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DAKTARO DISERTACIJA

DETERMINANTS OF THE REGIONAL HEDGE FUND PERFORMANCE: EVIDENCE FROM NORDIC COUNTRIES

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MYKOLAS ROMERIS UNIVERSITY

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KEY TERMS

Adjusted R^2 – represent how well modeled variables fit the dependent variables. Adjusted refers to the adjustment by many terms used in the model. The higher the adjusted R^2 is, the more robust the model is.

Alpha (Jensen's alpha) – is a risk-adjusted measure of portfolio performance estimating the manager's ability to contribute to the fund's returns (Jensen, 1967).

Alternative beta – beta is an investment strategy in which a fund structures its returns around an unusual index. Alternative beta usually involves a combination of long and short strategies.

Alternative investment – is an investment in any asset class excluding stocks, bonds, and cash (i.e., derivatives, ETFs, commodities, or CTAs). In legal terms, this also refers to an alternative investment to regulated mutual funds.

Arbitrage – is a practice of benefiting from the differences in asset prices between different markets (or different exchanges). In the finance terms usually used in portfolio management, arbitrage also refers to a possibility of a risk-free profit after the transaction fees.

Asset pricing (model) – deriving from Capital Asset Pricing Model is a model which describes the relationship between the risk (systemic or rather specific) and the expected return of the security or the portfolio. Asset pricing also refers to the decomposition of the return by the various specific or systemic risks.

Beta (or Asset-based beta) – the market volatility (or risk) measure of an investment instrument *i* that shows how the investment instrument return relates to the market. Beta is usually calculated as the covariance of the market and single investment instrument return divided by the market return variance (Sharpe, 1964).

"Bull" and "Bear" market – A bull represents growing market conditions in a good economy. A bear market exists in an economy that is receding and where most stocks are declining in value. The bull market usually imposes buying the stock or other assets in portfolio management terms, whereas the bear market – selling the assets.

Capital market instruments – are the instruments traded in the Capital market, usually referred to as Stock (equity securities) and Bonds (debt securities).

Covid-19 – referred to the crisis resulting from harsh locking down the economy by restricting working in the offices, traveling, and imposing other pandemic mitigation measures.

A crisis – is an unfavorable condition disrupting crediting and other economic processes. Depreciating the currency crisis also distresses the consumption and production processes and leads to a steep asset value decline affecting the investment portfolios.

Derivative – is a financial security with a value reliant upon or derived from an underlying asset or group of assets. Traditionally, derivatives are called Forward, Future, Swap, Option, and other instruments, which are usually higher risk than their underlying assets, and hedge funds use them heavily.

Drawdown – a peak-to-trough decline during a specific period for an investment, trading account, or fund. https://www.investopedia.com. However, some sources, including the HedgeNordic database, report drawdowns as a period from initial decline to recovery (e.g., the NHX index returns to the same level).

Elasticity at Means – presents how much the explanatory variable impacts the mean result of the modeled variable. The elasticity at means estimates scaled coefficients by the dependent variable's mean divided by the regressor's mean.

Hedge fund – an alternative investment fund that employs different strategies to earn excessive returns or alpha for its investors.

Heteroscedasticity is when the variability of a variable is inconsistent through the range of values predicted by the model. In the context of the linear regression models used in this dissertation, heteroscedasticity represents an uneven distribution of the error characteristic of very long-term time-series models.

Kurtosis – is a measure of the distribution too picked or too concentrated around the mean value – positive kurtosis or representing the fat-tailed distribution – negative kurtosis.

Leverage – is a technique involving using debt (borrowed funds) rather than own funds to purchase an asset. Leverage is associated with a higher risk in the hedge fund industry, referred to as the collapse of LTCM in 1998.

Mutual funds – are investment vehicles that invest in securities like stocks, bonds, money market instruments, and other assets. Mutual funds are regulated, limiting their concentration and alternative investment possibilities. Mutual funds usually aim to match the market index (benchmark).

The non-linear payoff is a payoff of non-linear financial instruments (usually derivatives held in hedge funds) where the value movement is determined by the direction of the underlying assets and depends on time, space, and other features. Non-linear payoffs distinguish hedge funds from stock assets when using pricing models.

Offshore (Offshore funds) – the funds registered or keeping the assets in the tax haven territories like the Cayman Islands, the British Virgin Islands, Bermuda, and the Bahamas or Luxemburg and Ireland in Europe.

The panel data model is the econometric model with both cross-sectional and time-series dimensions. Concerning this dissertation, cross-sections assume separate hedge fund returns within the selected pool of hedge funds. Panel data models enable assigning specific independent variables to a particular fund (e.g., National stock-related factors to the hedge fund based on the country of residence of the fund).

Regulation – a rule or directive made to conduct a specific business and maintained by an authority. The regulation imposes restrictions and conditions to safeguard the interests of hedge fund investors or reduce the possible impact of hedge fund strategies in sensitive parts of the financial world.

Sharpe ratio – the average return earned over the risk-free rate per unit of volatility or the risk (Sharpe, 1966). It is also commonly known as a risk-weighted return measurement.

Short-selling is an investment or trading strategy speculating on a stock's or other security's price decline. In this strategy, an investor opens an investment position by borrowing an investment asset that the investor believes will decrease in value.

Skewness – is a measure of lack of symmetry in the distribution of the variables. Usually, negative skewness is referred to as a long tail of returns below the mean value, presuming there are more periods in the distribution with lower variable values than the mean. The positive skewness is the opposite.

Smart beta – combines the benefits of passive investing and the advantages of active investing strategies.

Stepwise regression is the step-by-step construction model involving selecting explanatory variables (i.e., adding or removing potential explanatory variables in succession and testing for statistical significance after each iteration). In the context of this dissertation linear least squares method is used to determine the significant explanatory variables.

Note. If not referenced, definitions are taken from official organizations' websites, dictionaries, and other publicly available sources of information and revised by the author to match the meaning used in this dissertation.

ABBREVIATIONS

ADF – Augmented Dickey-Fuller Test, the test that checks for a unit root in a time series sample.

AIC – Akaike's (1973) information criterion is used to identify the most appropriate specification, thus, the relevant pricing factors.

AIFM – Alternative investment fund managers.

AIFMD – Alternative Investment Fund Managers Directive – a regulation framework for alternative funds distributed in the EU.

APT – Arbitrage Pricing Theory – a multi-factor asset pricing model based on the idea that investment returns can be decomposed using the linear regression model between the return and several market factors that capture systematic risk (risk factors).

ARU – Absolute Return UCITS compliance funds.

AUM – Assets under management are the total market value of the investments the fund manages on behalf of investors. Usually, refer to the size of the investment fund assets.

CAPM – Capital Asset Pricing Model – a pioneering model describing the relationship between systematic risk and expected return for assets.

CIU – Collective Investment Undertakings – a more general broader definition covering both mutual and hedge funds.

CRB – The Commodity Research Bureau Index is a representative indicator of today's global commodity markets.

CRD IV – Capital Requirements Directives IV entered into force on 17 July 2013 and implemented Basel III recommendations into EU law.

CTA – Commodity Trading Advisors – the funds trading listed financial and commodity futures and foreign exchange.

ERM II – Exchange Rate Mechanism of the EU was set up in 1999 as a successor to ERM, aiming to ensure that exchange rates between the euro and other EU currencies do not fluctuate and do not disrupt economic stability. The main aim is to help non-euro-area countries prepare themselves for participation in the euro area.

ESMA – European Securities and Markets Authority – an independent European Union (EU) Authority that contributes to safeguarding the stability of the EU's financial system by enhancing the protection of investors and promoting stable and orderly financial markets.

ETF – Exchange Traded Funds – security tracks a particular set of equities or indices that can be tradeable on an exchange.

FCIC – The Financial Crisis Inquiry Report: Final Report of the National Commission on the Causes of the Financial and Economic Crisis in the United States.

FSA – Financial Services Authority was the leading financial service regulator in the United Kingdom between 2001 and 2013. In 2013 the functions were split between the Financial Conduct Authority (FCA) overseeing financial markets and the Prudential Regulation Authority (PRA) supervising banks, credit unions, insurance firms, and investment firms.

FSI – Financial Soundness Indicators developed by the IMF and the international community to support macroprudential analysis.

GMM (IV GMM) – instrumental variables (IV) estimation in the context of the generalized method of moments GMM introduced by Hansen (1982).

GLS – generalized least squares model used to determine cross-section weights (EViews function).

HFR – Hedge Fund Research – trusted hedge fund data provider and analysis to investors, asset managers, and service providers.

HFRI – Hedge Fund Research Index – an equally weighted index used for benchmarking purposes.

ICAPM – Intertemporal Capital Asset Pricing Model – a consumption-based CAPM model extension that assumes investors are hedging their risky positions.

IMF – International Monetary Fund promotes international financial stability and monetary cooperation.

LM – Lagrange multiplier – a strategy for finding a function's local maxima and minima subject to equality constraints. A procedure used in performing Breusch-Godfrey Serial Correlation or Cross Section Dependence diagnostic test of Breusch-Pagan.

LTCM – Long-Term Capital Management hedge fund lost nearly 90 percent of its own funds of 5 billion USD in 1998 due to worldwide crises in Asia and Russia.

MPT – Modern portfolio theory of Harry Markowitz introduced in 1952 – a mathematical framework establishing the connection between the expected return and the level of risk. MPT also introduced the term diversification, reducing the risk level by mixing the assets in the portfolio.

MSCI – Morgan Stanley Capital International – a leading provider of critical decision support tools and services for the global investment community.

NHX – Nordic hedge fund index provided by HedgeNordic.com, Stockholm.

SABR – Stochastic Alpha Beta Rho volatility model attempts to capture the volatility smile (particular shape volatility curve of pricing financial options using the Black-Scholes formula) in derivatives markets.

SEC – Securities and Exchange Commission – a US government agency responsible for protecting investors, overseeing securities markets, and facilitating capital formation functions.

UCITS – Undertakings for the Collective Investment in Transferable Securities is also a name of the regulatory framework of the European Commission embedding mutual funds.

Note. If not referenced, definitions are taken from official organizations' websites, dictionaries, and other publicly available sources of information and revised by the author to match the meaning used in this dissertation.

INTRODUCTION

Relevance of the topic. Researchers mentioned hedge funds and their investments for the first time in the 1950s. In the 1960s, it became common for investors to apply long and short equity investment strategies. Initially, the purpose of hedge funds was to reduce the market risk for investments in traditional assets (capital market instruments). In the 1990s, hedge funds became an independent investment instrument for investors looking for total maximum return. Hedge funds are also known for their severe losses in 1998 when Long Term Capital Management Fund suffered a loss of 1.8 billion USD because of a severe decrease in bond prices and a high level of leverage. The sharp declines of the asset prices during the sell-offs of the financial instruments, which even further lost their value due to low liquidity, shrank the hedge fund AUM by 25 percent in the 2nd half of 2008 (BarclayHedge, 2020a). The Financial Crisis Inquiry Report (FCIC, 2011) claimed the sharp drop in the asset prices of the trading portfolios due to several hedge funds' activity was the reason for Lehman Brothers Bank's bankruptcy. Lately, the market crash of Covid-19 caused a decrease in hedge fund AUM from 3 194 billion USD in 2019 to 2 857 billion USD, reporting losses of almost 13 percent in Q1 2020 with a nearly complete recovery of AUM to 3 113 billion USD and bounce back with 15 percent gain by the end of Q3 2020 (eVestment, 2020; BarclayHedge, 2020a).

The outstanding hedge funds' performance lies in their investment phenomenon. On the one hand, hedge fund managers seek the maximum returns, trying to beat the market indices by employing skilled strategies and not being constrained by regulation. On the other hand – they achieved rather impressive diversification results and generated higher risk-adjusted returns in the class of alternative investments measured by the Sharpe ratio. Besides the high Sharpe ratio, hedge fund investors and managers seek high alpha, an excess return over the market-generated return. *Alpha* is also a primary driver of the hedge fund manager's remuneration presented as the management and success fee. However, some studies are talking about alpha trends decline post the Global financial crisis of 2007-2008.

Presenting the right alpha level and, even more importantly, disclosing the risks hedge fund managers undertake and shall allocate to beta indicators is still undergoing discussions between researchers. Over 20 years, the understanding of the risks the hedge funds have grown. The traditional risks expanded with new risks representing the size of the fund, growth momentum, or even more "exotic" so-called non-linear risks, which do not linearly depend on the market and have option-like features. The model of Fung and Hsieh introduced in 1997 addressed those non-linear risk criteria, and now the currently 8-factor model presented in 2012 is used as the benchmark and starting point in many types of research. Non-linear risks, however, are still undergoing a cognitive stage. Many researchers claim hedge fund *alpha* can be estimated precisely using conventional performance measurement tools like CAPM or Fama-French model.

Most models defined to determine the hedge funds' performance factors are based on Global hedge fund industry trends and represent core hedge fund industries such as the US, UK, central regions (i.e., North America, Europe, or Asia), or in Tax Havens. US dominance is evident as the models mentioned above use the US indices and other financial instruments reported in the US Dollar. The entire hedge fund industry is spinning around the five most prominent data suppliers: BarclayHedge, EurekaHedge, Hedge Fund Research (HFR), Morningstar, and Lipper Hedge Fund Database (TASS).

Even though Nordic hedge funds outperformed the global hedge fund industry represented by HFRI and MSCI indices during the severe drawdown of 2008 Q3-Q4 by nearly 10 percent[1], there is minimal research on the Nordic and other regional hedge funds. Such limited research raises the concern whether analysis of the hedge fund performance in small regions represented by possibly very biased return data may be too complex an assignment. Those rare cases of the regional hedge funds research papers are more focused on comparing the absolute return figures rather than discussing the hedge funds' performance assessment models and their performance determining factors. Adapted to the local market, hedge funds' performance measurement models can present how much of this outstanding performance depends on the local hedge fund managers' alpha and what comes as a market premium. Furthermore, can exploring the Nordic hedge fund performance contribute to the Baltic hedge fund development? Nordic Business Media anticipates inducing the Baltic hedge fund index to present Baltic hedge funds in the Nordic universe[2].

Research problem and the level of its investigation. The economic research in

1 Calculated by author based on: https://hedgenordic.com/; https://www.hfr.com/indices

2 Based on the first-hand information obtained from the representatives of the Nordic Business Media when discussing the research findings and publishing the findings in series of Nordic hedge fund reports in 2021.

the hedge funds' performance measurement area has various directions, some of which will be analyzed in this dissertation. The hedge funds' performance measurement models underwent a tremendous evolution: from single factor models like CAPM of Treynor (1961) or multifactor APT of Ross (1976); to models determining the performance of the hedge funds using non-linear dependences analyzing option-like return structure by Glosten and Jagannathan (1994), trend-following factors by Fung & Hsieh (1997a, 2001, 2002 and 2004a), or Fama-French three-factor model (or enhanced by Carhart's (1997) 4-factor model). Other researchers (e.g., Agarwal and Naik, 2004, Capocci et al., 2005, Dewaele et al., 2015, Moskowitz, 2020) also examine hedge funds' non-linear return. However, Fung-Hsieh's 8-factor model (Edelman et al., 2012) is still considered robust, explaining nearly 80 percent of all equity hedge funds by analyzing monthly returns. However, the likes of Agarwal et al. (2018), Stutzer (2018), and Knif et al. (2020) still claim that CAPM and ICAPM models well explain the hedge funds' *alpha*. The idea behind this strong belief derives from the main idea behind the CAPM model explaining the Modern portfolio theory of Markowitz (1952), describing the diversification of the portfolio and the ability of the hedge funds to generate high alpha or absolute return, also known as seeking "north-west" direction introduced by Mossin (1966). Hedge funds are known for applying leverage, which allows reaching further "north-west" positions identifiable by CAPM. However, successful investment ideas are usually limited.

Following the APT theory, the portfolio's performance depends on the portfolio's composition represented by various asset classes and instruments. Hedge funds tend to be focused on equities, fixed income (bond), or CTA (commodity and other financial asset classes). Analysis of various commodities in the hedge funds is prevalent in the CTA vehicles, as presented by Blocher et al. (2017), Elaut and Erdős (2019), and Shaikh (2019). There are many very focused pieces of research on the hedge fund performance dependence on the movement of the Gold or Oil commodities prices: Stafylas et al. (2018), Swartz and Emami-Langroodi (2018), Racicot and Theoret (2019), Shrydeh et al. (2019), Mensi et al. (2020), Chirwa and Odhiambo (2020), Lambert and Platania (2020). Other commodities, such as Copper, Silver, or Natural gas, are somewhat scarcely analyzed.

Besides the asset-based, researchers also widely analyze the hedge funds' performance dependence on specific risk factors. The liquidity factor introduced by Pástor and Stambaugh (2003) made a breakthrough in the hedge funds' performance measurement by determining how much the hedge funds' return depends on the liquidity risk the hedge fund manager undertakes. Underestimated liquidity risk was also a crucial factor in many hedge funds, which underwent significant drawdowns during the financial crisis of 2007-2008. There are many pieces of research covering the liquidity risk factor in the hedge funds' performance measurement area: Sadka (2010), Cao et al. (2018), Chen et al. (2018), Jame (2018), Liang and Qiu (2019), Canepa et al. (2020) and Li et al. (2020).

The other asset non-related widely analyzed factor is volatility as the volatility usually initiates more frequent trade, which is characteristic of hedge funds' investment. Oliva and Reno (2018), Thomson and van Vuuren (2018), Asensio (2019), Racicot and Theoret (2019), and Lee et al. (2020) also considered the VIX factor to impact hedge funds significantly.

In addition to the asset- or risk-based (liquidity and volatility) factors, so-called exogenous factors are also widely analyzed. Investment size introduced and widely used by Fama and French (2004). Freshly established, smaller funds have more freedom in amending their strategies to the changing market conditions; therefore, as outlined by Amman and Moerth (2005), Jones (2007), Teo (2009), Joenväärä et al. (2019), Becam et al. (2019), O'Neill and Warren (2019), Cumming et al. (2020), they have more potential. On the contrary, large-size funds have size-related advantages because the larger-scale fund managers can afford to spend more on analysis and due diligence of each asset or component of the fund. As outlined by Getmansky et al. (2004) and Xiong et al. (2009), the benefit of being well-informed works with large-size hedge funds. Investors' experiences analyzed by Carhart (1997), Pirotte and Tuchschmid (2014), Berglund et al. (2018), Rzakhanov and Jetley (2019), and Berglund et al. (2020) also can be compared with the hedge fund longevity lead the hedge fund managers to more sound decisions. Cui et al. (2019) and Shin et al. (2019) also supplemented the experience with strategy adjustment frequency providing frequent trading can strategically time the tail risk.

Despite the wide range of the hedge funds' performance measurement research focus, researchers such as Savage (2017), Groshens (2018), and Robertson (2018) proposed categorization of the hedge fund performance determining factors by their difficulty to implement and the complexity of the investment instruments and the strategies. Jaeger (2005) introduced the concept of "smart beta" and "strategic beta" (or Alternative beta), categorizing all factors into pure beta, smart beta, alternative beta, and alpha. Investment factor-based Betas (i.e., Value, Carry, Quality, Growth, Momentum, and Size) were defined and analyzed by Asness et al. (2013), Lustig et al. (2011), Moskowitz et al. (2012), Baltas and Kosowski (2013).

The researchers also widely analyze the hedge fund performance during the crisis or changes in the hedge fund performance and risk appetite due to the changes in the regulatory environment. Cao et al. (2018), Zhao et al. (2018), Liang and Qiu (2019), Gregoriou et al. (2020), and others analyze which strategies make hedge funds successful during the crisis. In contrast, Metzger and Shenai (2019), Sung et al. (2020), Denk et al. (2020), and others compare the performance of hedge funds compared to benchmarks or mutual funds. Although there are many explanations of the hedge fund performance during the crisis, adding the crisis factor into the comprehensive hedge funds' performance measurement models is somewhat sparsely attempted. Hespeler and Loiacono (2015) established the dependency of the hedge funds' return indicators on sector return distribution; however, they did not allocate this to the exact performance determinants.

The regulation imposed in response to the financial crisis of 2007-2008, represented by the US Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank) and EU 2011/61 / EU AIFM Directive, had a dual impact on hedge fund performance. According to Barr (2008), Brown et al. (2012), Chan et al. (2007), and Cerutti et al. (2010), hedge funds firstly encountered the limitation of the risk that hedge funds undertake. The requirement to register the hedge fund managers once the AUM of the hedge fund exceeds 100 million USD prevents the potentially very significant impact on the market. The reduced possibility to use higher leverages, increased borrowing costs, or a ban on using short selling reduced the options for earning a higher return by taking higher risk. However, Sullivan (2019) and Joenväärä and Kosowski (2020) also noticed a decrease in the risk appetite of the hedge fund investors, resulting in the more conservative hedge fund managers' approach and reduced *alpha* level. Fairchild (2018) concluded that this puts more pressure on hedge fund managers, as their fees are what they charge for success.

Regardless of the angle from which the hedge fund performance is analyzed, the one essential aspect of the hedge fund performance is the *alpha* factor and the ability of the fund manager to generate it. According to Siegel (2005), by taking the Smart beta approach, investors optimize the different market factors and achieve higher returns while experiencing the same level of risk. He concludes that what was initially considered pure alpha can now be considered premia of liquidity or opacity of other risk factors.

The development of the hedge funds' performance measurement models, selection of the factors, and interpretation of how performance depends on the changes in the investment environment was performed on the Global scale using the global or the US-based hedge funds in a USD dominant environment. Nevertheless, in 1982 Stambaugh proposed the initial idea of analyzing the investment portfolios (mutual funds) using or combining the various non-US-based indices. For the first time, Do et al. (2005) analyzed the Australian hedge funds; however, they found very little dependence on the Australian ASX index. However, they also discovered that a smaller region of hedge funds' return is subject to data biases, especially survivorship bias.

Other regions were also analyzed on an occasional basis: Asia was analyzed by Van Dyk et al. (2014), Japan – by Kanuri (2020), Saudi Arabia and Malaysia – by Oueslati and Hammami (2018), and Islamic countries – by Karim et al. (2020). China's hedge fund market is growing, and more research papers represent this region: Huang and Sun (2018), Huang et al. (2018), Chen et al. (2019), and Zhai and Wang (2020). Gibilaro et al. (2018) analyzed the Cypriot hedge fund market. However, all these research papers are more focused on analyzing the absolute return or quantifying the differences between the regional and global hedge funds.

