Panel data models are usually facing heteroscedasticity and endogeneity problems. Racicot (2015) developed and widely used in panel data models instrumental variables (IV) estimation in the context of the generalized method of moments (GMM) introduced by Hansen (1982). Racicot et al. (2018) applied GMM method when testing liquidity factor of Pástor and Stambaugh (2003) adding to Fama and French 4-factors model which works when number of cross sections greater than time-series period. Due to low number of Nordic hedge funds we added the lagged dependent variable as the control variable for residual autocorrelation used by Racicot and Théoret (2016), Ardia and Boudt (2018). The main finding of the robustness analysis is that including the extra control variable does not remove the statistical significance of the specific factors we suggested in this paper. In Nordic equity, fixed income and CTA models we also avoided the endogeneity of the liquidity ratio, which Adrian et al. (2017) and Racicot et al. (2018) stressed in their research.

The robustness of the models is also satisfied by seeking for the superior adjusted R^2 significance factors, which were consistent through adding National factors and adding the other specific factors into the models. CTA models are least consistent; however, this is a common issue of Commodity and financial derivative related hedge funds observed by Stafylas et al. (2018) and others. The detailed robustness analysis results are available from the corresponding author upon request.

The result of this research is also influenced by survivorship bias; therefore, the conclusions shall only be applicable to the selected funds. In order to assess how the results could change shall all funds including "dead" funds returns were included in the models, crisis impact factor was included into NHX strategy indices multiple linear regression models. The crisis alpha factors of multiple linear regression models are presented in Table 14.

In most of the cases the crisis factors were insignificant to the models, however, there are four models with negative crisis alpha what contradicts the crisis alpha obtained in the Nordic hedge fund panel data models (Table 13). Such contradiction in crisis alphas may either be caused by:

- Survivorship bias as "dead" hedge funds are included into the NHX strategy index at the time of their reporting, however not included into the pool of long living hedge funds, or

Table 14. NHX strategy index crisis alpha

Crisis	NHX equity	NHX fixed income	NHX CTA	NHX multi-strategy	NHX fund of funds
Banking Crisis	*	*	*	*	*
Global Drawdown	–	–	–	–	–
Global Crisis including Brexit	**–0.0063** (0.0014)	–	–	–0.0029 (0.0012)	–0.0022 (0.0010)
Global Crisis excluding Brexit	**–0.0042** (0.0015)	**0.0041** (0.0017)	–	–	–

Note: * Banking crisis was not included in the model, since Banking crisis factor is individual to each Nordic country, whereas NHX strategy indexes are general and do not assess the influence of each country individually.

– The panel data models in this paper are based on National stock and bond factors, which may have different reaction to the global crisis factors, therefore may show the opposite results.

Lastly, the models use long term time-series for compiling the factors. This diminishes the significance of some exotic risk factors characteristic to hedge funds as presented by Agarwal et al. (2018). Momentum of Fama and French (1993) and trend following factors of Fung and Hsieh (2001) may have different compensation during the crisis and quiet times, however models in this research only have generalised factor coefficients.

5. Discussion

This research analyses and focuses more on hedge fund asset pricing models (e.g., Fung and Hsieh) using a combination of traditional and exotic risk factors as outlined by Agarwal et al. (2018). All those risk factors represent the systemic risk factors and are not connected with any individual fund manager's investment decision-based attributes. Among those could be a degree of leverage, short positions, frequent trading, fee structure, etc. These attributes and risk factors could result in more fund specific model, however due to small number of Nordic hedge funds and limited information on the investment strategy elements does not allow analysing hedge funds on the micro level. The quantitative Nordic hedge fund return figures themselves present superior Nordic hedge fund performance comparing with the global indices, which raise further questions on what peculiarities of the Nordic hedge fund market or managers make this happen. The stability of the Nordic economies and a high focus on the regulation? Or the peculiarity of the Nordic temperament and attitude of the fund managers? Or ranking Nordic countries as top happiest countries in the world for over three years now, even regardless of the impact of the pandemic of Covid-19 (Helliwell et al., 2021). Extending the research horizon including the pandemic and other events shall divulge more consistent risk factors determining the performance of the hedge funds. There are separate studies the authors are undertaking to answer the specific questions on that specific period. There is, however, a significant return abnormality observed as of April 2021, which will raise even more questions about the performance measurement of the Nordic hedge funds and all over the Global hedge fund universe.

As regards the hedge fund return data used, the analysis could be extended by taking in to account the other funds operating in different regions. However, due to the differences in consolidating the hedge funds into pools by strategies and corresponding NHX strategy indices, more alignment by strategy and sub-strategy is needed. More detailed results could also be obtained by applying methods used by other researches: Vector Autoregression, Generalized Autoregressive Conditional Heteroskedasticity, applying Granger causality test to transfer significant lagged variables into Homogeneous Panel data.

Conclusions

We analysed the performance of the Nordic hedge funds. The funds embarking on different strategies were covered in the analysis. The capital asset pricing models were established to identify the effects of the environment on the fund returns. Multiple econometric models were specified based on different theoretical premises.

The analysis of performance of hedge fund pools selected for the research showed superior pooled hedge funds returns by 0.03–0.15% comparing with corresponding NXH strategy index. The selected hedge funds represent the long living hedge funds, whereas the indices returns are calculated based on all alive hedge funds during the reporting period. Due to its uniqueness as a strategy, CTA funds showed the opposite relationship between returns, where the highest returns are achieved by the hedge funds with lowest correlation with the NHX CTA index.

The most significant factors of the return of the Nordic hedge funds are national stock and bond risk factors (whereas less importance is attached to global stock and bond factors). The effect of national risk factors on the pricing of Nordic CTA funds was negligible leading to a conclusion CTA funds returns are least determined by the local or national stock and bond risk factors. The other specific factors were considered in light of the connections and recommendations made by other researchers. Liquidity factor was consistent through equity and fixed income hedge funds with HML factor – in equity hedge fund pricing models. However, CTA hedge fund models yielded significant relationship on SMB, Gold and Silver prices deviations. VIX volatility index is present also in most of the hedge fund strategies, however the coefficient values were significantly different from other studies and therefore need further adjustments and interpretation.

The utilisation of dummy factors to indicate various crisis periods allowed assessing the effect of the crisis on the alpha during the crisis and the quiet times. Equity hedge funds models significantly impacted by the Global crisis factor representing the financial crisis of 2007–2008, European dept crisis of 2009–2011 and continuation in 2012–2013, but not including the Brexit-related crisis. On the contrary, CTA funds models were significantly impacted by the Banking crisis and Global hedge fund drawdown periods. Fixed income models are somewhere in between: impacted both by Banking crisis and Global crisis periods, but not the Global hedge fund drawdown. The impact of all above mentioned crisis factors (also called a crisis alpha) persisted through all models showing the positive effect. It is important to note, those models are based on those Nordic hedge funds, which withstood more than one crisis and therefore already made Nordic region famous for long living hedge funds.

However, when taking the entire NHX strategy indices returns into the consideration and assessing the crisis impact, the controversy derives from "dead" hedge funds unaccounted in the pooled hedge funds models compiled in this paper.

Analysis of the time-series covering such long analysis horizon and covering both quiet and crisis periods presupposes the main limitation of the research. The models used the diminished effects of the exotic risk factors that may vary in the quiet times and crisis period. The future research shall explore the possibility to include in the analysis "dead" Nordic hedge funds and dividing the time horizon into crisis and quiet time.

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