Despite the impressive performance of the Nordic hedge funds, only a few research papers represent this market with focus on the investment environment itself or on analyzing the mutual hedge funds: Ekberg and Iversen (2018). The Nordic hedge fund industry analysis revealed that the Nordic region could be characterized by longevity and a lower rate of offshoring registration, making this region unique. The Nordic investment market also differs from the US investment market in how the communication between the fund managers and the investors is carried out. Preuss (2019) observed higher risk awareness of the Nordic equity fund managers resulting in lower volatility ratios than the US rivals. Although hedge fund regions have particular features (e.g., Nordics are known for their longevity, and the hedge funds shall have substantial experience in withstanding more than two crises), the methodology created in this dissertation is designed to apply to any smaller region regardless of the region's peculiarities.

Scientific problem – what factors determine the results of regional hedge funds, and how do the assessment models and factors depend on the changes in the investment environment?

Research object – regional hedge funds' performance measurement (asset pricing) models.

Research objective – after examining the hedge funds' investment phenomenon and based on the Nordic sample to develop regional hedge funds' performance measurement models adapted to different investment environment conditions.

The following **research tasks** are set to achieve the research objective:

1. After analyzing the scientific literature and based on the theoretical concepts of the hedge fund investment phenomenon, determine the preconditions for developing and applying hedge fund pricing methodology for regional hedge funds.

2. Considering the factors that characterize the region's investment environment and hedge fund investment strategies, define a methodology for creating regional hedge funds' performance measurement models.

3. Following the proposed methodology and based on Nordic hedge funds' return data, Nordic-specific risk factors, and investment environment conditions, identify determinants of the Nordic hedge funds' performance.

4. To assess the contribution of Nordic hedge fund managers (measured by *alpha*) in various investment environment conditions (i.e., crisis or regulatory constrained or unconstrained periods).

Research hypotheses.

H_1: Region-specific risk factors can better explain the regional hedge funds' performance rather than the Global risk factors using both conventional (e.g., CAPM, APT) or non-linear (e.g., Fung-Hsieh 8-factor) models.

H_2: Additional risk factors (e.g., commodity prices, derivatives, ETFs, other assets) and the dummy variables representing various periods of different investment environment conditions improve the statistical significance of the models allowing a more reliable assessment of the hedge fund manager's contribution to the performance of the hedge fund.

H_3: Changes in the investment environment impact the hedge fund performance is reflected on *alpha* rather than on the *beta* indicators.

H_4: Hedge fund managers adjust the investment strategies during the crisis to prevent drawdowns and generate positive *alpha*.

H_5: Regulation constraints applied to the hedge fund industry negatively impact the hedge fund's *alpha*.

Research methods.

The dissertation uses the following research methods in assessing Nordic hedge funds' investment results and in using asset-pricing models:

- Systematic analysis of the literature.
- Analysis of legal documents.
- Graphical data interpretation and analysis.
- Methods of statistical analysis.
- Empirical research.
- Expert evaluation method.
- Conclusions and recommendations.

Literature analysis: The study begins with reviewing and analyzing literature and recent research papers. Analysis of the research papers and identification of the methodological changes allowed perceiving the characteristics of hedge funds, the relationship of the hedge fund industry with the economic system, and the state of the methodology of the hedge funds. Recent trends in hedge fund pricing models are analyzed from scientific conferences and discussions aiming to research concepts adopted, methods, and models used.

Analysis of legal documents intends to clarify the principles of hedge funds in different economies and whether and how new legislation could impact the hedge fund investment process. As the regulatory environment may affect the investment of hedge funds, directly and indirectly, it is essential to gather and analyze the regulation changes during the entire research period. Special attention requires the solutions and regulatory consequences of alternative investment regulations that the European Union adopted in 2015.

Graphical data interpretation compares quantitative research results to different relative and absolute values. Visual data analysis well represents the weighted variables using the Elasticity at Means method. Using graphs and charts, the author presents the research framework, methodology, dependencies between different approaches, and the performance analysis of the hedge funds.

Statistical data and empirical analysis enable analyzing data published in official sources. The statistics provided by hedge funds that report primary financial data are somewhat analytical and not considered prudentially approved. However, modeling the statistical dependence of the hedge fund returns with market parameters and achieving robust results justifies the outcomes.

Data analysis uses MS Excel (data calculation, adjustment, initial research, and graphical presentation) and EViews (Panel data regressions, Cross-sectional panel data regressions, Statistical tests).

The expert analysis method determines the weights of the decisions made by hedge fund managers and investors in selecting a hedge fund's strategy and assessing the risk assumed by fund managers. The aim is to understand the key parameters that impact the hedge fund, its return, and which parameters hedge fund managers may intentionally accept to link the hedge fund strategy and, consequently, the pricing.

Research limitations. Hedge funds are known for their inconsistency of the return reporting deriving from their legal form, which does not require the comprehensive disclosure of their investment activity. Due to hedge fund managers' possibility to delay or ignore reporting the returns, the data in the hedge fund reporting databases is suffering significant biases, which the majority of the researchers solve by analyzing more generalized hedge fund index data and by validating the indices using various sources of the hedge fund returns. However, when analyzing the hedge funds and their respective indices in the smaller region, additional limitations arise from the market size. Small databases and small sample sizes cause an increase in confidence intervals and, consequently, decrease the accuracy of the models. Even trying to include as many hedge funds in the analysis as possible causes the other limitation – unbalanced panel data. The increasing analysis horizon also plays a crucial role in determining the long-term hedge fund performance factors. On the one hand, the long-term alpha gives a more fundamental view of the region-specific hedge fund investment peculiarities rather than differences observable only in the short run. On the other hand, building long-term models diminishes or even eliminates the factors which tend to change based on the investment environment changes (e.g., changing the long and short strategies or changing the alpha based on the growth of the hedge fund manager's experience with the time).

The non-linear dependence of the hedge funds' returns on the systemic market risks requires advanced research methods based on non-linear dependence models. Researchers use non-linear regressions and other more advanced and complex methods (e.g., dynamic panel data models, panel VAR models, panel ARDL models, and models with non-linear factor dependence). Using linear-only dependency-based models may exclude some of the determinants from the research; however, the explanation of the linear dependencies is more straightforward.

The researchers focusing their analysis on the Global hedge funds' databases have opportunities to group the hedge funds in coherent panels by strategy, age, size, and other characteristics. However, in a smaller region, the such grouping may lead to even further inaccuracies. Panel data models are used to include hedge fund-specific factors in the models. However, given the region size and the longevity of the research horizon, panel data models are also limited. E.g., there are no possibilities of using a generalized method of moments designed to solve endogeneity problems.

The scientific novelty of the dissertation and its theoretical importance:

1. The dissertation aims to explore the methodology of creating and adapting the robust model for assessing the performance of the regional hedge funds: what part of the return is attributable to taking on the known market risk, and which is the merit of the hedge fund manager. In the area of holistic hedge fund return, researchers predominantly analyze the Global hedge fund databases, whereas this research seeks various methods and factors which can best represent and determine the performance of the regional hedge funds.

2. The dissertation uses various methods: i.e., models using long-term time horizons with Dummy variables describing the investment environment factors (crisis and regulation); harmonized models analyzing separately periods affected by crisis and regulation against the models of unaffected periods; and finally, models analyzing different crisis periods determining which factors are persistent and which are not in using those different approaches. Such other methods see the alpha deviation from short-term to mid-term and long-term. Long-term alpha makes it possible to distinguish sensation-seeking funds analyzed by Brown et al. (2018) from actual long-term value-generating funds.

3. Calculating long-term *alpha* and long-term *beta* factors also reveal which are more stable in the long run. Most systemic risk factors (e.g., stock or bond market factors) depend on the investment environment. However, hedge fund managers are known for their ability to employ *exotic* strategies – i.e., updating or changing those systemic risk factors based on the effect of the investment environment (i.e., crisis or the regulatory regime).

4. The dissertation also focused on analyzing the hedge funds' performance using asset pricing models using the method with the standardized *beta* coefficients addressing the elasticity of coefficient at dependent variable means. Before that, Gelman (2008) analyzed mutual funds using standardized *beta* coefficients. Considering

this research analyzes long-term return data, scaled factors shall diminish the volatility of the factor value and present its long-term impact on the long-term hedge fund performance. Elasticity at Means also provides graphical of the generated model.

5. No researchers researched Nordic hedge fund pricing determinants before this dissertation. The initial analysis of the Nordic hedge fund return data presents several rather extraordinary observations. Firstly, Nordic hedge funds outperformed by 8% global hedge fund indices throughout the 2007-2008 financial crisis drawdown. Secondly, out of 72 analyzed Nordic hedge funds, 57 survived for more than ten years making Nordic the region of long-livers. McCrum (2014) concluded the series of reports claiming, "Most hedge funds fail: their average life span is about five years." Such a large number of long-living funds implies that Nordic hedge funds' managers withstood more than two crises raising the hypothesis that Nordic hedge fund managers shall be good at investment during the crisis. This hypothesis has not been under the radar of other researchers.

Practical benefits of the dissertation:

1. The methodology created in this dissertation shall be adapted to build the hedge fund pricing models in other regions. Although there still can be significant differences between hedge fund regions and consequently between the hedge funds, the methodology presents the model creating sequential flow adjustable to different conditions.

2. The dissertation assesses whether the investment environment, such as crisis or regulation, may **impact** the absolute return of the hedge funds regardless of the direct impact of the market risk factors. Can this specific return be **attributed** to the fund manager's contribution and individual skills, usually awarded by incentive fees? More transparent hedge fund pricing shall reduce the strong asymmetry in the relationship between hedge fund performance and investor sentiment (Zheng and Osmer, 2018) and harmonize long-term growth perspectives.

3. Research in a narrow Nordic hedge fund market, which only comprises 140 active hedge funds, shall motivate other researchers to segment the hedge fund market and analyze the smaller regions. The Nordic region is also very influential for the Baltic states, making the research findings applicable to the Baltic market.

4. The Nordic hedge fund industry presents the results of hedge funds' pricing models. These models can be used by hedge fund managers when showing their results to investors. The Nordic hedge fund award established by Nordic Business Media,

besides the absolute return numbers, shall also use the assessment of the hedge fund manager's contribution to the fund results *(alphas)*.

Defensive statements of the dissertation:

1. Adding the region-specific and other "hidden" risk factors into the hedge fund pricing models shall lead to a decrease in *alpha,* proving that hedge fund managers tend to limit the disclosure of the systemic risks taken by the hedge funds.

2. The hedge funds' investment environment factors (crisis and regulation) impact their asset pricing models and variables.

3. The alpha factor variation primarily explains the performance differences of the regional hedge funds, besides the variation of the systemic market risks (represented by beta factors).

The logical structure of the doctoral dissertation:

The dissertation includes an introduction, three main sections, conclusions and recommendations, references, and annexes. The dissertation comprises 143 pages (with references and annexes of 191 pages). The number of references – is 290. Figure 1 presents the logical dissertation structure.

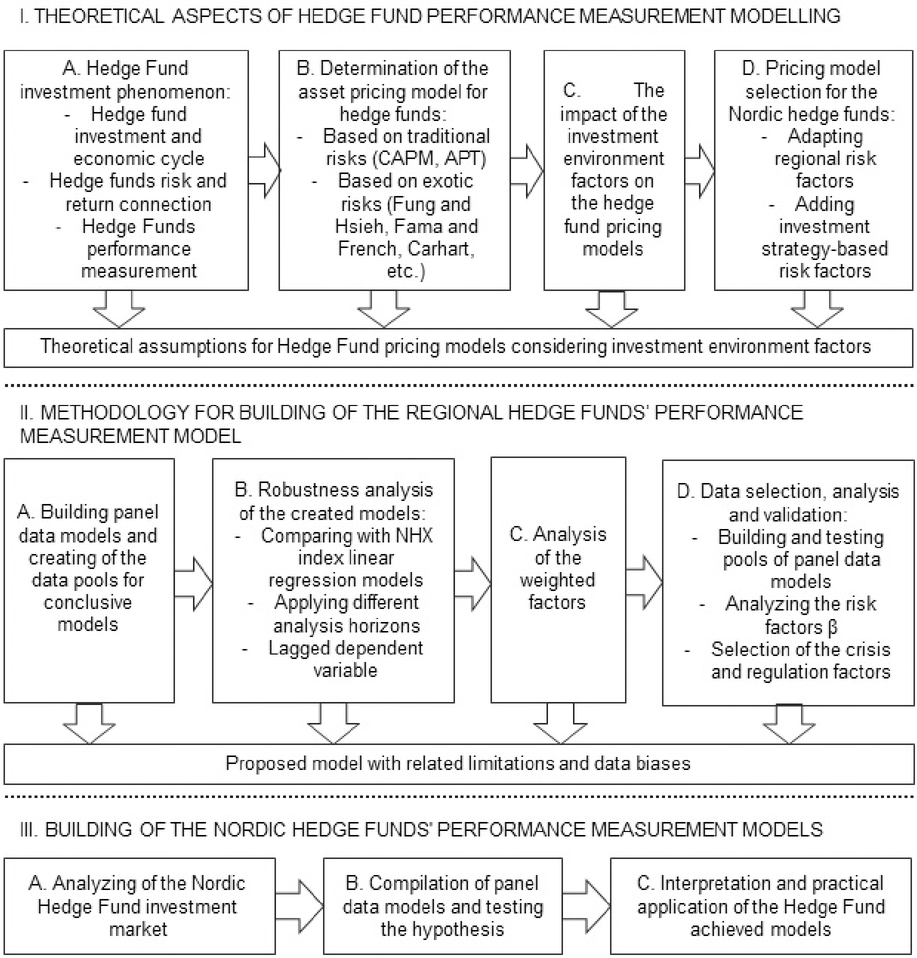

Figure 1. Dissertation logical structure

The first part focuses on presenting the hedge fund investment phenomenon and what are the theoretical aspects of developing the hedge funds' performance measurement models. The nature of the hedge funds classifies them as high risk and a high return investment undertaking; however, it is not the high risk but a high absolute return that distinguishes them from the other investment classes. As opposed to mutual funds (also known as well-regulated), hedge funds are well known for their unconstrained strategies that lead to somewhat antagonistic interrelations and rumors. Based on various calculations, hedge funds AUM comprises nearly 4% of the entire CIU market; they have that specific attention from the researchers due to the high *alpha* indicators. The evolution of the models used to define the performance determinants from CAPM, ICAPM, and APT to widely used Fung-Hsieh's 8-factor model faces discussions among the researchers on whether a more sophisticated model using non-linear dependencies prevail the simplified single of few factor based liner models. These models also need to embed the investment environment factors, which have not been used in the hedge funds' performance measurement models as a factor.

Neither of these models was used in the context of the regional hedge funds. Regional hedge funds are characterized by return data biases, which make regional hedge funds' performance measurement modeling even more complicated. However, the extensive range of the models and various factors presented in this part shall provide more opportunities to construct robust models and to test the methodology on Nordic hedge funds.

The second part presents the thorough methodological approach to constructing the regional hedge funds' performance measurement models. The methodology comprises three main aspects: selecting the modeling method for validating the hedge fund performance determinants, selecting the determinants themselves, and presenting the methods for performing various modeling robustness testing actions. The modeling is based on panel data pooled OLS method building the models using well-known Fung-Hsieh's 8-factor and Fama-French 4-factor models based on US-based (Global) and national factors. In the end, the models are enhanced by adding additional commodities or other financial asset-based as well as investment environments representing crisis and regulation factors using the Stepwise regression forward approach. For better result interpretation and graphical presentations, standardized coefficients are calculated, and the weighted contribution of each of the factors is presented.

The methodology also emphasizes the importance of using a single (USD) currency for all calculations. Therefore, the factors are adjusted to USD value change. Panel data models also require selecting the suitable Estimation model, which is determined using three effects (Common effect, Fixed Effect, and Random effect). Choosing the most suitable effect can improve the models and enable more practical use of the model results.

As regional hedge funds' performance measurement models are more affected by data biases, special measures are considered to ensure the models as somewhat unbiased. The primary and foremost important step in reducing the data biases is gathering the hedge funds into related and more coherent pools by strategy, correlation, and performance indicators. However, this research still encounters significant limitations, which are also presented at the end of part two.

The third part tests the hypotheses by performing the empirical calculations, modeling, and model result interpretation. The sequence of the models, various factors, and various model validating tests are applied to test the hypothesis set in the methodological part. Where models have identical, coherent, or comparable results provided by the other researchers, such models, coefficients, and validation factors (i.e., Adj. R^2 or AIC criterion) are compared and interpreted. However, empirical analysis is minimal due to the unique character of most of the models and the incredibly unique proposed method for embedding the investment environment factors in the model. However, the scientific discussion analyzing the economic impact of the models is performed as a conclusive step of this part.

Dissemination of scientific research results:

Interim and final research results have been disseminated in various national and international papers and presented at scientific conferences.

Publications:

1. Kolisovas, D., Giriūnienė, G., Baležentis, T., Štreimikienė, D. and Morkūnas, M. (2022) "Determinants of Nordic hedge fund performance," *Journal of Business Economics and Management (JBEM)*. Available at: https://doi.org/10.3846/jbem.2022.16170.

2. Škarnulis, A. and Kolisovas, D., (2015) "Pros and cons of inflation-linked sovereign bonds. Initial considerations of the Lithuanian case," *Pinigų studijos*, February 2015, pp. 56-73 [Online]. Available at: https://www.lb.lt/uploads/documents/docs/publications/pinigu_studijos_2015_m_nr_1.pdf

3. Teresienė, D., Kolisovas, D. and Pėstininkas, A. (2014) "2003-2013 published economic indicator's impact on yields of US treasury notes and bonds," *Business Systems & Economics*, Vol 4, No 2, pp. 181-195.

Conference presentations:

1. Kolisovas D. (2019) "Applying Panel Data models for Hedge Fund pricing, '5th International Conference – RAESR 2019. Recent Advances in Economic and Social Research." Romania Academy Institute for Economic Forecasting. May 23-24, Bucharest.

2. Kolisovas D. (2019) "Crypto Perspective: Beyond the 2017 boom," '6th In-

ternational Scientific Conference Whither our Economies – 2019 WOE'19. September 19-20, Vilnius.

Other publications:

1. Kolisovas, D., (2021) "Secrets of Long Livers: Crisis Alpha," *Nordic Hedge Fund Industry Report 2021*, March 2021, pp. 48-53 [Online]. Available at: https://hedgenordic.com/wp-content/uploads/2021/03/HNIR2021.pdf

2. Kolisovas, D., (2021) "In the Face of COVID-19: Unusual Crisis Performance," *Finding Alpha in Equities*, May 2021, pp. 38-43 [Online]. Available at: https://hedgenordic.com/wp-content/uploads/2021/05/Equities_2021.pdf

1. THEORETICAL ASPECTS OF HEDGE FUNDS' PERFORMANCE MEASUREMENT MODELLING

1.1. Hedge fund investment phenomenon

The main and the most distinctive aspect of the hedge fund investment derives from the hedge fund aiming to achieve top performance. Hedge fund managers usually aim for the maximum return to investors with a comparatively decent amount of risk; therefore, they are seeking to:

1. Take high return positions by using a variety of investment instruments and strategies. These strategies include using derivative financial instruments, short-selling, and a high level of leverage, consequently imposing higher risk. These strategies can provide a wider choice of markets, investment instruments, and actions. Higher risk strategies depend on the systemic risk channels: credit channels, capital market channels, and liquidity channels, widely presented by Aiken et al. (2012), Brown et al. (2012), Dixon et al. (2012), and others. The frequent aligning of the strategy and frequent trading complements the high-risk channels.

2. Increase the hedge fund *alpha* indicator, often using strategies that do not correlate with traditional capital markets. This approach gives real portfolio diversification, also known as neutral market (*zero-beta*), and finds the proper structure known as the optimal portfolio (or diversified portfolio), which derives from the modern portfolio theory of Markowitz (1952). When comparing hedge funds with mutual funds with the same investment profile (i.e., instruments, duration, directions, regions), hedge funds usually have lower volatility or higher Sharpe ratios, as discussed by Cederburg et al. (2018), Grinblatt et al. (2020) and others. Karehnke and de Roon (2020) estimated that the significant value to investors is delivered by 11% of hedge funds, while similar mutual funds provide an insignificant 4% in the long run.

The other pervasive distinction of hedge funds lies behind the legal definition of the funds. For example, European Commission (European Commission, 2020) defined the following groups:

- UCITS – Undertakings for Collective Investment in Transferable Securities.
- AIFM – Alternative Investment Fund (Managers) for professional investors, i.e.:
    - Hedge funds – high-risk funds aim to achieve an absolute return.

  - Private equity funds, comprising of:
    - Buy-out funds.
    - Mid-cap investment funds.
    - Venture capital funds.
  - Infrastructure funds.
  - CTAs or Commodity Trading Advisors.
  - Real estate funds.
- EuVECA – European Venture Capital Funds.
- EuSEF – European Social Entrepreneurship Funds.
- ELTIF – European long-term investment funds related to infrastructure projects.
- MMF – Money Market funds.

To conclude, hedge funds are Collective Investment Undertakings (hereafter CIU), usually provided to advanced investors. Hedge funds, by their definition, oppose mutual funds[3]. However, there is also a category of UCITS-compliant mutual funds called Absolute Return UCITS-compliant (ARU) presented by Joenväärä and Kosowski (2020), which are competitive with hedge funds. Hartley (2019) compared the performance of liquid alternative mutual funds (LAMF) with hedge funds of similar strategies and discovered an insignificant 1% on the average performance difference between hedge funds and LAMF. It is not the performance level but the strategy complexity that distinguishes hedge funds from the others. Grinblatt et al. (2020) state that hedge fund strategies are more contrarian and do not follow market trends, while mutual funds are the opposite.

While the primary idea of hedge funds was to "close" the position by using the Arbitrage strategy to achieve the market-neutral design, the variety of hedge fund strategies is much more comprehensive these days. Some hedge funds may have an apparent open direction and using the leverage can increase it. Hedge funds strategies comprise four main groups:

1. Directional.
2. Event-driven.
3. Market Neutral.
4. Fund of funds.

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3 Mutual funds – regulated funds with information on structure, income and other strategic items available to a wide range of beneficiaries.

To diversify the risk, the hedge funds may also conjoin several strategies. BarclayHedge (2020b) presents a comprehensive global hedge fund classification used as a basis for many pieces of research for over two decades (e.g., Garbaravičius and Dierick, 2005). Hedge funds are:

- Directional (Long/Short Equity Hedge, Dedicated Short Bias, Global Macro, Emerging Markets, Managed Futures/CTA).
- Event-Driven (Risk/Merger Arbitrage, Distressed/ High Yield Securities, Regulation D or Reg. D).
- Market Neutral (Fixed Income Arbitrage, Convertible Arbitrage, Equity Market Neutral).
- Multi-strategy.
- Fund of funds.

Other sources of information, such as Morningstar and Hedge Fund Research, use slightly different concepts or categories. Still, such differences are insignificant as the definitions of hedge fund strategies in literature and information sources are almost identical.

The smaller regions may have different hedge fund classifications, which may need a combination of the models and patterns used in the global hedge funds' performance measurement models. E.g., in Nordic countries, Nordic Business Media reports the following five hedge fund strategies: Nordic equities, Nordic fixed income, Nordic commodity trading advisors (CTAs), Nordic multi-strategy, and Nordic fund of funds[4]. The funds might indicate directional strategy, Event-driven, or Market Neutral; however, this information is irretrievable in the Nordic hedge funds.

Hedge funds have standard features regardless of the different categories and legal structures. Above all, hedge funds' commitment to generating an absolute return is the synonym for the hedge fund investment phenomenon. This phenomenon attracts investors, and over the past years, the interest in investing in hedge funds has only been increasing. According to data from eVestment (2020), Norrestad (2021), and Prequin (2021), global hedge funds' Assets under management (hereafter AUM) nearly tripled over the decade from 1.40 trillion in 2011 to 4.15 trillion USD by the end of the 1st quarter of 2021. However, the industry encountered a sharp squeeze in 2008 following the financial crisis by 1/3rd from 2.30 trillion USD to 1.45 trillion USD. However, regardless of such outstanding AUM growth indicators, other researchers (e.g., Swedroe, 2020)

4 https://hedgenordic.com/.

conclude that other investment classes have overperformed HFRX Global Hedge Fund Index over the last ten years. This trend was also relatively straightforward during the Covid-19 situation, with rather incredible record-breaking growth in most categories of financial assets (e.g., equities, commodities).

When looking into the overall statistics of investment funds or CIUs, the AUM of the top 400 Asset Management funds in June 2019 was 66.4 trillion USD, rising by 0.7 trillion USD from 2018 based on an IPE Report (IPE (2019)). PWC reports that global AUM reached 111.2 trillion USD by the end of 2020, Asuzu (2020). The hedge fund market comprises nearly 4% of the entire CIU. However, this part of the CIU market requires special attention due to the higher risk and more advanced knowledge of this risk required by the investors who rely on professional fund managers. Stowell (2012) expressed that hedge fund managers created value through technological and informational, competitive advantages and managers' skills.

Investors seek tools and solutions for selecting the right hedge fund which corresponds to their risk appetite and can deliver the anticipated return. Tejeda-Lorente et al. (2019) outlined that it is essential to quantify the hedge fund risk and the level the risk just right for the investors. However, the decision to invest in hedge funds also derives from so-called investors' sentiment, which also has relations with higher stock market volatility, as examined by Zheng and Osmer (2018). Kuzmina (2020) has proven using econometric tools that a model for determining hedge fund performance using risk factors is necessary. She stated that the Sharpe ratio alone (when the actual model of returns is unknown) does not provide patterns for hedge fund comparison during good and bad times.

Besides high returns and diversification, hedge funds attract researchers from the high-risk perspective. Long-Term Capital Management (LTCM) collapsed in 1998 due to worldwide crises in Asia and Russia, raising the first significant risk of the hedge funds – credit risk concentration. In that event, when bond credit spreads increased, the bond prices dropped accordingly. This price hike and high leverage led LTCM creditors to seek greater security for their investments. The massive outflow of positions had further encouraged the fall in asset prices, and the fund had hit a 4,6 billion USD loss, which accounted for 90 percent of the total LTCM own funds of 5 billion USD, Kambhu et al. (2007), Lloyd et al. (2012).

Credit risk concentration also occurred as a tight hedge fund relationship with prime brokerage resulted in concentrated collapses of hedge funds and the investment banks like Bear Sterns and Lehman Brothers. These banks had too much concentration at the peak of the financial crisis of 2007 – 2008. They faced liquidity problems similar to the Great Depression when banks could not settle with all depositors due to insufficient liquidity of bank assets, and liquidity problems made banks bankrupt Dixon et al. (2012). FCIC report (2011) and Hedge Funds and Systematic Risk (2012) show hedge funds' connection to liquidity problems (see Figure 2). Hedge fund investment and liquidity crisis was a hot topic post the crisis (Spiegel, 2009; David et al., 2010; Boyson et al., 2011; Aiken et al., 2012; Gropp, 2014; Costa, 2014).

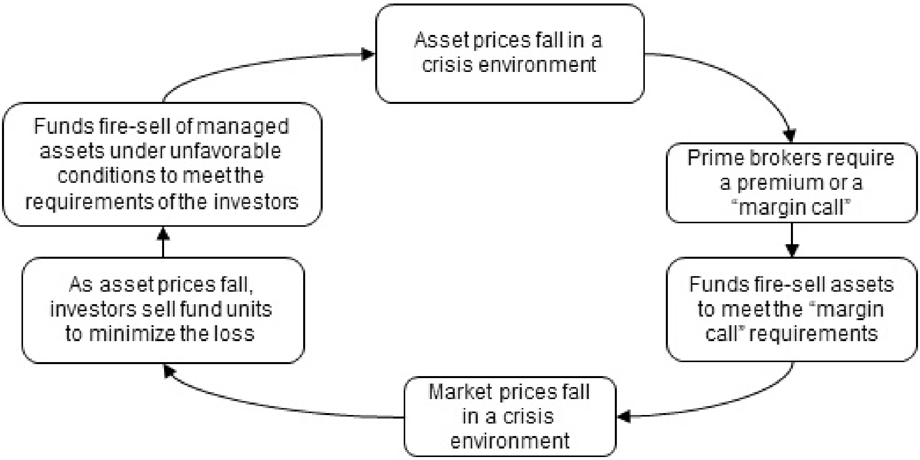

Figure 2 Algorithm of Evolution of the Investment Fund Liquidity Crisis
Source: adapted the model presented in the FCIC report (2011) and Hedge Funds and Systematic Risk (2012).

Following the financial crisis of 2007-2008, Brown et al. (2012) outlined the importance of hedge funds in determining the market efficiency of distressed assets. However, many hedge funds can open a bear ride when opening short positions. George Soros with Quantum Fund in 1992 is the classical example called Black Wednesday. The financial crisis of 2007 – 2008 also realized such cases. Governments and regulators adopt temporary bans on short-selling transactions to prevent further collapse of the investors. UK FSA and the US SEC adopted a temporary ban on short-selling transactions. This ban affected the securities of 799 institutions and mainly targeted hedge funds (Barr, 2008; US SEC, 2008). European Union also imposed the same bans (Fletcher, 2011; Xydias and Brunsden, 2012). The EU's securities markets regulator ESMA issued the European Union Short-Selling Position Transaction Regulation in 2012 (Preece, 2013), which introduced a strict commitment to disclosing information on short-position transactions and a ban on certain types of transactions. However, researchers also presume that US supervisory authorities see the hedge funds as *too big to fail*.

These days hedge funds are also seen as providing liquidity to the market. Jame (2018) and Li et al. (2020) analyzed the performance of those hedge funds, which provide liquidity to the specific market segment (e.g., dealing with distressed assets and distressed debt). Despite the stance that hedge funds are the engines that deepened the liquidity crisis, funds with more significant liquidity provision factors earn significantly higher alpha and Sharpe ratios. This performance directly connects with more complex than mechanical short-term reversal strategies and good timing. The outperformance of liquidity-supplying funds is also higher in periods with liquidity or funding constraints when rivals with less flexible structures cannot catch liquidity issues. Sung et al. (2020) looked in-depth to explain hedge fund capability to withstand liquidity shocks and outperform their rivals. They concluded that the running positions are usually reduced or even closed by the hedge fund managers before the stop-loss measures usually catch the other investors. However, Cao et al. (2018) discovered the other phenomenon of hedge funds investing in an inefficient or illiquid stock. While in non-crisis times, the liquidity of such stock increases more than any additional investment, it also falls drastically during the crisis. Despite different or even opposite discoveries in the research mentioned above, the liquidity risk shall always impact hedge funds from the market conditions or the fund's cash-flow point of view.

Besides credit risk concentration and liquidity risk, the researchers also see boredom and myths surrounding hedge funds, which often present them in a negative context. Such attention to the hedge funds' investment lies behind:

- Researchers and commenters do not treat hedge funds as the investment market's most transparent and healthy instruments. Some people make these conclusions because the funds have limited reporting to the public and the regulators. These conclusions connect the hedge funds and the entire hedge fund investment industry with the crisis.
- Khurana et al. (2018) examined how hedge funds' attention affects the performance of the companies they intended to include in the portfolio. The increased awareness from hedge funds usually impacts the companies' strategic informa-

tion and earnings disclosure. Such intervention of the hedge funds may also impact the company's internal control and affect the executives' careers.

- Hedge fund managers are also talented and willing to gather unique information and keep the investment strategy at a high level of secrecy. However, Murdock (2019) warns about the Law on insider trading, which may restrict possessing unique information. Bargeron and Bonaime (2020) analyzed short-selling managers' advantage and claimed it is not myopia but private information resulting in a 7.5% better return annually. Gimbutaitė (2016) gathered a comprehensive list of commonly used myths, such as hedge funds causing higher liquidity risk or hedge funds contributing to the crisis and denying those myths.
- Brown et al. (1999) examined the other hedge fund investment phenomenon: their high proportion registered in tax haven territories. They identified that over 50% of all US-based funds are registered offshore, and if excluding funds of funds, the offshore part exceeded 67%. Investors tend to locate and report their investments in the Cayman Islands, the British Virgin Islands, Bermuda, and the Bahamas. Garbaravičius and Dierick (2005) analyzed the structure of EU hedge funds. They discovered that Luxemburg and Ireland, also known as tax havens of the EU, domicile over 70% of European hedge funds. Aragon et al. (2014) confirmed the trends of hedge funds to be more often domiciled offshore (i.e., in the US case, over 60%). The proportion of Offshore domiciled hedge funds of total Nordic hedge funds does not exceed 38%[5]. The low level makes the Nordic hedge fund market more nationally domiciled than Global markets.

The concluding remarks. Hedge funds are alternative, less regulated investment undertakings for professional (usually known as wealthy) investors. Despite its focus on the absolute return, led by the wrong highlights in the media surrounded by rumors, hedge funds are also known for contributing to the financial system's stability. Hedge funds provide market liquidity; hedge funds still act as hedging for some investments and ultimately give some talented investment managers jobs. Despite the upsides and downsides of the hedge fund industry, some hedge funds prosper and live long while others suffer losses or collapse during the market turmoil. The decomposition of the hedge fund performance factors may disclose what part of the performance depends on the manager's success and what part is market-related.

Notably, the information presented about the hedge fund's performance is usu-

5 Based on https://hedgenordic.com/.

ally biased and delivered from the best qualities the manager wants to contribute. However, the investors need to see the "correct" or unbiased determinants of the hedge fund performance and the performance indicators themselves.

1.2. Hedge fund performance determinants and assessment models

The fair assessment of the hedge fund's risk-adjusted performance and determination of the performance-based remuneration requires applying various methods, which decompose multiple factors contributing to the final result. Value Research Desk (2020) presents the leading portfolio technical ratios: alpha, beta, R-squared, standard deviation, and the *Sharpe Ratio*. However, Grau-Carles et al. (2017) determined *Sharpe ratio* is biased in the case of non-normally distributed returns characteristic to the hedge funds. The Sharpe ratio also does not present risk composition and proportion in the portfolio; therefore, the more in-depth analysis uses asset pricing models.

Over more than 20 years, hedge fund asset pricing underwent significant development by Fung and Hsieh (1997, 2001, 2004, 2008), Liang (2000), Agarwal and Naik (2004), Kosowski et al. (2007), Bali et al. (2011), Brown et al. (2012), Edelman et al. (2012), Cao et al. (2018), Joenväärä and Kosowski (2020). These days' the main issues relate to recognizing traditional risks (i.e., the impact of the size or value) and more exotic risks inherent to the hedge fund investment process (i.e., momentum or various non-linear and option-like return generating investments). Many successful attempts still exist to use traditional asset pricing models for hedge funds. Therefore, these days there are still two main streams of asset pricing models considered by researchers to evaluate the performance of hedge funds:

- Conventional pricing models deriving from leading theories – Capital Asset Pricing Model (CAPM) (Treynor, 1961) and Arbitrage Pricing Theory (APT) (Ross, 1976), and
- Fung and Hsieh (2004b) elaborated on exotic risks, characteristic of hedge funds aiming for absolute return and employing dynamic styles and high leverage.

The conventional pricing models' concepts start with Markowitz's (1952) Modern Portfolio Theory (MPT) which addressed portfolio-related issues hedge fund managers and investors face, and that gave grounds to the Capital Asset Pricing Model (CAPM) of Treynor's (1961). French (2003) presented the evolution of CAPM in the following phases: Jack Treynor introduced CAPM in the early sixties, and William

Sharpe and John Lintner developed it further in 1964 - 1965. The Nobel Foundation awarded William F. Sharpe, Merton H. Miller, and Harry M. Markowitz a Nobel Prize in 1990 for their pioneering contributions to the theory of financial economics and corporate finance (Nobel Foundation, 1990).

Investors reduce their risk by holding positions in the portfolio that are not perfectly positively correlated (i.e., Pearson correlation). Diversification allows for reducing the risk for the same portfolio's expected return. Based on Mossin (1966), all rational investors seek more returns with less risky investments in the CAPM. A tangency represents the portfolio, also called a market portfolio. The portfolio's upper left location (higher return and less risk) indicates its efficiency and the so-called "north-west" direction. Suppose the portfolio is optimal to reach the higher volatility with a possible higher return. In that case, investors shall apply leverage rather than overweighting the portfolio with high-volatility stock or other assets. Hedge funds seek a "north-west" direction; however, successful investment ideas are usually limited.

MPT and CAPM theories entail the *linear relation* between the risk and return with the risk-free rate of return point on the Y-axis and Capital market Line (hereafter CML) representing the optimal portfolio allocation points. CAPM also explains selecting the right asset when adding to a well-diversified or optimal portfolio. Racicot and Theoret (2019) analyzed how hedge fund managers trade off high kurtosis and skewness of hedge funds to diversify their portfolios. Oliva and Reno (2018) focused the CAPM model on assessing how hedge fund managers achieve optimal portfolio allocation in a high-volatility environment. They also analyzed the portfolio volatility with jumps in hedge fund prices, which derive from allocating the risky assets of the hedge funds. Permana (2020) applies the optimal portfolio theory of Nicolosi (2018) and finds that the optimal portfolio strategy is also possible to hedge funds using Black–Scholes (1973) model using a combination of the risky asset and the money market account.

Without limiting the style of the investment (mutual or hedge fund), the CAPM model states that investors' expectations are rational and consistent. CAPM model initially introduced the variable, called *beta*, representing the proportion of risk premium of an asset with the portfolio's return reduced by the risk-free rate of return. Sharpe and Lintner's CAPM equation could present below:

$$E(R_i) = R_f + \beta \times (E(R_m - R_f) \quad 1.$$

Where market Beta:

$$\beta_{im} = \frac{COV(R_i, R_m)}{\sigma^2(R_m)} \qquad 2.$$

Where:

$E(R_i)$ is the expected return on an investment instrument *i*.

R_m is a market return typically represented by a stock index return.

R_f – a risk-free rate of return.

β is the market volatility (or risk) measure of an investment instrument *i* that shows how the investment instrument return relates to the market. *Beta* is a covariance of the market and single investment instrument return divided by the market return variance.

Sharpe (1964), Lintner (1965), Black (1972), Merton (1973), Lucas (1978) and Breeden (1979, 1989), Fama and French (1993, 1996), and Ross (1976, 1977) continuously developed the CAPM model. Merton (1973) came up with the Intertemporal Capital Asset Pricing Model (ICAPM), which analyzes the market variables from the T-1 period, and how they impact the future prospective beyond the T period, considering that investors may have various investment opportunities even consume the gained profit of the investment. Stutzer (2018) concluded ICAPM model is consistent for the hedge funds following the style of the assets (e.g., Energy hedge funds are compatible with Utility indices/benchmarks) and concluded that mixed strategy hedge funds might not be able to generate the multifactor models.

The other significant discovery of the CAPM model widely used in hedge funds is leverage. Stattman (1980), Rosenberg et al. (1985), Bhandari (1988), and Chan et al. (1991) analyzed leverage in a more general context as well as with their direct impact on the hedge funds in old times. Asness et al. (2013), Frazzini and Pedersen (2014), Hübner and Lambert (2019), Li J. et al. (2020), Bian et al. (2020). Hübner and Lambert (2019) analyzed hedge funds that do not have the restriction of using leverage. The CML counterclockwise shifts represent the use of leverage, as presented in Figure 3.

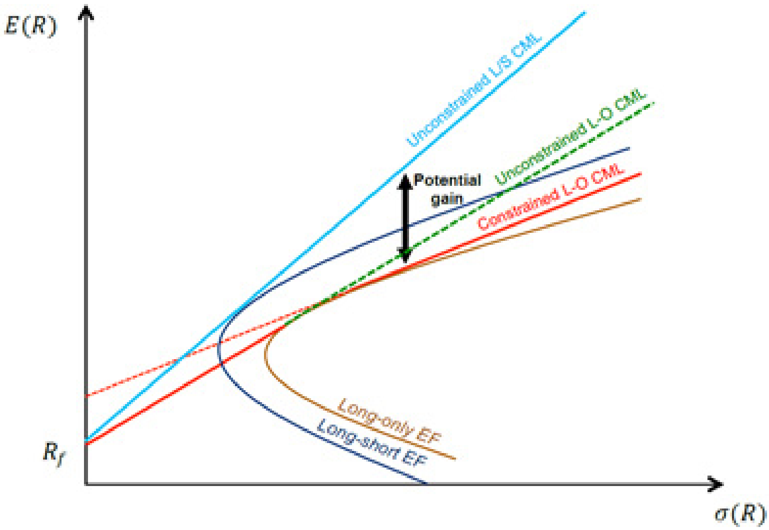

Figure 3 The Capital Market Line (CML) under leverage and short sales constraints
Note. EF stands for the Efficient Frontier and CML – for Capital Market Line. Brown EF and red CML represent investors who are only constrained to a long strategy. The green dashed CML line represents investors unconstrained to long strategy. However, introducing a short strategy significantly shifts the EF and CML lines' "north-west" direction presented by electric blue and navy-blue lines. The axis here represents E(R) – the expected return on portfolio or investment, σ(R) – the standard deviation of the portfolio or measure of the risk, and the R_f point on the E(R) axis represents a risk-free rate of return.
Source: Hübner and Lambert (2019).

Leverage with the possible use of short-selling, which was long time unlimited for the hedge funds (Jank and Smajlbegovic, 2015), shifts the CML line even further (as presented above).

Since CAPM models have various drawbacks, mainly regarding their testability and general applicability, the Arbitrage Pricing Theory (Ross, 1976, 1977, Roll and Ross, 1980) and other multivariable models attempt to respond to the drawbacks mentioned above. Arbitrage Pricing Theory (APT) allows linear regression models with highly correlated model factors if the portfolio assets follow the normal distribution (Reinganum, 1981).

The concept of conventional asset pricing models, especially those based on APT logic, is based on determining the right asset or investment instrument-based factors which best explain the performance of the investment undertaking. This dissertation should provide any risk factor related to region specifics, with investment strategies, or even being vastly employed as an investment instrument. Following the recommendations of Agarwal et al. (2018), Fama and French 3-factor model, Capocci et al. (2005), and Dewaele et al. (2015), asset-based factors shall analyze along with the other exotic risk factors.

Giuzio et al. (2018) also looked somewhat differently at the hedge funds' performance, focusing only on the liquid asset class factors related to the hedge fund style (i.e., the stock index for equity hedge funds). They built Log-clone models to replicate the hedge funds' performance and captured out-of-sample properties of hedge fund indices. Those clones closely tracked the returns of hedge fund indices with fewer factors rather than those built with more state-of-art methods. Subhash and Enke (2019) also widely analyzed strategy-specific factors, who also constructed cloned models showing that using strategy-specific risk factors to replicate common hedge fund strategies can offer superior risk-reward performance. However, Duanmu et al. (2018, 2020, and 2021) propose concentrating more on analyzing the momentum and the alpha, which reflect good investment ideas rather than just good beta. Based on Duanmu et al. (2020), clone funds that replicate the asset structure lack the time momentum and, therefore, cannot replicate the performance of the hedge funds.

APT also is a subject of the drawbacks outlined by Dybvig and Ross (1985), Shanken (1985), and Reilly and Brown (2003), which are very much applicable to the utilization of hedge funds. So, portfolios depend on different models, aligned individually to each portfolio of a group of coherent portfolios in the hedge fund industry, usually referred to as the other strategies. Since APT allows using any "almost random" risk factors, it becomes almost impossible to generalize them and thus test within the scope of a universal theory.

The other drawback of the APT model is its risk-neutral assumption or so-called rational pricing principle, where asset prices are considered arbitrage-free as any deviation from them. Delbaen and Schachermayer (2011), Pascucci (2011), and Delbaen et al. (2016) broadly analyzed this issue. Cao et al. (2018) agree that hedge funds as arbitrageurs contribute to market efficiency, especially during the liquidity crisis related to the 2007-2008 financial crisis.

Commodity trading advisor[6] hedge funds is a widely analyzed group of the hedge funds concentrating mostly on the Commodity market. Ross (1976), in the APT

6 CTA – Commodity Trading Advisor – a category of the investment fund usually considered as belonging to the hedge fund industry.

model, included oil, gold, and other precious metal prices as Arbitrage pricing theory models. Analysis of various commodities in the hedge funds is prevalent in the CTA vehicles , as presented by Blocher et al. (2017), Elaut and Erdős (2019), and Shaikh (2019). However, with their primary focus on equity or debt instruments (i.e., fixed income strategy hedge funds), hedge funds can also produce a relatively high correlation with specific commodity prices. Stafylas et al. (2018), Swartz and Emami-Langroodi (2018), Racicot and Theoret (2019), Shrydeh et al. (2019), Mensi et al. (2020), Chirwa and Odhiambo (2020), Lambert and Platania (2020) analyzed hedge funds performance dependence on the movement of the Gold, Copper, Oil, and other commodities prices.

Bohl et al. (2020) raised the Spot prices vs. Future prices debate about which of those two qualifies better in determining the performance factors of CTAs. The main conclusion is that speculative activity in the commodity trading market made future prices more accurate and increased their relative contribution to the price discovery process. The finding stems from this discovery, and hedge funds pricing models shall use commodity prices as the determinants.

Mensi et al. (2020) used the Granger causality test to find time-lagged connections between precious metals (gold, platinum, and silver) and main energy commodities futures (crude oil, natural gas, gasoline, and gas oil). Zhang and Wu (2019) also sought whether hedge funds' net positions may Granger cause oil futures prices. Mensi et al. (2020) showed that gas oil, natural gas, and gasoline intensify co-movements between crude oil and precious metals, proposing practical solutions to the investors in the commodity-related funds. The reflection of the hedge fund net positions also caused the oil price bubble in 2008 but did not affect the oil price in 2014.

Deng et al. (2017) analyzed the other particular hedge fund asset class, real estate. Even though some real estate hedge funds performed well during the financial crisis of 2007-2008, their study revealed the opposite. Real estate risk is negatively associated with hedge funds' long-term investments and long-term external financing in equity and debt instruments.

There is no unified approach to identifying the determinants of the CTA hedge funds; therefore, following the APT theory and the author's observation on the APT above, the CTA models shall allow using any tradeable Commodity or commodity-related indices.

CAPM and APT models have common drawbacks when using them to determine the performance factors of the hedge fund (including equity, fixed income, and CTA strategies). These models rely on linear risk factors, which hedge fund managers can quickly eliminate by using derivatives or option-like strategies. However, based on Agarwal et al. (2018), Stutzer (2018), and Knif et al. (2020), CAPM and ICAPM models still well explains the hedge funds' *alpha*, regardless of hedge funds provide a more comprehensive range of risk exposures deriving from the instruments the fund invests. The main outtake of these models and the conclusion of previous researchers – they provide economically sound provision of using various asset-based factors, especially when seeing regional hedge fund unusual results compared with the Global rivals.

Non-linear or "exotic" risk-based models are the other hedge funds' performance measurement concept categories. Since hedge funds contain different financial instruments with linear and non-linear payoffs, they may employ hedging/derivative instruments and very dynamic trading. Therefore, based on Fung and Hsieh (1997a), neither the Fama-French three-factor model (or enhanced by Carhart's (1997) 4-factor model) nor conventional CAPM or APT models may be applicable to measure Nordic hedge funds' performance.

Fung and Hsieh (2001) provided the other view on hedge fund pricing, who identified five major risk components out of the most common ones in the hedge fund universe. They also created five return drivers within an asset class concerning those five components. They attributed these drivers to categories of value, system/trend following, system/opportunity, distressed style factors, and global/macro. Although these drivers represent almost all choices available for hedge fund returns, it is essential to note that they have a non-linear connection to the traditional asset market. Fung and Hsieh created a portfolio of lookback straddles, allowing them to simulate these components. Accordingly, they revealed how hedge fund returns correspond with the asset market by following risk factors and hedge funds. This view means that major standard features of hedge funds must be selected and interconnected with the apparent assets to establish a linear relation to the asset market.

The further developments of this model allowed Fung and Hsieh (2004b) to develop a model with as many as seven risk factors incorporated. Moreover, these factors form three main categories: equity, which consists of the equity market and size spread risk factors; a bond, which consists of the bond market and credit spread risk factors; and trend following that, which consists of bond trend-following, currency trend-following, and commodity trend-following risk factors as described by Fung & Hsieh

(1997a, 2001, 2002 and 2004a).

It is important to note that by that time, Fung and Hsieh could explain nearly 80 percent of all equity hedge funds by analyzing their monthly returns, thus becoming the most efficient tool for observing the hedge fund returns. It further improved the model and contributed the eighth factor to the model – the emerging market index (Edelman et al., 2012). The model is now called Fung and Hsieh's 8-factor model.

Agarwal and Naik (2004) mentioned that hedge funds exhibit non-normal payoffs when applying derivative strategies with an option-like structure. However, Glosten and Jagannathan (1994), for the first time, used the call and the put options market index in the models:

$$R_p = \alpha + \beta_1 \times R_m + \beta_2 \times max(R_m - k_1, 0) + \beta_3 \times max(R_m - k_2, 0) + \beta_4 \times max(k_1 - R_m, 0) + \beta_5 \times max(k_2 - R_m, 0) + \varepsilon \qquad 3.$$

Where:

R_p is the return on a portfolio,

α is the intercept of the regression,

$\beta_{1\text{-}5}$ stands for the sensitivity of the portfolio to factor; also called factor loadings,

R_m is excess return on the systemic market risk,

$max(R_m\text{-}k)$ and $max(k\text{-}R_m)$ are payoffs on call and put options,

ε – residual or error.

Adding an option-driven risk factor to the linear factor model, Agarwal and Naik (2004) increased its precision in assessing hedge funds' performance by 5-20 percent (measured by adjusted R^2) compared with models without options. They also suggested additional alterations to this model by compiling risk factors based on assets and those found on options, including at-the-money (ATM) and out-of-the-money (OTM) European call and put options. This way, by buying and selling the call/put options on the S&P 500 index at the beginning of each month, hedge fund returns can be observed monthly. Adding risk factors based on options allowed to shape of various hedge fund strategies (e.g., Event arbitrage, Restructuring, Event-driven, Relative value arbitrage).

Savage (2017), Groshens (2018), and Robertson (2018) widely used the "smart beta" and "strategic beta" (or Alternative beta) concepts introduced by Jaeger (2005). This concept extends the traditional view on pricing models using four categories of variables: pure beta, smart beta, alternative beta, and alpha, as presented in Figure 4 (Groshens, 2018). They linked the risk factors with their relative price, considering exotic risk factors are more difficult and expensive to achieve. Therefore, investors and fund managers must choose between the effort to achieve the return and the payoff. Investment factor-based Betas (i.e., Value, Carry, Quality, Growth, Momentum, and Size) supplement or oppose Fung and Hsieh's 8-factor model. Asness et al. (2013) analyzed the global value and global moment risk factors. They found them the most popular among researchers since they deal with the two most massive irregularities in the investment industry. Lustig et al. (2011) analyzed currency exchange rates and excessive return in portfolios, which borrow at a lower forward interest rate (or using the currency or in the market with a low-interest rate) and invest into high-interest rate assets (in the currencies producing high-interest rates). They discovered that such portfolios are exposed to currency risk, especially in turbulent conditions.

Moskowitz et al. (2012) analyzed the condition where assets generate steady returns over a short period. They applied a time-series momentum strategy to diversified commodity, currency, equity index, and bond futures portfolio and achieved a 2.5 times higher Sharpe ratio than the stock market portfolio.

Baltas and Kosowski (2013) complemented Moskowitz's work by expanding a database for their time-series momentum factor. They grew their database to thirteen more future contracts and stretched the observations from 1974 to 2012. They also obtained a similar result to Moskowitz by applying time momentum yielded a 1.2 higher Sharpe ratio above the equity portfolio. The most significant benefit of this model is that it demonstrates how the momentum factors of time series correlate with the returns of commodity (CTA) strategy hedge funds.

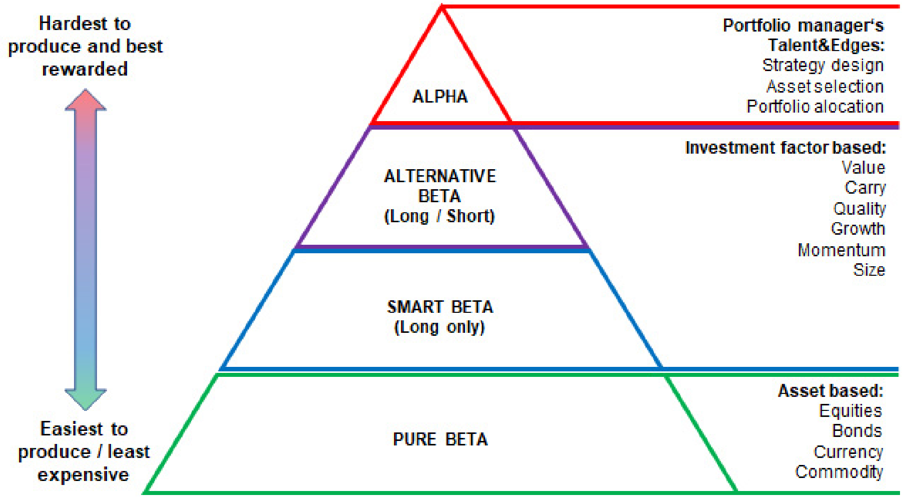

Figure 4. Pyramid of hedge fund variables

Source: Groshens (2018).

The incentive fees reflect the perception of the difficulty for the hedge fund manager in achieving the *alpha* factor. The dissertation reveals this as having a practical use in presenting the actual contribution of the fund manager. According to Siegel (2005), by taking the Smart beta approach, investors optimize the different market factors and achieve higher returns while experiencing the same level of risk. He concludes that what was initially considered pure alpha can now be considered premia of liquidity or opacity of other risk factors.

Fama and French (1993, 1996) proposed the three-factor model. According to them, the researchers shall analyze three factors: the firm's size, book-to-market equity ratios, and other price ratios. Fama and French proved their model using the cross-section regression approach (1992) and the time-series regression approach (1996). Carhart (1997) and Bali et al. (2011, 2012) revived Fama and French model, transforming it into a model concerned with four factors. The main elements of this model consist of market risk factors (e.g., stock index), size factor, value factor, and momentum factor. Chevalier and Darolles (2019) empirically investigated the impact of time-series momentum returns on the performance of hedge funds in the cross-section. The constructed volatility-adjusted daily time-series were covering stocks, bonds, and commodities. They discovered that trend exposure could partially explain CTA, Global

Macro, and Fund of hedge funds strategies by a trend exposure. The other substantial part of the research is on the additional risk-related factors, most of which are related to liquidity or volatility risks.

Liquidity as a factor is not new in the hedge fund pricing practice. Pástor and Stambaugh (2003) constructed the liquidity index, which many other researchers continuously reported and used. As presented in the previous part, liquidity problems were a crucial factor in Lehman Brothers' collapse during the financial crisis of 2007-2008. They proposed adding a liquidity risk factor into the asset pricing model since it reduces the abnormal return of the stock by 1.5 percent. Cao et al. (2018) and Liang and Qiu (2019) analyzed the negative impact of the liquidity risk factor. Following the liquidity crisis evolution, the higher the leverage, the more sell-off discounts the hedge funds will encounter. Therefore, the liquidity risk of leveraged funds multiplies during the sell-off periods. On the contrary, Sadka (2010) discovered that hedge funds with a high liquidity risk exposure are more likely to outperform those with less liquidity risk by 6 percent annually.

Chen et al. (2018), Jame (2018), and Li et al. (2020) also analyzed the performance of hedge funds, which deal with low liquidity assets (e.g., distressed debt). They identified that high alpha reporting funds underestimate and underreport high liquidity risk. However, higher liquidity risk taken by the hedge fund provides liquidity cushions to the market. Although this has connections with high liquidity discounts during the crisis, they estimated that funds with more significant liquidity provision factors earn significantly higher alpha and Sharpe ratios.

Canepa et al. (2020) looked for the factors that bring top performance and those with mediocre performance. The top-performing funds do not passively rely on the illiquid exposures but earn their returns by accepting the higher market risk. However, the positive association with liquidity implies that there is still a certain amount of the liquidity risk premium earned by these funds. On the other hand, these funds tend to accept a higher market risk and seek strategies to gain momentum.

Volatility risk is associated with more frequent trade, especially by those who rely on algorithmic trading and those implying strict control loss and stop loss measures. Asensio (2019) looked for the connections between the slope of the VIX futures term structure and the spread trades characteristic of the hedge funds. The general conclusion was that profits from beta-neutral hedge funds focusing on the spread trades' variations do not compensate for taking on equity downside risk but correspond to the long positions into VIX futures.

Oliva and Reno (2018), Thomson and van Vuuren (2018), Racicot and Theoret (2019), and Lee et al. (2020) also considered the VIX factor to significantly impacts the hedge funds, especially when comparing different economic conditions (e.g., crisis or quiet times) and comparing the top-performing and worst-performing funds.

Besides the endogenous risk factors, which represent themselves as asset-based factors (stock price, commodity price, interest rate, credit spread) or macro-economic environment, which impacts the asset pricing (e.g., Inflation, FX rate), there are exogenous factors:

Investment size: Fama and French (2004) argued that there is strong evidence that the investment size variable may explain the variation in expected return, which traditional beta cannot explain:

Research, such as Amman and Moerth (2005), Jones (2007), Teo (2009), Joenväärä et al. (2019), Becam et al. (2019), O'Neill and Warren (2019), Cumming et al. (2020) and others, indicated that freshly established. Smaller funds show better results than large and experienced funds since they are more flexible in choosing between small and limited good ideas with great potential. Smaller funds with smaller exposures also have less liquidity risk.

Large-size funds have their benefits, which best work with a highly diversified fund of funds strategy. As outlined by Getmansky et al. (2004) and Xiong et al. (2009), large-size funds have size-related advantages because the larger-scale fund managers can afford to spend more on analysis and due diligence of each asset or component of the fund. The benefit of being well-informed works with large-size hedge funds.

Stafylas and Andrikopoulos (2020), besides the size outlined by other researchers, found that hedge funds deliver excessive returns during stable times, irrespective of their fundamentals. During bad times, fund managers try to minimize systemic risk. Small and young funds, especially those with redemption limitations, deliver higher alpha than their peers during good times. Therefore, distinguishing between good and bad periods is also essential when determining the size and other factors.

Investors' experience: Carhart (1997), Pirotte and Tuchschmid (2014), Berglund et al. (2018), Rzakhanov and Jetley (2019), and Berglund et al. (2020) state that the experience of investment executives, especially crisis experience, affects the appreciation of the risk and lead to more sound decisions: winners continue to be winners, and losers continue to be losers.

Strategy adjustment frequency: Shin et al. (2019) analyzed whether frequent adjustment of the hedge fund exposures can strategically time the tail risk. The main conclusion presents that top-ranked funds outperform bottom-ranked funds by 5-7% annually after adjusting for risk factors. Frequent adjustment of the strategy is also known as a characteristic of hedge funds. Tail risk is also widely analyzed by Cui et al. (2019), who focused on the fund of hedge funds. Their study suggests tail risk improves the pricing model and more explanatory power it has on more diversified portfolios.

This dissertation also foresees the strong possibility that the return of region-specific hedge funds vastly depends on the different assets and their differences that are not possible to track using the publicly available global hedge fund return data. Therefore, this research aims to expand pure beta factors from prevalent asset classes to unique and previously not tested risk factors (e.g., commodities, volatility, and liquidity).

The concluding remarks. Based on French (2017), there the following guidelines the pricing theories need to be taken into account when selecting the factors:

1. Variables' impact on portfolio price changes is unexpected.

2. Variables have to impact the returns directly, but they must be macroeconomic rather than specific and applicable to the asset.

3. Variables have to meet Doran's (1981) SMART (specific, measurable, achievable, relevant, and timely) definition, and

4. There has to be some economic justification behind the variable.

Table 1 below presents the author's proposition of the pricing model factors of the hedge funds based on Fung-Hsieh's 8-factor model enhanced with other factors combined from the analysis presented in this section. Fung-Hsieh's 8-factor model has risk factors adjustable to the local market (e.g., stock market indices, 10-year governmental bond yield, risk-free rate of return), further discussed in chapter 2.5. Data selection, preparation, and validation. Different researchers (e.g., Agarwal and Naik, 2004, Capocci et al., 2005, Dewaele et al., 2015, Moskowitz, 2020) use more factors in determining the performance factors of hedge funds. However, the dissertation does not rely on them due to the primary focus on building the models for regional hedge funds.

Table 1. Hedge fund pricing model factors' summary

Risk factor	Factor description
Stock index*	Monthly return of the S&P 500 stock market index (or another main stock index) minus Risk-free rate
D_10YRF*	Monthly return of the FRB 10Y constant maturity bond (or another local Governmental 10-year bond) minus Risk-free rate
Size spread*	Monthly return of the Russell 2000 stock market index (or another Small-Cap index) return minus Monthly return of the S&P 500 stock market index (another main stock index) return
D_Baa10Y*	Monthly return of Moody's Baa bond minus Monthly return of FRB 10Y constant maturity bond
MSEMKFRF*	Monthly return of MSCI Emerging Market index minus Risk-free rate
PTFSBDRF*	Monthly return of the PTFS Bond lookback straddle factor minus Risk-free rate
PTFSFXRF*	Monthly return of the PTFS Currency lookback straddle factor minus Risk-free rate
PTFSCOMRF*	Monthly return of the PTFS Commodity lookback straddle factor minus Risk-free rate
SMB**	A small minus big factor
HML**	A high minus low factor
MOM**	Global Momentum factor
FX	Currency risk factor (Risk factors of Adrien Verdelhan, 2012)
GOLD***	Monthly gold spot price change minus Risk-free rate
COPPER***	Monthly Copper future price change minus Risk-free rate
SILVER***	Monthly Silver Futures price change minus Risk-free rate
BROIL***	Monthly Brent oil spot price change minus Risk-free rate
NGAS***	Monthly Natural Gal future price change minus Risk-free rate
COCOA***	Monthly Cocoa future price change minus Risk-free rate
LIQ****	Liquidity risk factor
OCM-DRWT***	Monthly Risk Weighted Enhanced Commodity TR index[7] change minus Risk-free rate

7 Risk Weighted Enhanced Commodity Ex Grain 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

VIX	30-day expected volatility of the US stock market, derived from real-time, mid-quote prices of S&P 500® Index (SPX^{SM}) call and put options[8].

* Fung and Hsieh factors of Edelman et al. (2012), David A. Hsieh's Data Library available at: https://faculty.fuqua.duke.edu/~dah7/HFRFData.htm, US market data at: https://fred.stlouisfed.org

** Fama and French factors of Carhart (1997)

*** Other factors are collected form https://www.investing.com/

****Liquidity risk factor available at: https://faculty.chicagobooth.edu/-/media/faculty/lubos-pastor/data/liq_data_1962_2019.txt

Despite many trustworthy factors presenting the hedge fund performance, they were discovered analyzing the global hedge fund industry and have not distinguished various investment environment conditions. The dissertation presents that the investment environment needs to be considered when analyzing how the conventional and newly proposed risk factors contribute to the hedge funds' performance.

1.3. The impact of the investment environment factors on the hedge fund performance measures and pricing models

The investment environment itself impacts the performance of the hedge funds and the decisions of the hedge fund managers besides the traditional and asset-based or strategy-based risk factors. Therefore, there is a need to describe the entire investment environment, which may impact asset pricing models by changing the risk composition for the portfolios – beta factors, or by changing the hedge funds manager's decisions – alpha factors. The investment environment constitutes the condition of the financial system, the regulatory environment, legal and international environment. The dissertation examines two main categories of investment environment factors: stability of the economy (or crisis vs. quiet time) and regulation environment (regulatory constrained time vs. liberalized period), which significantly impact the hedge fund investment. However, the dissertation aims to determine the impact of the investment environment factors on the pricing models. However, it is necessary to define what conditions shall represent the investment environment and how they must be determined.

Frankel and Rose, 1996; Kaminsky et al., 1998; Kaminsky and Reinhart, 1999; others considered **the crisis** as a traditional condition of an emerging market before

8 It is recognized globally as the primary measure of volatility – used by the researchers and in the media (http://www.cboe.com/vix)

the financial crisis of 2007-2008. However, right after the financial crisis of 2007-2008, researchers started to look at the crisis in more stable countries (Rose and Spiegel, 2011; Frankel and Saravelos, 2012). Keoun (2011), Laeven and Fabián (2012), Levy-Yeyati and Panizza (2011), and Reinhart and Rogoff (2014) encompassed debt crises together with currency crises and banking crises.

More recent research in the crisis and hedge fund investment areas takes different angles. Cao et al. (2018), Zhao et al. (2018), Liang and Qiu (2019), Gregoriou et al. (2020), and others differentiate between the strategies that struggle the most during the crisis and those with positive results, usually adjusting their strategies or reducing the leverage just before the crisis period occurs. At the same time, Metzger and Shenai (2019), Sung et al. (2020), and Denk et al. (2020) look rather specifically at hedge funds that showed better performance during the crisis than benchmarks or mutual funds. Brandt et al. (2019) were looking for whether hedge funds adjust their portfolio composition in response to crisis conditions or other severe macroeconomic turbulences and, if so, how it impacts the hedge fund performance. They did not see the homogeneity of the hedge fund managers' response; however, those which procyclical time the market surpasses the peers' performance by over 4% annualized. Heuson et al. (2020) analyzed hedge funds with skewed returns, usually associated with hedge fund managers' ability to avoid big drawdowns. Their proposed measure shows the significant risk-adjusted outperforming by 5.5% annually for those funds during economic crises. However, there is an even bigger extreme – Nordic hedge funds outperformed global hedge funds by as much as 8% during the severe drawdown in 2009 connected to the financial crisis of 2007-2008. However, regardless of the different angles, most researchers' main conclusion is that hedge funds react to crisis conditions and do it differently depending on many conditions.

By adding the crisis condition as the hedge funds' pricing model variable, the dissertation aims to understand what determines the different reactions of the hedge funds to the crisis: following the negative trends of the market reflected by the *beta* factor or changes in the individual contribution by the hedge fund manager reflected in the *alpha* factor. Brandt et al. (2019) estimated that high-performing hedge funds generated a risk-adjusted alpha of 5.5% during the crisis. Other researchers were looking for other factors impacting the hedge funds' performance during the crisis.

However, there is no unambiguous way to incorporate the crisis in the hedge funds' asset pricing models. Hespeler and Witt (2014) analyzed the macroeconomic indicators' impact on the hedge funds' return during the financial turmoil. They built a comprehensive model[9], which examined the relationship between the hedge funds market and their managers with the financial system's vulnerability and found the association was insignificant. Hespeler and Loiacono (2015) improved the model and established the dependency of the hedge funds' return indicators on sector return distribution. Interest rates and lending rates are those affected by the crisis. Babecký J. et al. (2014) analyzed tightened lending by constructing and exploring a dataset covering crisis episodes in 40 developed countries; however, they did not focus on the hedge fund market. Maloney and Moskowitz (2020) analyzed the impact of the interest rate environment on stock performance. They concluded that the performance of stocks is not easily assessed based on the interest rate environment. Therefore, the crisis time becomes a significant determinant, especially considering the hedge fund manager's contribution to the financial results as hedge fund beta indicators also reflect the crisis impact through the interest rate or the financial instruments' pricing. Berglund et al. (2018), as well as Dutta and Thorson (2019), analyzed the announcements' (e.g., US monetary policy announcements of interest rates). They found that announcements impact the hedge fund performance more than the actual interest rate change. Berglund et al. (2018) also concluded that the US monetary policy announcements harmed the alpha but found no evidence of whether this would impact systemic risk beta factors.

Pástor and Stambaugh (2003), Billio et al. (2010), Sadka (2010), Zheng and Osmer (2018), and Pástor et al. (2020) enlightened in their research that some investors tend to panic, starting the margin spirals, churn, and redemptions. The impact on the hedge fund derives from the decisions to align the strategy, not only from the direct impact on the assets held in the portfolio value. Fong et al. (2018) analyzed the magnitude of the Hong Kong investment fund redemptions during the crisis. They concluded that the fund trading activity reflects the return-chasing behaviors of fund managers and investors, which increases during turbulent conditions and decreases the AUM of the equity funds.

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9 The model analyses the five indicators created by Hespeler and Witt (2014): 1) Hedge funds resulting residual (HFILLIQ) – a residual reflecting the hedge fund return on illiquid assets; 2) Prime Brokerage Excess Return (PBER) indicates the proportion of income generated by prime brokerage from non-banking activities; 3) Short-term (single night) Financing Rate (FINANCING) – an indicator showing the net short-term position of the hedge funds; 4) Long-term Lending Indicator (longer than a single night) (LENDING) – an indicator showing the net long-term lending position of the hedge funds; 5) Net Position of Held Securities (NETPOS) – excessive position of securities held for trading obligations.

The other factors explaining why different hedge funds perform differently during the crisis are: information exchange during the shocks in the market analyzed by Chen et al. (2020) and access to capital, risk-taking, and performance of the hedge funds affiliated with financial conglomerates, which showed as better preserve the hedge fund AUM (Franzoni and Giannetti, 2019).

As hedge funds are a rather significant financial market instrument, especially in the regions with high concentration, there is an opposite connection between the hedge fund investment and the system's financial stability. Garbaravičius and Dierick (2005) analyzed the hedge fund investment impact on the financial system stability before the financial crisis of 2007-2008. They calculated the correlation between the bond and stock indices and the monthly return on main categories of hedge funds for the decade before the crisis (i.e., 1994-2004). They found that neutral funds have a low or insignificant correlation with main stock (DJ EURO STOXX $, S&P 500, MSCI World Equity $) and bond (GBI Global $, GBI US $, GBI EMU $, GBI Europe $) indices. With higher standard deviations, the directional funds were more attractive to the investors and used higher leverage, which was a significant factor in the LTCM collapse. Roncalli and Weisang (2015) analyzed recommendations for distinguishing systemically important banks, insurance companies, and other financial institutions and their impact on systemic risk, developed by the Financial Stability Board or the International Organization of Securities Commission. Based on the empirical research, they identified the significant impact of the hedge fund industry on systemic risk during the 2007-2008 financial crisis. After investigating the dependency, they offered a reliable and risk-sensitive approach to identifying systemically important institutions determining that hedge funds are one of them.

It is also essential to agree on the crisis periods, distinguish the crisis, and adjust the hedge funds' pricing model later. Swartz and Emami-Langroodi (2018) widely used drawdowns as a variable in hedge fund pricing and proved that all Downside variables are significant in Statistical / Behavioral and a combination of Statistical / Behavioral and economic independent variables models. Since the drawdown reflects a loss situation, the drawdown length until the depreciation period is over shows tough times for the fund manager. Therefore, a drawdown could impose fund managers taking extra measures and employing survival strategies that may improve the hedge fund's performance regardless of market beta. When hedge fund index returns decrease, market drawdown allows some fund managers to outperform the hedge fund industry.

However, drawdown indicators of the hedge fund index may also replicate index returns or stock index returns, and therefore these factors will face the autocorrelation problem. There is also an assumption that drawdowns represent the periods that caused some hedge funds with heavy losses to stop reporting due to financial troubles or liquidation. Therefore, drawdowns might not linearly depend on the hedge fund returns.

Hespeler and Loiacono (2015), in their model, used the following crisis periods: the Asian crisis, the Russian default crisis (also LTCM), the "dotcom" crisis of 2000, the crisis following September 9/11, the financial crisis of 2007-2008, the EU debt crisis starting in 2009 and its continuation in 2012.

Other and the latest crisis periods related to the Brexit vote, Brexit execution, negative interest rates, and Covid-19 first wave (this research does not cover any Covid-19-related developments after June 30, 2020) have not been vastly analyzed in hedge fund performance and especially asset pricing aspects. Pástor and Vorsatz (2020) examined the performance of mutual funds and how the Covid-19 crisis impacted AUM. This research does not look specifically into the regions but instead looks globally. They also discovered that funds with more passive strategies during the crisis withstand drawdowns and AUM outflows better than those traditionally more active in their strategy. The latest research and the author's view on Covid-19 in the Nordics present Covid-19 as an unusual crisis period; therefore, only the initial drawdown phase is a reliable period to analyze in this dissertation as a crisis.

The other essential investment environment factor is **hedge fund regulation**. Although hedge funds are known as barely regulated, the leading hedge fund regulation attempts are related to the financial crisis of 2007-2008. Two principal regulatory regimes are affecting the essential part of the industry:

- The US Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank), enforced in July 2010, and
- EU 2011/61/EU AIFM Directive was adopted in 2011.

Dodd-Frank promotes the financial stability and soundness of the entire financial service industry, including the hedge funds. Dodd-Frank primarily affects hedge fund managers or hedge fund advisors by requiring:

- Hedge fund managers and advisors register with SEC once the hedge fund AUM reaches or exceeds 100 million USD.
- Hedge fund managers need to fill the systemic risk information of such funds

with Commodity Futures Trading Commission (CFTC). This way, all derivative and leverage contracts between banks, insurance companies, and hedge funds will be oversight by the Federal or State level regulators.

In 2006, the European Commission established a group of experts to conclude the future EU regulatory approach to hedge funds, private equity funds, and other alternative investment instruments. In 2009 the European Commission introduced a directive on the management of alternative investment funds (AIFM). By 2010 European Commission held public conferences and meetings to develop a regulatory regime for alternative investment instruments. The same year, European Parliament and Council made a relevant political decision on the Directive's text, and in 2011 they adopted the 2011/61/EU AIFM Directive.

This Directive provides the legal status of the hedge funds and other alternative funds. It aims to increase the transparency of the AIFM's instruments and ensure their contribution to market efficiency. In 2013, the European Commission adopted Amendments 2011/61/EU defining different types of AIFM. The Directive distinguishes open and closed alternative investment entities, ensuring the best conditions for investors. Figure 5 presents the AIFM directive implementation timeline.

Figure 5. Legal acts of the EU establishing regulation mechanisms for the hedge funds
Source: created by the author based on EU directives implementation timeline.

To limit this risk, the European Commission aims to ensure that there are standard rules for monitoring potential risks to investors, counterparties, other market participants, and overall financial stability. Alternative investment fund managers must comply with UCITS requirements to access EU markets (Directive 2009/65/EC of the European Parliament and of the Council of July 13, 2009, on the coordination of laws, regulations, and administrative provisions relating to undertakings for collective investment in transferable securities (UCITS)) (OL 2009 L 302, p. 32) (reviewed edition) (Directive 2010/78/EU of the European Parliament and the Council with relevant amendments as of November 24, 2010 (OL 2010 L 331, p. 120)).

The researchers identified the following impact of the regulation on hedge fund investment:

- Imposing the bans on short-selling strategies in 2008 for banks strongly affected the hedge fund industry. Barr (2008) states that the HFRI lost 5% in September 2008, and convertible bonds arbitrage lost 9%.
- Imposing the additional reporting requirements. Brown et al. (2012) analyzed the Dodd-Frank requirement to provide further information to SEC. It did not lead to hedge fund managers providing critical information to the investors or regulators. This requirement increased the entry cost. However, for the hedge funds, which report their returns for a longer time, this did not significantly impact.
- Imposing the leverage limits. Although Chan et al. (2007) did not see any clear evidence of leverage impacting the hedge funds, it was evident that hedge fund managers reacted to the leverage limitation; therefore, this might affect the hedge fund performance and pricing.
- Increasing the cost of leverage. Increasing the cost of borrowing might lead to shrinking the leveraged investment. As Cerutti et al. (2010) concluded, the increase in leverage cost impacted the decrease of the number of funds or the hedge fund asset under management (AUM).
- Decreasing fund performance. Joenväärä and Kosowski (2020) analyzed Absolute Return UCITS-compliant (ARU) and other hedge funds, trying to find the performance differences between those two groups. With higher liquidity and other risks, ARU provided investors with less risk-adjusted returns than hedge funds. In general, this means that the regulation reduces the performance ability of the funds, and new or straitened regulation shall decrease the fund's performance. However, Joenväärä and Kosowski (2020) analyzed liquidity and leveraged differences between ARUs and hedge funds. Other market indicators may show the change in the regulatory environment. These indicators could be yet another challenge to Hedge Fund managers.
- Decreasing the risk appetite. Sullivan (2019) analyzed the decline in hedge fund alpha after the Global Financial Crisis of 2007-2008 and concluded that the decrease in alpha was related to reducing the investors' risk due to a better understanding of the hedge fund-specific risk factors. This experience resulted in the

reduction of the level of risk in their portfolios.

The overall objectives of the regulation are to protect some or all parties related to hedge fund investment. However, as already discussed in the case of liquidity, the higher the liquidity risk the hedge fund takes, the more liquidity the hedge fund provides to the market (or the more illiquid assets fund the fund takes off the market and the more efficient market is). Therefore, regulators need to find the balance between reducing the hedge fund risk and allowing the hedge funds to provide the necessary liquidity to the market. Fairchild (2018) concluded that regulators try to foresee the hedge fund managers' steps and impose the regulatory measures that motivate the fund manager to choose the right proportions of the considerations. As hedge fund investment is procyclical, regulators must follow that cyclicality. Besides the above-stated regulation impacts, Fairchild (2018) also concluded that regulation of the fees that fund managers charge the investors is under regulators' radar. Such regulators' considerations confirm one of the objectives of the dissertation that the alpha net of any undisclosed beta factors is essential for the regulators.

Flood (2013) reviewed the results and rates of UCITS regulated and UCITS non-regulated (most frequently registered in tax relief areas) hedge funds and stated that UCITS regulated funds apply lower management (1.37 and 1.58 percent.) and success (13.3 and 18.8 percent) fees. These price differences reflect a higher risk of UCITS non-regulated funds and, consequently, higher returns. Stulz (2007) compared hedge funds with mutual investment funds and concluded that gaps between hedge funds and mutual funds are getting narrower. Further regulatory changes ultimately limit the flexibility of hedge funds and make hedge funds more institutionalized.

Sun and Teo (2019) also analyzed the connection between the hedge fund performance and the legal form of the asset management company. Listed asset management companies underperform funds managed by unlisted ones. There is a connection between underperformance and poor governance, no manager co-investment. The additional regulatory burden of public asset management companies is consistent with underperforming results.

The dissertation analyzes the following connection to assess the possible impact of the regulation investment environment on hedge fund performance. As financial market players, hedge fund managers usually work closely with prime brokers and related banks. Among other market indicators, they look into the financial soundness indicators (or FSIs) endorsed by the IMF Executive Board in June 2001. There are 40 FSIs published by IMF (2006) overall measuring deposit-taking institutions (i.e., Banks), Financial and non-financial corporations, households' core, and additional parameters, such as overall market liquidity and real estate markets. There were several updates intended (e.g., of IMF, 2013); however, the analysis is made based on FSI data published by IMF, as well as on local reports supplementing FSI data, regulation consultations, and predictions made an impact on the FSI indicators even before the official enforcement. E.g., CRD IV. AIFMD. Solvency II came into force on January 1, 2015; however, based on the author's observations, indicators, such as those related to capital adequacy, liquidity, credit exposure, FX position, and derivative exposure, have started their corrections before the official enforcement. Such an initial reaction can be explained either by local authorities that work closely with market participants and promote those regulations before the official date of enforcement or by market participants themselves, who try and start changing their policies before the official enforcement and make sure they are not caught unprepared on the day the regulation comes into force. Encouraged by the rumors published by many different analysts and actions taken by the ECB and other non-Eurozone European central banks, the market started its transformation with the most noticeable flat interest rates on the interbank market.

The World Bank Group introduced and regularly published commonly used World Bank Governance Indicators[10] (WGI) can also represent the regulatory environment.

The concluding remarks. Following the analysis above, both crisis and regulation impact the performance of hedge funds. However, few research papers disseminated embedding the crisis or regulation factors into the hedge funds' asset pricing model. The dissertation does not rely on the factors commonly used to present the crisis and regulation impact (e.g., interest rate, financial asset prices), which will cause autocorrelation with the stock or other indices. Therefore, crisis and regulation periods but not the measures of impact will further represent the investment environment in this dissertation.

Various global and national crisis and regulation periods may impact and reliably contribute to hedge fund performance measurement (asset pricing) models. As for the crisis periods, the dissertation will examine the following determinants: banking crisis, debt crisis, currency crisis, Global crisis, and Global hedge fund drawdowns. As for the regulation periods – AIFMD implementation, FSI (of IMF), and WGI (of World

10 World Bank Governance Indicators available at: http://www.govindicators.org.

bank) shall be considered. The models shall also distinguish between the global and national crisis and regulatory constraint factors and their interpretation in more detail presented in chapter 2.4. Data selection.

1.4. Development of the hedge fund performance measurement models in regions

As outlined in the previous chapters, most researchers conduct their hedge funds' performance measurement research on global hedge fund databases. However, analyzing the differences between different regions and what determines this region's entire hedge fund market was not the subject of any research. There is neither research on the alpha indicators available on the regional hedge funds, making a question what drives the return differences between the regions: the local market conditions or the different hedge fund manager contribution to the return impacted by the investment environment (e.g., crisis or regulation) as well as the national investment peculiarities.

Stambaugh (1982) proposed the initial idea of analyzing the investment portfolios using or combining the various non-US-based indices. However, this idea has not evolved into the hedge funds industry but focused more on defining the liquidity risk outlining factors of Pástor and Stambaugh (2003). The researchers mainly analyzed regional hedge funds in terms of their performance and expansion or compared their performance to mutual funds. Do et al. (2005) compared Fama and French three-factor model with additional factors discovered by Capocci et al. (2004). This research also showed that the Australian hedge fund returns are relatively independent of local indexes obtained from the Australian ASX indexes[11]. Although the Australian hedge fund market in size and maturity is not comparable to the US or global hedge fund market, the research of Do et al. (2005) and Dou et al. (2020) showed statistically significant hedge fund return dependence on incentive fees and management fees. The other considerable conclusion, though with the need for further justification, is that smaller market hedge funds' return data is subject to data biases, especially survivorship bias.

Asia is the other region sought by researchers. Overall, Asia was analyzed by Van Dyk et al. (2014), Japan – by Kanuri (2020), Saudi Arabia and Malaysia – by Oueslati and Hammami (2018), and Islamic countries – by Karim et al. (2020). The most attractive region of Asia is China. In China, research papers go beyond the simple ab-

11 Indices published at: https://www.asx.com.au/products/index-charts.htm

solute return analysis:

- Huang and Sun (2018) analyze Chinese stock and how the Neutral equity strategy funds perform.
- Huang et al. (2018) analyze how short-selling regulation impacts China's Hedge Fund industry.
- Using the nonparametric method, Zhai and Wang (2020) proved that only top-performing Hedge Funds produce long-term positive *alpha*, while mutual funds do not.
- Chen et al. (2019) have also analyzed Chinese stock's practicality and effectiveness by applying the CAPM model. Calculations showed that CAPM is not applicable in China's primary stock index market. The research proved the limitations of the immature and smaller markets.

On the European landscape, besides the representatives of the Global market, such as the UK, and some Offshore or specialized territories like Cyprus analyzed by Gibilaro et al. (2018), Nordics is another quite distinctive region that local papers praise for its outstanding performance. According to Gibilaro et al. (2018), the regional hedge funds shall show different risk exposures and performance to the global hedge funds. Taking the definition of the Nordic hedge funds database[12], it shall be apparent that hedge fund managers also prefer investing in the nearby geographical region because of the information availability and market efficiency. So, there is an assumption that hedge funds' performance measurement models shall incorporate the local risk factors.

The main interest in choosing the Nordics to analyze the decomposition of the hedge fund return and test the raised hypothesis derives from the adaptability of the dissertation to the development of the hedge fund industry in the Baltic countries, as well as the author's observation that Nordic hedge fund indices generally outperform the US and global hedge fund index rivals. The monthly mean returns of the NHX Composite and HFRI index for 2005 – 2020 is 0.36% or 4.32% annually when using the uncompounded calculation method. However, the difference in the return's Standard deviation (0.0118 and 0.0183, respectively) makes the Sharpe ratio of the NHX Composite index much more favorable compared to the one of HFRI (30.51% and 19.67%, respectively).

This rough performance comparison raises questions about whether it derives

12 The hedge fund considered Nordic if the targeted market is Nordic countries or the Fund is managed by the Nordic hedge fund manager, se presented at https://hedgenordic.com/.

from the different risk awareness of Nordic investors or the better contribution of the hedge fund managers of the Nordics. Brown et al. (2018) object that the high results are unrelated to how fund managers present themselves or seek sensational results. However, investors usually do not avoid such sensation seekers due to the lack of knowledge and criteria for assessing their performance. Cai et al. (2018) distinguished between luck and long-term success, which allows identifying those real leaders from the temporary stars.

The literature analysis does not reveal any substantial research on the Nordic hedge funds, as also claimed by Ekberg and Iversen (2018). Preuss (2019) analyzed mutual Nordic equity fund managers with US equity fund managers, the differences in communicating the investment results, and how this communication differs from outperforming funds. He observed higher risk awareness of the Nordic equity fund managers resulting in lower volatility ratios than the US rivals. Risk awareness was also a focus in the research of Tejeda-Lorente et al. (2019), who applied fuzzy linguistic modeling and provided personalized recommendations for matching hedge funds. Therefore, there is a definite need to do more in-depth studies on Nordic investment, particularly hedge fund industry benchmarking studies with the US, global, or even peer markets.

Based on 98 Nordic Hedge Index (NHX) members, the Nordic hedge fund industry reported an AUM of 27.86 billion EUR (USD 31.52 billion) during October 2018, making only 1% of the global hedge fund AUM categorizing the Nordic hedge fund market as a Small. Another feature of the Nordic hedge funds relates to their longer life span compared to international hedge funds. McCrum (2014) concluded the series of reports claiming, "Most hedge funds fail: their average life span is about five years." However, out of 72 Nordic hedge funds analyzed, 57 survived for more than ten years making Nordic the region of long-livers, i.e., having evidence of withstanding more than two crises.

The impressive Nordic hedge fund performance figures already generalize how regional hedge funds' performance measurement models may differ from the global ones. On the one hand, Nordic hedge funds deliver better results and higher Sharpe ratios than global benchmarks. On the other hand, the Nordic countries are also not isolated or underdeveloped. Positive and consistent results shall be related to the stability of the Nordic economies and a high focus on regulation (presented in the regulation factor analysis). Nordic countries are also known for specific temperaments and attitudes. Based on Helliwell et al. (2021), Finland ranked 1st, Denmark 2nd, Norway 6th, and Sweden 7th happiest country in the world in 2021 and has stayed in those positions for over three years now, regardless of the impact of the pandemic of Covid-19.

The concluding remarks: The analysis of the theoretical aspects of hedge funds' performance measurement modeling provided a broad spectrum of various models with over 20 years of continuous research on this subject. However, this long analysis period does not address the peculiarities and whether the regional hedge funds require any different approach. Below are the primary outcomes of the study of the hedge funds' performance measurement theories and their application to the small regions:

1. Although an extraordinary investment undertaking, hedge funds still use the same portfolio measurement tools to measure their performance: i.e., Sharpe ratio, Jensen's alpha, and beta (betas), which correspond to systemic market risk. Hence, hedge funds seek the absolute return; therefore, Jensen's Alpha becomes a top priority performance measurement indicator. Various research papers (e.g., Pirotte and Tuchschmid, 2014) underline the increased tension in delivering the alpha both due to the tendency to decrease the risk profile of the investment and due to more challenging market conditions (especially after the financial crisis of 2007-2008), Sullivan (2019).

2. The fair estimation of the *alpha* net of undisclosed risk factors is considered a high priority in the hedge fund industry since alpha represents the hedge fund manager's skills and triggers the decision-making for the investors. Based on the majority of the research and the conclusive view of Agarwal et al. (2018), who, together with such significant contributors to the subject as Fung, Hsieh, Edelman, Naik, Kosowski, Moskowitz, describe the main principles of the hedge funds' performance measurement models, they have to rely on twofold risk factors' groups: traditional risks (such as stock or bond indices) and "exotic" risks (such as momentum or option-like investments) also often classified as alternative beta strategies. Fung and Hsieh's 8-factor model (Edelman et al., 2012) is the basis for this research as it is proven to be the most common and prudent in the industry, explaining up to 80% of US-based equity or bond hedge funds. However, contemporary research still uses CAPM and APT theories. Chen et al. (2018), Gibilaro et al. (2018), Jame (2018), Stafylas et al. (2018), Asensio (2019), Racicot and Theoret (2019), Shaikh (2019), Li et al. (2020), Mensi et al. (2020) propose analyzing the broader list of traditional risks instead of "exotic" ones:

a) Local stock and bond market indices.

b) Commodities futures and financial futures.

c) Fama and French factors.

d) Liquidity factor of Pástor and Stambaugh (2003).

e) VIX volatility factor.

3. Even though alpha is becoming a top priority risk factor determining the performance of the hedge funds, all the risks listed in the previous point have also an impact on the performance, especially when looking into the different regions and comparing the funds' performance over the period, which may represent the shifted business cycle or different investment environment conditions. On the one hand, the long-term time series even out the fluctuations caused by the various investment environment conditions. On the other hand, it promotes incorporating the investment environment conditions into the performance measurement model so that this factor would make different region hedge funds' performance measurement models comparable.

4. The analysis of the impact of the investment environment on the hedge fund performance and the strategy adjustments of the hedge fund managers is widespread in the research papers. E.g., Brandt et al. (2019) estimated that those hedge fund managers who follow procyclical strategy adjustments outperform their peers by 4% long-term annualized. The primary and often analyzed investment environment conditions are:

a) Crisis – extensively analyzed by Cao et al. (2018), Zhao et al. (2018), Liang and Qiu (2019), Metzger and Shenai (2019), Denk et al. (2020), Gregoriou et al. (2020), Sung et al. (2020).

b) Regulation – extensively analyzed by Chan et al. (2007), Barr (2008), Brown et al. (2012), Cerutti et al. (2010), Sullivan (2019), and Berglund et al. (2018 and 2020).

However, those research papers do not use the crisis and regulation factors in the performance measurement models. They can neither distinguish whether the main impact on the models is reflected in changes in the hedge fund risk compositions and respective *beta* indicators or on the individual hedge fund manager decisions represented by the *alpha* indicator.

To sum up, developing a methodology for regional hedge fund performance measurement must consider the models and the factors listed above and answer the defensive statements and hypotheses raised. Considering smaller hedge fund regions present biased return data, special attention to the model robustness and using of alternative models need to be considered when building regional hedge funds' performance measurement models. Table 2 below presents the aggregated asset pricing model combining various performance determining factors. Each performance determinant could potentially depend on the specifics of the regional market. The dissertation will follow this dependence when going through the methodology and creating the model.

Table 2. Hedge fund pricing model aggregated model

Performance determinant / Risk factor	**Category**	**Dependent on region**
Systemic/base risks (stock, bond, IR, FX market)	beta	Yes
Other asset-related (commodities, other assets)	beta	No
"Exotic" / Smart / Alternative (derivatives, leverage, frequent trading, etc.)	beta	No
Individual contribution	alpha	"1"
Investment environment (crisis vs. non-crisis; regulated vs. liberalized)	"2"	Yes

Source: created by the author based on Agarwal et al. (2018) and Groshens (2018).

Table 2 also presents two areas of this dissertation that need further investigation:

1. There is no clarity on how region peculiarities may impact the *alpha* performance factor. The combination of Hypothesis 1 and Defensive statement 1 imply that the alpha shall not only reflect the individual contribution of the hedge fund manager, but also there must be region specifics of the alpha. The individual specifics of the alpha, though, will be examined by applying the fixed effect in chapter 3.3.

2. Although the investment environment is dependent on the region of incorporation of the hedge fund or even on the financial assets of the hedge fund, there is no clarity on whether and how much the changes in the investment environment condition impact the individual contribution of the hedge fund manager (i.e., *alpha* factor). This unclarity triggers Hypothesis 3 in the next section.

Both Other asses-related and "Exotic" / Smart / Alternative factors shall not be region specific as proposed in Table 2. However, based on the APT theory, hedge funds may depend on the factor if such factor reflects the financial instrument in the portfolio/hedge fund. Therefore, the dissertation will analyze and test all factors selected with each hedge fund strategy regardless of prejudice.

2. METHODOLOGY FOR BUILDING OF THE REGIONAL HEDGE FUNDS' PERFORMANCE MEASUREMENT MODEL

2.1. Selection of the regional hedge funds' performance measurement models

The theoretical aspects of the hedge fund pricing outlined that researchers historically analyzed the hedge fund performance on the Global level using US-based market systemic risk factors. Researchers added the "exotic" risk factors, which may determine part of the performance related to Smart and Alternative investment strategies (e.g., size, momentum, frequent trading, short strategies). However, these methods lack the adaptability to the regional hedge funds and do not embed the region-specific performance determinants. The other category of factors that impact the performance of the hedge funds is the investment environment factors, defined as the economic stability status (i.e., crisis or non-crisis situation) and the regulatory environment.

The dissertation's methodology begins with the panel data model and Pooled OLS method to validate hedge fund performance determinants. Panel data analysis allows cross-sectional analysis of separate funds within the same hedge fund strategy. Serlenga et al. (2002), Do et al. (2005), and other researchers at the early stages discussed panel data models. They argued that conventional approaches had ignored the benefits of using panel data techniques. However, in many instances, stock pricing explored panel data models. In more recent research, Narayan et al. (2014) discovered the impact of the 2007 global financial crisis on variables used in pricing models, which is best discoverable by applying panel data models. Bernard et al. (2019) and 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.

The primary model of most researchers analyzing the factors determining the performance of the hedge funds, however, relied on a more conventional multiple linear regression model. Hung and Hsieh developed Fung-Hsieh's 8-factor model by relying on the published hedge funds' index return data or compiling their indices from the selected modified hedge fund return data. A similar approach to finding the determinant of hedge funds' performance is still widespread in the research area. Likes of Agarwal et al. (2018), Berglund et al. (2018), and Duanmu et al. (2018) followed the same approach indicating the linear dependence of the factors is also somewhat convenient to discuss the results from the economic angle.

However, when the researchers seek the connection between the hedge fund return and the anomalies in the short run (e.g., price shocks, drawdowns), non-linear regressions and other more advanced and complex methods (e.g., vector autoregressive method) are more helpful here. Cao et al. (2017) used a vector autoregressive (VAR) model estimating pricing error variance (PEV) to find the relation between the hedge fund exposures and the information efficiency of the equity prices. Gregoriou et al. (2020) studied how downside risk taken by hedge fund strategies responds to macroeconomic and financial shocks. They relied on the non-linear VAR method to learn market timing in the hedge industry. Other models and methods are also quite widespread in hedge fund performance analysis, including, but not limited to, dynamic panel data models, panel VAR models, panel ARDL models, and models with non-linear factor dependence. The researchers emphasize that those more advanced models and methods allow for greater statistical significance of the selected factors. However, these methods are somewhat less informative when analyzing the results from the economic angle and may lack adaptability when adapting to other regions or conditions.

The main important idea behind the panel data model and Pooled OLS method selection lies in the factors determining the performance of the hedge funds, economic interpretation presented in the Theoretical aspects of hedge funds' performance measurement modeling presented in Chapter 1. The author also notes that different hedge fund strategy triggers different risk factors for the model. In the case of equity hedge funds, the risk factors will represent global or local stock positions, whereas in the case of CTA hedge funds – more correlation and consequently dependence derive from the commodity prices.

Figure 6 presents the model building methodology and the expected outcomes (methods), i.e.:

1. Comparing the Panel data models with different factors (global, regional, and "exotic"). Pooled OLS is used to assess the statistical significance of the determinants.

2. Extending the model using the investment environment factors.

3, Model improvement by narrowing the hedge funds pools into coherent pools, selecting the panel data effect, and analyzing and interpreting the model results.

4. Performing various robustness tests.

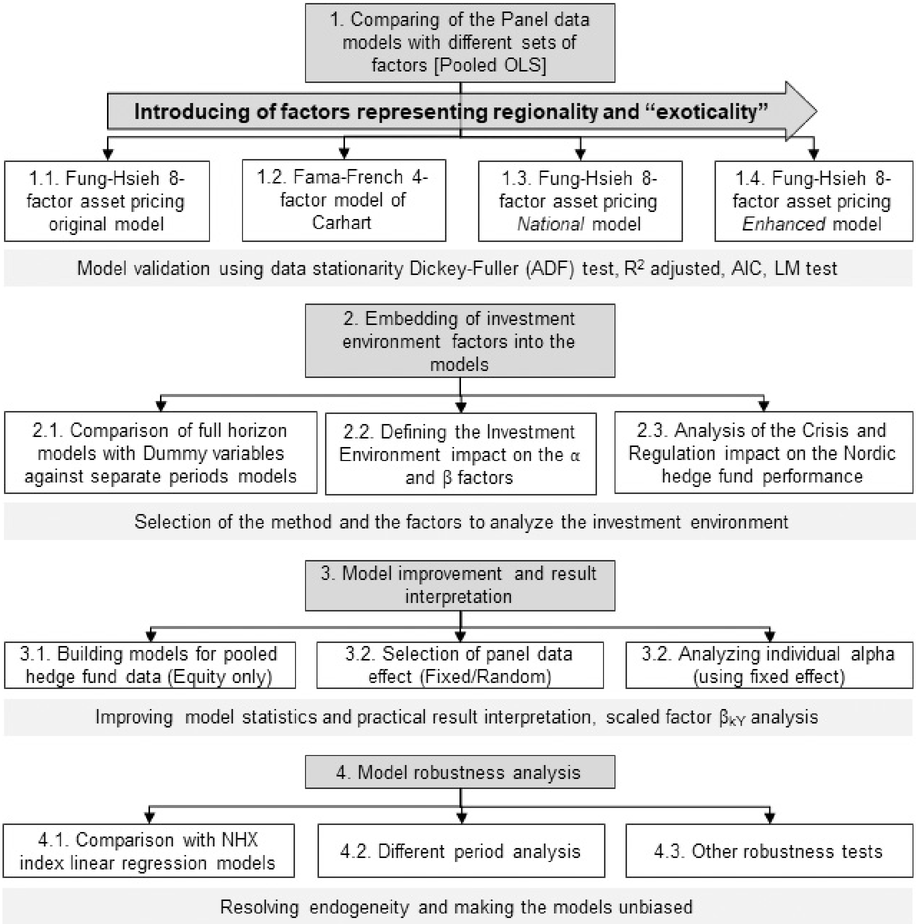

Figure 6. Hedge funds' asset pricing model development and testing steps
Source: Created by the author.

In developing the methodology and proving the validity of the model selection, the dissertation examines and tests five primary hypotheses:

H_1: Region-specific risk factors can better explain the regional hedge funds' performance rather than the Global risk factors using both conventional (e.g., CAPM, APM) or non-linear (e.g., Fung-Hsieh 8-factor) models.

The general idea behind this hypothesis lies in the APT model, which states that the most significant factors in determining the portfolio's performance are those present as a financial instrument (or investment class). Considering Nordic hedge fund managers allocate local financial instruments into hedge funds and may even hedge the exposures against the FX risk, local market-based factors (stock, bond, and currency) will most impact the hedge fund return. Such hedge fund managers' strategy shall confirm the hypothesis (i.e., obtaining higher adjusted R^2 indicators and lower AIC). Replacing the international stock index (e.g., S&P500), bond, and currency-related risk factors (model variables) with national factors related to each of the Nordic countries shall better explain the hedge fund's return considering Vrontos et al. (2008). However, the hypothesis may fail if the hedge fund manager invests in international assets (e.g., Global stock or Commodities) only, reports to the investors in USD, and even hedges the FX effect of the local currency (if that is the strategy). CTA hedge funds will likely follow those international assets and USD currency-aligned investment strategies.

> *H_2: Additional risk factors (e.g., commodity prices, derivatives, ETFs, other assets) and the dummy variables representing various periods of different investment environment conditions improve the statistical significance of the models allowing a more reliable assessment of the hedge fund manager's contribution to the performance of the hedge fund.*

The additional risk factors analyzed and considered by Chen et al. (2018), Gibilaro et al. (2018), Jame (2018), Stafylas et al. (2018), Asensio (2019), Racicot and Theoret (2019), Shaikh (2019), Li et al. (2020), Mensi et al. (2020), and others were already identified as having an impact on the hedge fund performance and shall determine the performance of the hedge funds. The researchers mainly focused on determining the Pearson correlation between the hedge fund return and the risk factors and defining which hedge funds typically depend on these factors. The other hidden dilemma behind the hypothesis derives from the provision that adding statistically significant risk factors will shift performance weight from alpha to those systemic or other risks. Using the traditional Assets Pricing models such as CAPM or APT underestimates these risks. Agarwal et al. (2018), Stutzer (2018), and Knif et al. (2020) also point out that there is no need to provide additional factors to explain hedge funds' *alpha* which would deny the hypothesis. As provided in the H_1, there is a possibility that some hedge funds will not focus their investment strategies on the local market. Therefore, the hypothesis anticipates more impact from the other risk factors in such cases (e.g., in the case of CTA strategy).

H_3: Changes in the investment environment impact the hedge fund performance is

reflected on alpha rather than on the beta indicators.

Amenc and Martellini (2003), Siegel (2005), Pirotte and Tuchschmid (2014), and others analyzed significantly positive *alpha* of the hedge funds. E.g., Amenc and Martellini (2003) noted that hedge funds usually have extremely positive *alphas* even if models account for various factors, including those unusual ones related to liquidity risk or various credit risk factors. The positive *alpha* idea makes hedge funds relatively more market neutral. Therefore, market changes should have less impact on the hedge fund's performance than the hedge fund manager's decisions and possible idea flaws reflected in *alpha*. If the *alpha* remains the substantial source of hedge fund return, it is alpha, but not *beta,* which the changes would significantly impact the investment environment. The *alpha* and *beta* impact proportion may vary depending on whether this is a crisis or regulation impact. If the hedge funds are more trend-following or directional, they will deny the hypothesis.

In parallel with determining which of the investment environment factors impact the hedge funds' asset pricing models, the dissertation also targets to assess the Nordic region-specific outcome of the crisis and regulation constraints on the hedge fund managers' contribution to the returns of their hedge funds. The author set two auxiliary hypotheses to present this outcome:

H_4: Hedge fund managers adjust the investment strategies during the crisis to prevent drawdowns and generate positive alpha.

Hedge funds are known for their focus on the absolute return, which implies the assumption that the market's drawdown shall not have the same negative impact on the returns and AUM of the fund. A timely decision to switch between a long and short strategy or execute an arbitrage strategy, which guarantees a risk-free return (i.e., also known as a neutral strategy, which does not react to market fluctuations) shall affect the performance. The positive and even more significant than during calm time alpha also explains the increased hedge fund manager efforts to prevent the losses and convince the investors to stay within the fund and prevent the investment run process. Metzger and Shenai (2019), Sung et al. (2020), Denk et al. (2020) also support that position in their research. However, there is a part of researchers (Cao et al., 2018; Zhao et al., 2018; Liang and Qiu, 2019; Gregoriou et al., 2020) who oppose such a position stating it is a matter of successful funding to produce the positive *alpha*, but there is also a significant amount of funds which struggle to generate positive *alpha*.

H_5: Regulation constraints applied to the hedge fund industry negatively impact

the hedge fund's alpha.

Researchers noted that regulation directly impacts the performance and risk when comparing hedge funds with mutual funds. The performance is modest in the case of regulated mutual funds. Of course, there is a connection between underperformance and poor governance. However, the regulation in many aspects causes a decrease in the risk of the hedge fund. Although regulators do not aim to reduce the return, Sullivan (2019), Sun and Teo (2019), and others found a connection between decreased risk appetite and returns with the regulation. However, is this reduction of the risk appetite reflected in the reduced *beta* factors, or does it impact *alpha? There* is no definite answer. The idea behind the hypothesis lies behind the detailed analysis of what the regulators target. The author believes it is not the asset risk represented by credit risk, concentration, or liquidity. It is instead leverage, short-selling strategies, and conglomerates with systemically significant banks. These factors shall have an impact on *alpha*.

Therefore, the above-stated hypotheses are focused on answering the methodological question of whether replacing or adding the factors is appropriate in the regional hedge funds' performance measurement model creation. However, proving the H_1 and H_2 hypotheses does not disregard the importance of the selected factors determining the performance of the regional hedge funds.

"Fixing" of the base model is also used to further model development, analysis, and embedding the investment environment factors (represented in H_3, H_4, and H_5) into the unchanged base model. Using the entire base model allows comparing the various models, which differ based on the investment environment factor and the factor introduction method.

The common effect equation [4] allows for conducting the panel data model and validating the statistically significant variables for the forthcoming modeling.

$$Y_{i,t} = \alpha + \sum_{k} \beta_k X_{k,t} + \varepsilon_{i,t} \qquad 4.$$

Where:

Y – dependent variable – hedge fund return.

β – estimated market risk coefficient.

X – dependent variable.

α – model intercept.

ε – residual or error.

i – the number of cross sections / hedge funds (i = 1,2, ..., N).

t – time periods (t = 1,2, ..., T).

k – number of factors (k = 1,2, ..., K).

In the case of a time series-based multiple linear regression model made for a single object (e.g., hedge fund or NHX index), the cross-section dimension *i* is omitted.

The Elasticity at Means method is employed to visualize better and assess the risk factors' weighted contribution to the hedge fund return. Gelman (2008) proposed using Standardized beta coefficients with Elasticity at Means [5] to outline the factors that impact the dependent variable (return) with more weight.

$$\eta_k = \beta_k \frac{\overline{X_k}}{\bar{\bar{Y}}} \qquad 5.$$

Where:

Based on [4] specifications with additional terms:

η_k – elasticity at means of factor *k*.

$\bar{Y}, \overline{X_k}$ – means of variables.

The dissertation provides visualization of the weighted risk factors contributing to the hedge funds' performance, calculating the absolute monthly return values using the equation [6].

$$\mathrm{B}_{k\bar{Y}} = \eta_k \bar{Y} = \beta_k \frac{\overline{X_k}}{\bar{\bar{Y}}} \bar{Y} = \beta_k \overline{X_k} \qquad 6.$$

Where:

Based on [5] specifications with additional terms:

$\mathrm{B}_{k\bar{Y}}$ – an absolute return of factor *k* on the .

Most researchers use Fung and Hsieh's 8-factor model with its explanatory factors as the starting point of most recent research. Researchers usually compare the model with other models, such as Fama & French, Capocci, and Dewaele. Regardless of the region hedge fund managers represent, they aim for the absolute return, therefore, trying to be relatively neutral to the specific market developments, considering the market development may be changing direction (i.e., going up or down). The model needs to have those dimensions to understand how the hedge fund performance measurement (or asset pricing) model depends on the specific market assets (equities and bonds). According to the APT of Ross (1976), this model works well with highly correlated model factors in the portfolio, which also have to follow the normal distribution (Reinganum, 1981). The APT implies that the local hedge fund contains the local assets. However, researchers such as Agarwal et al. (2018), Stutzer (2018), and Knif et al. (2020) also point out that for *alpha* estimation, there is no need to provide a comprehensive range of risk exposures deriving from the instruments the hedge fund invests. Stock indexes, yields, and FX rates present the local variables of the Nordic region.

The dissertation builds the models based on the following order:

1. Selection of the factors or the group of factors, which allows for building the most statistically significant regional hedge funds' asset pricing model,

2. Selection of the method how to embed into the modeling the investment environment factors representing: crisis vs. quiet periods; regulated vs. liberalized periods,

3. Splitting the hedge fund data into narrower pools allows for analyzing more harmonized hedge fund returns and aims to achieve even higher statistical significance of the models.

Selection of the factors is the primary process of hedge fund pricing-model creation, as indicated in the conclusion of the academic research analysis. Fung-Hsieh's 8-factor model of Edelman et al. (2012) is the most appropriate starting point for collecting the risk factors for creating the hedge funds' asset pricing model, combining assets-based and exotic risks (Agarwal et al., 2018). The following steps allowed the selection of the base model and validation of the selected variables:

Step 1. Running Fung-Hsieh's 8-factor[13] model [7]. David A. Hsieh's Data Library offers the following risk factors:

- Trend-following factors: Bond Trend-Following Factor, Currency Trend-Following Factor, and Commodity Trend-Following Factor.
- Equity-oriented Risk Factors: Equity Market Factor (SP500) and The Size Spread Factor (Russell 2000 index monthly total return - Standard & Poors 500 monthly total return)

13 Factors available at: https://faculty.fuqua.duke.edu/~dah7/HFRFData.htm

– Bond-oriented Risk Factors: The monthly change in the 10-year treasury constant maturity yield and the monthly change in Moody's Baa yield less the 10-year treasury constant maturity yield.
– Emerging Market Risk Factor – MSCI Emerging Market index monthly total return.

$$R_{i,t} - RF_t = \alpha + \beta_1 SPRF_t + \beta_2 TYRF_t + \beta_3 RLSP_t + \beta_4 BAATY_t + \beta_5 MSEMKFRF_t + \beta_6 PTFSBDRF_t + \beta_7 PTFSFXRF_t + \beta_8 PTFSCOMRF_t + \varepsilon_{i,t} \quad 7.$$

Where:

R – the return of hedge fund or NHX index.

RF – the risk-free rate of return.

SPRF, TYRF, RLSP, BAATY, MSEMKFRF, PTFSBDRF, PTFSFXRF and PRFSCOMRF – 8 factors of Fung and Hsieh model, presented above and in Table 1.

$\beta_{1\text{-}8}$ – factor coefficients.

α – model intercept / Jensen Alpha.

ε – residual or error.

i – the number of cross sections / hedge funds (i = 1,2, ..., N).

t – time periods (t = 1,2, ..., T).

Step 2. Running a Fama and French 4-factor model [8] of Carhart (1997), which is an extension of the stock index-based CAPM model with additionally added factors: SMB – "Small [market capitalization] Minus Big," HML – "High [book-to-market ratio] Minus Low" and MOM – "monthly premium on winners minus losers."

$$R_{i,t} - RF_t = \alpha + \beta_1 (RM_t - RF_t) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_{i,t} \quad 8.$$

Where:

Based on [7] specifications with additional terms:

RM – total market return (Each of the Nordic country stock indices replacing the stock-based index of S&P500).

SMB – size premium (small cap index – large-cap index).

HML – value premium (high book-to-market value – small book-to-market value).

MOM – a premium of outperforming positions minus underperforming positions.

$\beta_{1\text{-}4}$ – factor coefficients.

This model alone enables testing validity of the Agarwal et al. (2018), Stutzer (2018), and Knif et al. (2020) observation that estimating the hedge funds' *alpha* using a simple model (e.g., CAPM) is sufficient.

Step 3. Running Fung-Hsieh 8-factor model based on the national (local) hedge fund Equity-oriented and Bond-oriented factors replacing US-based factors as presented above.

$$R_{i,t} - RF_t = \alpha + \beta_1 STI_{j,t} + \beta_2 10YRF_{j,t} + \beta_3 SZS_{j,t} + \beta_4 BAATY_t + \cdots + \varepsilon_{i,t} \qquad 9.$$

Where:

Based on [7] specifications with additional terms:

STI, 10YRF, and *SZS* – national risk factors, substituting respectfully originally used *SPRF*, *TYRF,* and *RLSP* factors of Fung and Hsieh model.

j – countries (j = 1,2,3,4).

Although the coefficients $\beta_{1\text{-}3}$ correspond to replaced factors, the dissertation considers them coherent[14] to those of the original Fung-Hsieh 8-factor model based on originally used *SPRF, TYRF,* and *RLSP* factors in equation [7].

Step 4. Presuming the latter are producing statistically more significant models, Fung-Hsieh 8-factor national models are enhanced [8] with other risk factors (e.g., Fama and French factors, liquidity – Liq., stock market volatility – VIX) and uniquely proposed in this dissertation (e.g., Silver and other commodities not used in the modeling before).

$$R_{i,t} - RF_t = \alpha + \sum_{l} \beta_l XE_{l,t} + \beta_1 STI_{j,t} + \cdots + \varepsilon_{i,t} \qquad 10.$$

Where:

Based on [9] specifications with additional terms:

XE – additional risk factors, presented in table 1.

l – number of additional factors (l = 9,10, ..., L).

Such selection of factors enables relying on the statistical methods (OLS, Stepwise, AIC), enhancing the quality and the robustness of the calculations.

14 These factors are free from local currency rate impact as all are converted into the USD equivalent.

Stepwise regression is a method that automatically looks for variables that fit the model best. The models used *a forward approach* adding the variables and testing if such inclusion gives a statistical improvement. This procedure repeats until no new variable improves the statistical significance of the model. To avoid omitted variable bias, only additional risk factors $XE_{l,t}$ are a subject of the Stepwise selection process. The stepwise method includes explanatory variables based on Akaike Information Criteria, used by Vronton et al. (2008) in estimating uncertainties of the hedge fund pricing, and only factors, which achieve at least 95 percent of significance level, remain in the generated model.

It is important to note that the local currency's hedge fund return and national risk factors were translated into USD. Using USD allows possible inclusion into the models of the non-Nordic hedge funds, which focus their strategies and report their performance in different regions' stocks and bond markets.

The dissertation presents a unique **set of methods reflecting crisis and regulation periods** which enable the research to estimate the fund managers' contribution to the total return of the hedge fund in different investment environment conditions. Fung and Hsieh (2004) presented a set of market events that take the pressure off overburdening the data set by identifying the regression equation structure. The other researchers usually analyze the hedge fund performance by looking into a specific period (e.g., crisis) and comparing the outcomes with the other periods (e.g., pre-crisis or post-crisis periods). However, such an approach may define very narrow and specific performance determinants, which may not allow drawing a generalized conclusion on the long-term hedge fund performance driver. Therefore, crisis and regulation impacts are not considered time specific but are persistent through different events.

To select between the approaches and to address the above-stated assumption that the hedge funds' performance depends on the long-term performance drivers (i.e., they are not time specific), the two main periods detection methods are used:

1. Combining the crisis or regulation periods into a single time series and the other (non-affected) periods into the other.

2. Using the Dummy variable to define the crisis or regulatory constrained period and null for the other (non-affected) periods. In this case, the dissertation assumes using the long-term entire research horizon time series.

$$R_{i,t} - RF_t = \alpha + \mu_i D_i + \sum_l \beta_l XE_{l,t} + \beta_1 STI_{j,t} + \cdots \varepsilon_{i,t} \qquad 11.$$

Where:

Based on [10] specifications with additional terms:

μ – coefficient representing the impact of the investment environment on α.

D – dummy variable presenting the investment environment as presented in chapter 2.5.

The selection of the hedge fund **return data into pools** was twofold. The first and foremost tool applied is the segregation of the hedge funds into groups by their correlation with the strategy index returns of the hedge funds and their performance against the index performance. Hespeler and Loiacono (2015) widely analyzed the grouping of hedge funds in terms of their correlation with the market benchmark. Lee and Kim (2018) also used equity hedge fund correlation with the stock index; however, due to the small number of hedge funds and four Nordic stock indices used in this research, the research disregards the correlation with stock indices.

The second tool applied is splitting the funds into pools by performance. Ardia and Boudt (2018) and Canepa et al. (2020) split analyzed hedge funds into categories by performance (e.g., Top performance funds to minimum performance funds and four categories in between). According to Canepa et al. (2020), grouping the funds by their performance shall also prove that the funds with more returns usually do not keep positions for a more extended period and usually do not take significant liquidity risk exposure as they prefer to avoid losses from rapid fluctuations. Therefore, these outperforming funds shall rely more on *Alternative beta* factors with less relation to the *Asset-based beta*, which should be more common in a more stable investment strategy of hedge funds.

As outlined above, the research aims to justify the proposed hedge funds' asset pricing model enhancement by performing a series of statistical steps and tests. The outcomes of the models undergo several phases of comparisons with other studies and with the author's previous research.

The following chapters present the combination of the economic suitability analysis and the statistical models and the respective methods designed to prove the objective of this dissertation. While some variables directly impact the investment and are reflected by high levels of Pearson correlation, others may make a fractional impact and can be reflected only on a portion of the hedge fund population (e.g., on a specific hedge fund strategy).

A key success factor in hedge funds investment is their investment strategy, usually achieved through information asymmetry compiled by the fund manager. The dissertation does not investigate whether hedge funds could employ any asymmetric information; however, the models gathered by the hedge fund investment strategy and the country use as many related variables as possible. Since most hedge fund performance depends on information not published anywhere and is only known to the fund manager, the quality of models for the individual hedge funds is significantly lower when those hedge funds apply market-neutral strategies.

In the author's view and based on the observations of other researchers, the connections between the hedge fund returns and the market/risk factors were considered the main factors which enable the extraction of the *alpha* from the entire hedge fund return (mean return) variable.

2.2. Performing the statistical tests and assessment of the robustness of the selected hedge fund pricing models

As outlined in the objective of the dissertation, the models need to be adjustable to different investment environment conditions. The models must present an unbiased explanation of how hedge fund managers contribute to the performance. The research will test the models defined in the above section using Nordic hedge fund return data because the Nordic market size is somewhat biased. Therefore, it is essential to determine the appropriate statistical and robustness testing methods.

Firstly, as this is a panel data model, traditional tests[15] applicable to linear regression models are not performed on the panel data model. These tests, however, are performed only on the multiple linear regression models employed in this dissertation as an additional robustness measure. Panel data models mainly rely on the ordinary least squares (OLS) estimator, which shall give the Best Linear Unbiased Estimation (BLUE) estimation result.

Firstly (I), the approach to assessing the statistical qualities of the panel data model lies in selecting the suitable Estimation model, which is determined using three methods defined by their effects:

15 For the autocorrelation – Durban-Watson or Lagrange multiplier test; for the heteroscedasticity – White test; for the normality – Jarque–Bera normality test.

1. Common Effect Model or Pooled Least Square (PLS) as presented in equation [4].

2. Fixed Effect Model or Least Squares Dummy Variable (LSDV). This model can calculate the individual intercept for each of the hedge funds. The fixed effect model uses the ordinary least square principle. The regression equation of fixed effects model panel data [12] is as follows:

$$Y_{i,t} = \alpha_i + \sum_k \beta_k X_{k,t} + \varepsilon_{i,t} \qquad 12.$$

Where:

Based on [4] specifications with additional terms:

$\alpha_i = \alpha + Z_i$, and

Z – cross-section effects of Fixed Effect Model.

Applying cross-section dependence with fixed effects allows the practical applicability of analyzing the individual hedge fund *alpha* assessment.

3. Random Effect Model or Generalized Least Square (EGLS). These models accommodate the differences between the intercepts in each hedge fund's errors. The random effect model eliminates the heteroscedasticity problems. The other difference from the fixed effect model is that this model does not use the ordinary least square but uses the principle of maximum likelihood or general least square. The regression equation of random effects model panel data [13] is as follows:

$$Y_{i,t} = \alpha + \sum_k \beta_k X_{k,t} + \upsilon_i + \varepsilon_{i,t} \qquad 13.$$

Where:

Based on [4] specifications with additional terms:

υ – individual residual, which is the random of unit observation i and remains at all times.

The tests performed in the following sequence will allow selecting the most appropriate model:

1. For correct specification of the panel regression and proper inference, it is essential to test for cross-section (individual) and time effects. Baltagi (2005) listed a

large number of both F-statistic (likelihood ratio) and Lagrange multiplier (LM) tests. The Breusch-Pagan (1980) LM test is the most popular random effects test. The null hypothesis upholds that there are no effects present in the panel data model. When the p-value is less than 0.05, it rejects the null hypothesis, and two-sided effects (only for the Conventional LM test – Breusch-Pagan) shall be present.

2. A central assumption in random-effects estimation is that the random effects are uncorrelated with the explanatory variables. Selected Hausman's (1978) method enables testing this assumption to compare the fixed and random effects estimates of coefficients as discussed by Wooldridge (2002) and Baltagi (2005). The null hypothesis is that the preferred model has random effects. The alternate hypothesis is that the model has fixed effects. Essentially, tests enable us to see if there is a correlation between the unique errors and the regressors in the model. The null hypothesis stands for no correlation between the two. When the p-value is less than 0.05, it rejects the null hypothesis. Considering the theory of hedge fund pricing, the fixed-effect model reveals individual hedge fund alpha. It is somewhat likely that different funds within the same hedge fund strategy results must depend and depend differently on the personal contribution of the fund manager.

3. Cross Section Dependence test shows whether a fixed effect model is conclusive. Sarafidis and Wansbeek (2010) noted that disturbances in panel data models are cross-sectionally independent, especially when the cross-section dimension is large. However, since some cross-sections consist of very few hedge funds (e.g., Nordic Fixed income total funds do not exceed ten or even less when looking at smaller groups based on correlation), cross-sectional dependence is likely. Ignoring cross-sectional dependence can result in invalid statistics, and therefore Cross Section Dependence diagnostic test of Breusch-Pagan's (1980) Lagrange Multiplier (LM) needs to be performed. This test is relevant for smaller cross-section dimensions. The null hypothesis states that there is no Cross-section dependence (correlation) in residuals. If the p-value is less than 0.05, it rejects the null hypothesis, and there is Cross-Section Dependence or interconnection between cross-sections. Cross-Section Dependence will likely be in positive correlation groups, confirming the null hypothesis for neutral correlation groups.

Secondly (II), using panel data models overcomes the heteroscedasticity issue if the data used in the models are stationary. To assure that the values in the regressions are stationary, Moffatt (2019) suggests testing every single variable with an augmented

Dickey-Fuller (ADF) test checking for a unit root in a time series sample. The dissertation builds regression models using non-stationary variables based on the ADF test. In that case, the standard assumptions for asymptotic analysis, which will not be valid, can be proven (i.e., "t-ratios" will not follow the model's t-distribution, and the hypothesis test about the regression parameters cannot be valid).

Thirdly (III), panel data models are usually facing 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 the GMM method when testing the liquidity factor of Pástor and Stambaugh (2003), adding to Fama and French 4-factors model. Regional hedge fund databases face a small number of hedge funds issues. Therefore, the GMM method was replaced by **adding the lagged dependent variable** [14] as the control variable for residual autocorrelation used by Racicot and Théoret (2016) and Ardia and Boudt (2018).

$$Y_{i,t} = \alpha + Y_{i,t-1} + \sum_{k} \beta_k X_{k,t} + \varepsilon_{i,t} \qquad 14.$$

Where:

Based on [4] specifications with additional terms:

Y_{t-1} – 1 month lagged dependent variable.

In Nordic equity, fixed income, and CTA models, the endogeneity of the liquidity ratio was avoided, which Adrian et al. (2017) and Racicot et al. (2018) stressed in their research.

The other method for improving the model's statistical accuracy is detecting **the outliers** and removing them from the model. Removing the outliers shall result in an increase in R^2 and a decrease in the AIC criterion. Therefore, the funds are divided into correlated and neutral, outperforming and underperforming. Considering the small number of hedge funds, dividing into groups was only possible in Equity hedge funds.

The Robustness analysis aims to obtain proof: a) the selected factors, b) the selected investment environment factors, and c) the method of embedding these investment environment factors are robust. The robustness of the models is satisfied by seeking the **higher adjusted R^2** significance factors, which were consistent through adding National risk factors and other specific risk factors into the models.

The robustness can be checked by comparing **NHX strategy index linear regression models** with Nordic hedge funds' panel data models. Although NHX strategy indices reflect the hedge funds reporting the returns at a specific time, these hedge funds may discontinue reporting returns to the database, and such hedge funds are excluded from this research. The hedge funds analyzed in panel data models represent so-called long-living hedge funds. Multiple linear regression models without cross-sectional dimension *i* were also a subject of statistical tests (selected by the author):

1. Breusch-Godfrey Serial Correlation LM test looks for serial correlation that multiple linear regressions have not included. The idea of Lagrange multiplier testing lies behind the test, and it is sometimes referred to (Asteriou and Hall, 2011) as an LM test for serial correlation. The null hypothesis upholds that there is no serial correlation of any order. This research used two lags to seek the serial correlation. In order not to be rejected, the p-value shall remain over 0.05. Durbin–Watson test can make a similar assessment that helps to detect if there is an autocorrelation present at lag 1 in the residuals (prediction errors) from a regression analysis. Durbin-Watson critical values obtained from[16] and presented next to the DW test results confirm the positive test results.

2. White (1980) proposed a test for heteroskedasticity – the "White test," which assumes testing of the homoscedasticity hypothesis. The White test can use auxiliary regression analysis by regressing the squared residuals from the original model on a set of original explanatory variables, the cross-products of the regressors, and the squared regressors. The null hypothesis assumes homoscedasticity and, with p-values of less than 0.05, rejects the null hypothesis and considers the alternate hypothesis of the presence of heteroscedasticity. Again, in this test, the values above 0.05 are favorable. If a model fails the homoscedasticity assumption, Huber-White standard errors (or Heteroscedasticity-consistent standard errors) (White 1980) enable a model fitting without heteroscedastic residuals. Moreover, heteroscedasticity may also be removed by applying data logarithms, selecting different X variables, applying a weighted least squares estimation method, or using Minimum Norm Quadratic Unbiased Estimation (MINQUE).

3. Jarque–Bera normality test (Thadewald and Büning, 2007) is used to determine if a data set is well-modeled in terms of normal distribution and to assess whether a random variable is likely to be normally distributed. Despite its weaknesses of having

16 Durbin-Watson Significance Tables available at: https://www3.nd.edu/~wevans1/econ30331/Durbin_Watson_tables.pdf

low power for distributions with short tails, especially for bimodal distributions, this test is more recommended than the well-known Shapiro–Wilk, Kolmogorov–Smirnov, Lilliefors, and Anderson–Darling tests (Razali and Wah, 2011). Jarque-Bera normality test determines whether the sample data has skewness and kurtosis matches a normal distribution. The null hypothesis for the test states that the data follows normal distribution; the alternate hypothesis is that the data does not come from a normal distribution. With a p-value greater than 0.05, it cannot reject the null hypothesis; therefore, modeled residuals follow regular distribution, and the model is conclusive.

Data preparation and validation presented in the next chapter are essential in minimizing the hedge fund reporting data biases and combining the most conclusive hedge funds' performance measurement models.

2.3. Data selection, preparation, and validation

This section presents a step-by-step presentation and analysis of the NHX index data, Nordic hedge funds return data, core and supplementary pricing risk factor data, and investment environment crisis and regulation data. The data used in this research derives from various sources based on the provided principles in the theoretical part. The dependent variables are hedge funds' and respective indices' return data supplied by Nordic Business Media Aktiebolag – a leading media focusing on alternative Nordic investment, writing news, analysis, and research through its team of journalists and analysts. Hedge funds can be analyzed individually, i.e., using an atomic or micro-level approach, and on the industry or market level, using a holistic approach. Therefore, the dissertation proposes constructing the pricing model, which disregards the fund manager's individual and usually unknown strategy. Instead, the research looks for determinants generally affecting the hedge fund returns within the particular hedge fund strategy or pool and the pricing trends during the crisis and tightened regulation periods.

Nordic hedge funds represent the following strategies: Equities, Fixed income, Multi-Strategy, CTA/Managed Futures, and Fund of funds. Although other hedge fund strategies are also present in the Nordic market, no officially reported hedge fund strategy index exists. The funds representing other known strategies (e.g., market neutral) belong to any of the abovementioned strategies.

All NHX strategies underwent significant depreciation in 2008, especially the

NHX Fixed income index, which went down by nearly 20 percent. Whereas NHX CTA index had an almost 10 percent increase in the same period. Considering the graphical differences between NHX CTA and NHX Fixed income lines alone, it presumes that pricing models for those two strategies will differ. Annex 1 presents more detailed NHX indices performance figures, descriptive statistics, Sharpe ratios, and Unit root tests reflected by ADF one-sided p-values. Figure 7 presents NHX strategy indices returns compared with HFRI index.

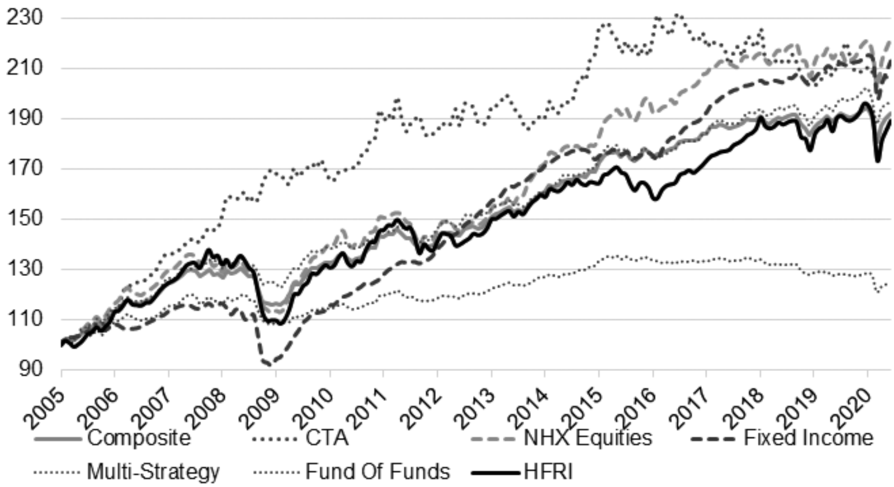

Figure 7. NHX strategy indices dynamics
Source: Prepared by the author based on: https://hedgenordic.com/, https://www.hedgefundresearch.com/?fuse=indices-str.

Despite the NHX index return data, the dissertation aims to construct the hedge funds' performance measurement models based on the hedge funds' return data. Building the hedge funds' performance measurement models based on long-living hedge fund performance data may result in a biased model; hedge funds' return data is somewhat biased, as presented in the next chapter. Comparing the models built for the NHX hedge fund indices and Nordic hedge funds grouped by the investment strategies is a measure to perform the robustness text (see the previous chapter). Table 3 presents the composition of the dependent variables comprising Hedge funds' monthly return and Nordic hedge fund indices' monthly return.

Table 3. Dependent variable composition

Variable	Description	Number of variables	Range	Frequency	Parameters
HFR_j	Hedge fund return	72 funds	2005M1-2020M6	monthly	Country. Strategy
$HFIR_k$	Strategy index return	5 strategy indexes	2005M1-2020M6	monthly	-

Based on the correlation matrix of the respective Nordic hedge fund indices (see Table 4), the funds are also grouped in the following pools:

1. Equity related:
   a) Equities funds only (27), and
   b) Equities correlated funds (50), i.e., Equities, Multi-Strategy, Fund of Funds.
2. Fixed income (10).
3. CTA (12).

Such a small number of hedge funds in certain groups may result in research limitations addressed in the next section.

Table 4. HFRI and NHX index correlation matrix

$\rho_{x,y}$	NHX Composite	NHX CTA	NHX Equities	NHX Fixed income	NHX Fund of funds
NHX Multi-Strategy	0.91	0.31	0.84	0.55	0.79
NHX Fund of funds	0.92	0.44	0.80	0.60	
NHX Fixed income	0.67	-0.09	0.65		
NHX Equities	0.94	0.14			
NHX CTA	0.39				

Note. The table presents only one-way correlations.

The scatter chart (Figure 8) presents the respective hedge funds grouped by the strategy and connected with the corresponding index. However, despite presenting the trend grouped by strategy, they are still widespread in the risk-return scatter plot.

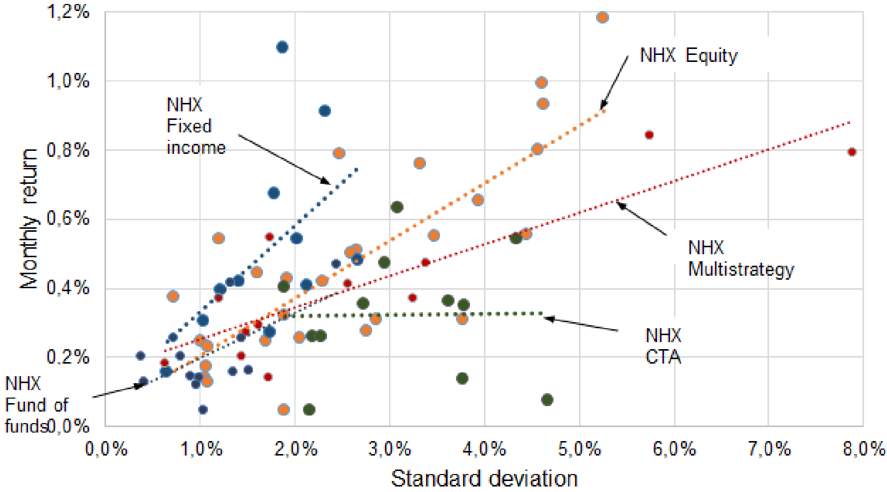

Figure 8. Monthly return and Standard deviation for all Nordic hedge funds
Note: the dotted lines represent the trend lines of all hedge funds of the same strategy and present the Sharpe ratio of the entire portfolio – the steeper the slope, the higher the ratio is.

Figure 8 replicates the coherence among Nordic Equity, Multi-Strategy, and Fund of funds as the trend lines are very close to parallelism. On the contrary, Nordic fixed income and Nordic CTA trend lines have an angle over 45 degrees. Although hedge funds make relatively small groups, only equities hedge funds with 27 funds in total were split into smaller, more coherent pools. Teo (2009), Edelman et al. (2012), Hespeler and Loiacono (2015), and Lee and Kim (2018) created hedge funds pooled portfolios merging them by the correlation with the hedge fund index. Almeida et al. (2019) revealed that fewer hedge funds have positive alpha when grouped into pools by performance, co-skewness, and co-kurtosis with the benchmark (index) compared to Jensen's alpha estimated using traditional linear regressions. In this dissertation, the correlation values ≥ 0.3 and ≤ -0.3 represent high or moderate degree correlation (Statistics Solutions, 2020). The values in the range between -0.3 and 0.3 are a low correlation, close to industry/strategy neutral (i.e., $\rho_{HFRj\ HFIRk}$), where HFR_j and $HFIR_k$ are hedge fund and hedge fund index returns respectively (Table 3).

Hespeler and Loiacono (2015), Ardia and Boudt (2018), and Canepa et al. (2020) also proposed splitting hedge funds into categories by performance (e.g., Top performance funds to minimum performance funds and four categories in between).

Due to the relatively moderate number of hedge funds in the equity strategy, it is reasonable to split funds into two groups: Outperforming the index and Underperforming the NHX strategy index. Table 5 presents the hedge fund split by correlation and the long-term mean performance, considered a benchmark NHX Equity index.

Table 5. Distribution of Equity hedge funds

Nordic hedge fund strategy	**Outperforming**		**Underperforming**		**Total**	
	Corr.	Neut.	Corr.	Neut.	Corr.	Neut.
Nordic Equity	10	2	10	5	20	7
	12		15		27	

Annex 2 presents more detailed Nordic hedge fund performance figures, descriptive statistics, Sharpe ratios, and Unit root tests reflected by ADF one-sided p-values.

Table 1 presents **the risk factors** selected in this dissertation for further testing their impact on the performance of the Nordic hedge funds. Edelman et al. (2012) and other researchers analyzed global hedge fund databases (BarclayHedge; Eureka Hedge; HFR; Morningstar, and TASS), which gathered over 25 thousand single funds on aggregate. Other researchers analyze the hedge funds registered or related to the USA, therefore determined by the global risk factors. This dissertation tests the hypothesis and builds the models based on the Nordic hedge fund data, which represent the Nordic countries' stock market as well as stock market index quite often reported to local investors and therefore managed in the local currencies (Sweden – SEK; Finland – EUR; Denmark – DKK, and Norway – NOK). Therefore, those in local currency reported indices / factors are dependent on the currency exchange fluctuations against USD[17] – the base currency. Table 6 presents the local variables that substitute the following pricing model risk factors (e.g., Used in Fung and Hsieh 8-factor model).

17 USD is considered a base currency due to its dominance in the FX trading market, being a world primary reserve currency and being a currency for the commodity market, i.e., petrodollars.

Table 6. Substituted risk factors

Risk factor	Description	Substituted variable
OMXSRF	Monthly OMX[18] Stockholm 30 Index (SE0000337842) minus monthly[19] 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[20] Bond Yield	
OSEBXRF	Monthly Oslo Børs[21] 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[22] 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	

Source: proposed by the author.

18 OMX indexes are uploaded from www.nasdaqomxnordic.com/indexes website
19 Here and where other yield (or rate) is reported annual, monthly rate is computed by division of 12.
20 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
21 Oslo Børs indexes were uploaded from https://www.oslobors.no/ob_eng/markedsaktivitet website
22 All yield information was uploaded from https://www.investing.com/rates-bonds website

Since both hedge fund and explanatory variables are US dollar (USD) denominated, local and replaced variables are also recalculated using the local currency, and the USD exchange rate changes as the discount rate when calculating the local variables. Unless contrariwise stated, Fama and French rate Risk-free rate[23] are used to construct the various variables.

Tables 36, 37, and 38 (in Annex 3) contain the summary statistics data of all the above-stated factors, replaced factors, and ADF one-sided p-values defined by MacKinnon (1996).

The dissertation considered the following **investment environment periods**: distressed by crisis or non-crisis and constrained by regulation vs. less regulatory constrained. Based on the overview of the crisis definitions and various other researchers' considerations, the following crisis categories were specified:

- Global crisis as defined by Hespeler and Loiacono (2015), Pástor and Vorsatz (2020) and others.
- Banking crisis as defined by Babecký J. et al. (2014).
- NHX index drawdown as reported in HedgeNordic database[24] and
- Global Hedge Funds' Industry Drawdown reported by eVestment (2018) and in Eurekahedge 2020 Q1 report.

The other approach to analyzing the impact of the crisis on investment of the hedge funds, how the crisis impacts the hedge fund risk or *beta,* and the contribution of the hedge fund manager – *alpha* is building the hedge funds for crisis and non-crisis periods only. Both approaches are tested and presented in the next part of the dissertation. Annex 4 presents the detailed crisis periods and their descriptions.

Another factor representing the hedge fund investment environment is regulation, which can be considered a burden on fund managers and may impose limitations on implementing various investment solutions.

The most essential and widely presented measure of the regulation affecting European hedge funds is the AIFMD directive.

The Alternative Investment Fund Managers Directive (hereafter – AIFMD) (2011) serves as a regulatory framework for alternative investment fund managers (AIFMs), including managers of hedge funds, private equity firms, and investment trusts.

23 Data library of Fama and French available at: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html
24 Hedge Nordic database available at: https://hedgenordic.com/.

Based on EY (2013) report, 15 EU countries, including Sweden, Denmark, and Finland, transposed the AIFMD on 22 July 2013. As presented by ICLG (2020), Norway, as a non-member EU state, issued the Alternative Investment Fund Act 2104 with a slight delay compared to the rest of the EU.

AIFMD's primary focus is to address the systemic risks that occurred during the financial crisis of 2007-2008. Although the AIFMD is focused more on the regulation of fund managers, two relatively straightforward requirements had to have an impact on the funds as well:

- The disclosure of the hedge fund manager's information to the investors and regulators, including Custodial and Anti Money Laundering authorities under the "conduct or business" section, and
- Restriction of leverage explored in the hedge funds either as a leveraged long or short position. The restriction includes those for arbitrage strategies and using derivatives and requires calculating the total exposure using the value of the underlying assets on top of the difference between derivative market or book value.

An in-depth analysis of the effect of AIFMD on various investment environment indicators by various researchers (presented in Annex 5) revealed slight differences in how this directive becomes effective in each country. However, considering the insignificant differences and the countries' proximity, the research horizon is split into two periods: prior to the AIFMD ending 2014-12 and AIFMD effective beginning 2015-01.

Berglund et al. (2018 and 2020) addressed the monetary policy regulation after the crisis and how this regulation impacted the hedge fund alpha. They evidenced that long and short equity hedge funds and fixed-income arbitrage hedge funds are affected the most by the unexpected monetary policy announcements, whereas the other strategies are less affected. A significant discovery of theirs is that the alphas decline due to those announcements. The study, however, is focused on the US market, and the Nordic countries have a rather complicated situation with the monetary policies. While Finland is in a Eurozone and jointly applies the ECB's monetary policy, Denmark is in an ERM II regime[25], Sweden is still affected by the Eurozone, and Norway is entirely independent of the ECB. Therefore, this dissertation disregards monetary policy regu-

25 Denmark National bank is limited to freely apply the monetary policy and has to keep EUR:DDK exchange rate within the tolerance of ± 2.25% the officially announced exchange rate (EUR 1 = DKK 7.46038)

lation as an exogenous regulation risk factor.

As an alternative, World Bank Group introduced and regularly published commonly used World Bank Governance Indicators (WGI) can be a good reflection of the regulatory regime and its impact on the hedge funds' investment environment. WGI distinguishes six governance measuring dimensions:

1. Voice and Accountability.
2. Political Stability and Absence of Violence/Terrorism.
3. Government Effectiveness.
4. Regulatory Quality.
5. Rule of Law.
6. Control of Corruption.

Based on the WGI values[26] and their dynamics, the dissertation presents the following periods of increased regulation in Nordic countries (Table 7).

Table 7. Regulation quality dummy values in the Nordic countries

Nordic country	***Well-regulated* period**
Sweden	2008 January – 2008 December; 2011 January – 2020 June
Denmark	2005 January – 2013 December
Finland	2005 January – 2006 December; 2009 January – 2020 June
Norway	2017 January – 2020 June

The corresponding crisis occurrence or regulation occurrence index takes the value "1" when a crisis or regulation occurs and "0" when there is no crisis or regulation.

2.4. Research limitations and Nordic hedge funds' data biases

Most of the research papers emphasize the limitations related to hedge fund return data. Fung and Hsieh (2004b) noted that contrary to Mutual Funds, hedge funds do not have to report their returns to the regulators or the public regularly. Since single hedge fund return data may be inconsistent, the simplest way to construct the hedge fund factor-based pricing model is to use the hedge fund index data. On the one hand, hedge fund indices consist of average market return data of the hedge funds; on the

26 WGI values available at: http://www.govindicators.org.

other hand, they eliminate some special hedge funds. Fung and Hsieh (2000), Liang (2000), Brown et al. (2012), and others broadly analyzed the issues of **data inconsistency of the hedge funds' indices** at the early stages of their research.

The hedge fund index data is widely impacted by hedge fund reporting abandonment, as indicated by Alliance Bernstain (2012). In the research, they used the Lipper TASS hedge-fund database. At the time of the study (end of 2011), 3,502 hedge funds had already stopped reporting the returns, while only 1,419 were still reporting to the database. They got two somewhat different average returns for the funds, which still reported the results (i.e., 9.8% per annum) and only 7.3% if they discontinued reporting after adjusting with the funds.

The report above, as well as Fung and Hsieh (2004b), Hespeler and Loiacono (2015), Bunnenberg et al. (2019), Kanuri (2020), Stafylas and Andrikopoulos (2020), addressed the following hedge fund data biases:

1. *Survivorship Bias*. Usually, hedge fund indexes do not include those hedge funds which discontinued reporting due to poor results. It is also relatively common for hedge funds to report their outstanding performance to undertake a marketing campaign and attract new investors. Once the level of investors reaches the predefined level, the reporting may discontinue. Such hedge funds are also known as "graveyards" even though they are alive and generate relatively positive returns.

2. *Backfill Bias*. Some hedge fund indexes accept the fund results backdated (backfilled) to assure more accurate and comprehensive index calculation. However, hedge fund managers decide whether to report the return only when they see the longer-term success track; therefore, they may choose to publish or not the results even after several quarters. They do not report returns of the funds that need more attention to fix the strategy.

3. *Sample Size*. Nordic hedge fund database has data from 2001; however, very few funds have reported their return since 2001. To reduce the differences in duration of the hedge fund reporting period, the earliest selected date of starting reporting was January 2005 to cover all hedge funds which survived the financial crisis of 2007-2008 and not later than December 2009, so hedge funds started their reporting after the financial crisis was still on the verge in the crisis consequences. The second batch of funds has investment experience in the post-crisis conditions; however, fund managers would lack experience investing under the stressed conditions.

4. *Unreported Final-Period Results*. As presented before, some funds discontinue

reporting due to poor results. Some funds close due to those poor results and are very likely to stop reporting even earlier than their closure. According to some analysts, these funds return 0.7% worse than the index returns for the past 12 months.

In the author's view, the limitations may also arise from:

- The reporting data does not present changes in the investment managers.
- Incoherent investment strategic and tactical decisions, as well as
- Unknown and unrevealed risk factors blended in Jensen's Alpha and often in errors (model residuals).

There are **region-specific limitations** also present in this research. First and foremost, important is the population of the regional hedge funds. The total number of reporting hedge funds in the Nordics is 147 as of 2020-11-02 compared to 174 as of 2018-10-06. Out of 147 funds, only 72 reported their data from no later than 2009, and research only analyzes those 72 funds. The population and selected sample sizes point to the other limitation. The small sample sizes cause an **increase in the confidence interval** and a decrease in the precision of the models. Table 8 presents the calculation of the confidence intervals of Nordic hedge funds by strategy.

Table 8. Distribution of Nordic hedge funds by strategy

Hedge funds	**Number of funds**[27]	**Reported funds**	**Reported**	**Selected funds**	**Selected/ analyzed**	**Confidence interval**[28]
Equities	68	55	81%	27	40%	13.58%
Equities+	159	98	62%	50	31%	9.75%
Fixed income	35	33[29]	94%	10	29%	26.27%
CTA	25	16	64%	12	48%	14.61%
All Nordic hedge funds	219	147	67%	72	33%	-

The top strategy in the Nordics is Equities comprising 31% of total funds and 36% of funds selected for analysis. It is also important to outline that 57% of all funds and 61% set for analysis funds come from Sweden. Sweden's representation by offshore

27 The total number of funds is estimated in early 2018, when the first part of the research occurred. These numbers were lower in 2020.

28 Calculated using: https://www.surveysystem.com/sscalc.htm

29 Despite such high number of reporting Nordic Fixed Income funds, there is a high turnover of those funds and most of the funds in the index are relatively new.

funds makes less than one-third, whereas other countries have a more evenly distributed proportion. Trying to figure out the possible impact on the pricing of hedge funds by offshore domicile, “offshore” was attempted to be used as a dummy independent value in the independent values data set (see independent variables in the next chapter). However, no models included the offshore variable due to the lack of statistical significance.

Besides the sample size issues, only 58 funds continue reporting the returns after the cut-off date of this research (i.e., June 30, 2020). The number of hedge funds that started reporting from the beginning of the research horizon is also not significant. Table 9 presents the number of funds by the reporting inception year.

Table 9. Funds by reporting inception year

	Before 2005	**2005**	**2006**	**2007**	**2008**	**2009**	**Total**
Reporting funds	27	7	9	2	12	15	72

Such distribution of the reporting inception dates also points to the **unbalanced panel data**. As the missing data represents the beginning of the reporting, not the middle periods or the ending, it was evident that all selected funds have reported the returns after the financial crisis of 2007-2008, including all future crisis periods. It is also evident that hedge funds (or their managers) have overcome at least several crises, as indicated in the description of the crisis periods. According to Berglund et al. (2020), the experiences of executives[30] and investors can significantly affect their subsequent behavior and performance. The crisis experience can affect the risk appreciation and increase the soundness of investment decisions. Zheng and Osmer (2018) outlined panic as one of the consequences of the market situation, which also stimulates the unique skills of hedge fund managers. There is a limitation in calculating panel data models’ variable Elasticity due to unbalanced panel data. In cases where the hedge funds report the returns for fewer periods than the total number (i.e., 186), the mean return of such hedge funds differs. However, the larger the panel data model’s sample, the more accurate Elasticity at Means is.

The other limitation deriving from the **long-term time series** is the assumption that hedge funds follow the same strategies or patterns during various crisis periods or post-crisis periods. Bares et al. (2003), Jagannathan et al. (2010), and Kolokolova and

30 The research captures Credit Suisse Hedge Fund Index, however, shall correspond the peculiarities of Nordic investment business.

Mattes (2018) also used long-term research horizons. Kolokolova and Mattes (2018) discovered seasonal patterns in hedge fund risk-taking. While hedge funds with high management and performance fees may perform poorly, there is a tendency they will be changing the risk profile and try to catch up with the performance in the second half of the year. Such seasonal procyclical variation of the return may distort the asset pricing model and be solved by eliminating procyclical variations or applying longer-term time series, mitigating the effects of those seasonal fluctuations. In order to reduce the limitations of long-term time series, the dissertation analyzed various crisis (or non-crisis) periods separately and compared them.

The long-term time series also limits the view of how the alpha factor variates with the time compared between different regions of hedge funds or even the hedge funds within the same region. However, the hedge fund has long-term strategy fund managers may change with time. Fund managers also may learn from their past decisions and gain investment skills. However, analyzing all those hedge funds in pools reduces seasonal fluctuations, procyclical variation, and any shifts in different investment environment conditions.

As already presented, hedge funds started to report their returns extensively only in the late 1990s. The researchers may choose the five most prominent hedge fund databases from BarclayHedge, EurekaHedge, Hedge Fund Research (HFR), Morningstar, and Lipper Hedge Fund Database (TASS). These databases cover global markets and do not provide data specified by local areas, such as Nordic Countries. Fung and Hsieh (2004b), Joenväärä et al. (2019), and other researchers also found differences between these databases; therefore, researchers who analyze on a global scale choose several of all five databases' combined data.

The prominent uniqueness of fund returns is their **non-linear dependence** on the systemic market risk factors, which promoted the development of advanced hedge funds' performance measurement models. Besides creating and promoting their non-linear hedge fund performance determinants, researchers also use non-linear regressions and other more advanced and complex methods (e.g., dynamic panel data models, panel VAR models, panel ARDL models, and models with non-linear factor dependence). A non-linear dependency shall allow for greater statistical significance of the selected factor; however, the explanation of such variable dependency may be an issue.

As presented in the analysis of the potential hedge fund performance determinants, precious metals analyzed by Mensi et al. (2020) and energy commodities analyzed by Zhang and Wu (2019) can have time-lagged connections with the hedge funds and CTA performance. **Not using the time-lagged variables** also causes the limitation of this research.

The concluding remarks: The hedge funds' return data does not necessarily follow the market. Therefore, the methodology combines linearly dependent variables representing the main financial instruments and trend-following factors of Fung-Hsieh's and Fama-French's models. A proposed panel data model with Pooled OLS method for initial selection and validation of the hedge funds' performance determinants that many researchers have used in the past. However, the author exploited this model by including country-specific factors, which APT recommends, but researchers do not widely use.

The selection of the research data, analysis, and preparation of the data for forthcoming modeling led to a breakdown of the Nordic hedge funds' return data into four main groups by investment strategy: equity, fixed income, CTA, and equity+. The analysis also disclosed that while equity and fixed income strategy hedge funds shall be more dependent on the local financial market prices (i.e., stock, bond, currency); CTA strategy hedge funds shall depend more on the commodities and other hedge fund strategies representing factors, including, but not limited to trend-following factors. This observation directs the expectations of hypothesis 1 to be more aligned to equity and fixed income hedge funds. Whereas hypothesis 2 shall achieve a higher statistical significance with CTA funds. Equity+ strategy, which combines equity, multi-strategy, and fund of funds strategies, may be affected by hypotheses 1 and 2. The Nordic hedge funds' return data presents an unbalanced panel, which reduces the modeling accuracy. However, as the unbalanced panel only represents the period from 2005 to 2009, this can be considered when splitting the panel into shorter periods.

The dissertation proposed two methods to embed the investment environment representing crisis and regulation factors into linear regressions and panel data models. The first method splits the time-dependent panel data into periods depending on which phase of the investment environment is taking place (e.g., in the case of crisis factor – crisis period vs. non-crisis period). The second – introduces the dummy variable representing the affected period and the null valued factor in the unaffected period.

In the end, the panel data models allow applying the fixed or random effect to solve the endogeneity problem, estimate the individual effect for the hedge fund, and increase the practical application of the models. Other limitations derive from the small size of the regional hedge fund databases, the long-term analysis horizons, and the hedge funds' return data reporting biases. The dissertation is respectively aiming to reduce those limitations where possible.

3. BUILDING OF THE NORDIC HEDGE FUNDS' PERFORMANCE MEASUREMENT MODELS

3.1. Selection of the factors determining the regional hedge funds' performance

Defined models presented in the previous part allow testing the hypotheses and achieving the main objective of this dissertation – to adapt the hedge funds' performance measurement models to specific regions taking into account different stages of economic conditions (determined as affected by crisis or non-affected) and changes in the regulatory regime resulting in robust models and transparently presenting the contribution of the hedge fund managers (i.e., providing the *alpha* net of undisclosed risk factors).

The dissertation examines the following base models for 3 Nordic hedge funds strategies: Equities, Fixed income, and CTA, and the fourth pool of hedge funds combines Equities, Multi-strategy, and Fund of funds strategies based on their Pearson correlation coefficients ranging from 0.79 to 0.84 as presented earlier in Table 4.

The following models' panel data Common Effect Models were conducted:

- Fung-Hsieh 8-factor model based on equation [7].
- CAPM model based on Nordic country stock index [1].
- Fama and French 4-factor model of Carhart (1997) presented in equation [8] with variable *RM* –corresponding Nordic country stock index.
- Fung-Hsieh 8-factor model based on the national (local) hedge fund Equity-oriented (Main stock index and Small Cap minus Large Cap factor) and Bond-oriented factors (10-year Governmental bond yield change in each country) replacing corresponding US factors based on equation [9], and
- Fung-Hsieh 8-factor national model enhanced (equation [10]) with other risk factors (e.g., Fama and French factors of Carhart (1997) model, liquidity – LIQ, stock market volatility – VIX, most commonly used commodities as Gold, Oil or Natural gas future price change). The model also included the unique risk factors (e.g., Silver and other commodities) not used in the modeling before.

The other variables for the "Fung-Hsieh 8-factor national enhanced" model were selected using the Stepwise regression method. Table 10 presents the Adjusted R^2

and AIC criterion of the initial OLS panel data (base) models.

Table 10. Selection of the initial OLS panel data model

Model	Equity	Equity+†	Fixed income	CTA
Fung-Hsieh 8-factor model	Adj. R^2 43.70% AIC -3.7743	Adj. R^2 44.32% AIC -3.8879	Adj. R^2 41.98% AIC -4.2794	Adj. R^2 21.02% AIC -3.2906
CAPM national model	Adj. R^2 52.00% AIC -3.9355	Adj. R^2 49.24% AIC -3.9815	Adj. R^2 40.64% AIC -4.2609	Adj. R^2 14.92% AIC -3.2197
Fama and French 4-factor model	Adj. R^2 52.97% AIC -3.9351	Adj. R^2 49.38% AIC -3.9839	Adj. R^2 41.82% AIC -4.2791	Adj. R^2 17.49% AIC -3.2489
Fung-Hsieh 8-factor national model	Adj. R^2 60.33% AIC -4.1246	Adj. R^2 58.22% AIC -4.1751	Adj. R^2 60.77% AIC -4.6708	Adj. R^2 26.26% AIC -3.3592
Fung-Hsieh 8-factor enhanced model	Adj. R^2 60.44% AIC -4.1266	Adj. R^2 58.87% AIC -4.1899	Adj. R^2 62.04% AIC -4.7024	Adj. R^2 32.93% AIC -3.4504

† Equity+ pool comprises Equity, Multi-strategy, and Fund of funds strategies with a correlation of over 70%.

The dissertation concludes with the following observations on how the base models contribute to hypotheses $\boldsymbol{H_1}$ and $\boldsymbol{H_2}$:

H_1: Region-specific risk factors can better explain the regional hedge funds' performance rather than the Global risk factors using both conventional (e.g., CAPM, APT) or non-linear (e.g., Fung-Hsieh 8-factor) models.

a) CAPM national model in both Equity and Equity+ strategies increased Adj. R^2 from 43.70% to 52.00% and from 44.32% to 49.24%; and decreased AIC from -3.7743 to -3.9355 and from -3.8879 to -3.9815 proving the national stock index alone is the dominant risk factor for equity hedge funds, whereas not for Fixed income and CTA hedge fund strategies.

b) Fama and French 4-factor model of Carhart (1997) based on the national stock index also has similar results to the observation of the CAPM model. So national factors have not increased the statistical significance of Fixed income and CTA strategy hedge funds, **rejecting** the H_1 hypothesis. However,

c) Fung-Hsieh's 8-factor national model was designed to prove hypothesis H_1 **confirmed** in all strategies, including Fixed income and CTA hedge funds.

H_2: Additional risk factors (e.g., commodity prices, derivatives, ETFs, other assets) and the dummy variables representing various periods of different investment environment conditions improve the statistical significance of the models allowing a more reliable assessment of the hedge fund manager's contribution to the performance of the hedge fund.

The hypothesis of extending the models was already analyzed before by Fung and Hsieh (2004b), Baltas and Kosowski (2013), Edelman et al. (2012), Christoffersen et al. (2014), and others; however, they did not perform it with regional hedge funds which return data depends on local National Stock and Bond risk factors. Fung-Hsieh 8-factor enhanced model **proves** or **rejects** hypothesis H_2 in the following hedge fund strategies:

a) Equity and Equity+ the improvement of Adj. R^2 and AIC are very fractional, which can be explained by the logic of APT theory assuming Equity representing hedge funds have very little or no exposure in those assets or investment strategies represented by the additional factors. As presented in Table 11, the liquidity risk premium LIQ of Pástor and Stambaugh (2003) and the OCMDRWT commodity index slightly impacted the Equity model. The equity+ performance assessment model has a statistically significant connection to most of the newly proposed factors; however, these factors look relatively insignificant when estimating their Elasticity at Means (presented further).

b) Fixed income improvement of Adj. R^2 and AIC are slightly better compared to Equity and Equity+ models. However, as with Equity, there is little connection between the newly proposed factors and the Fixed income strategy, in which funds presumably invest in bonds and other interest-bearing instruments. As presented in Table 11, the Fixed income funds model selected the same factors as the Equity model: liquidity LIQ and OCMDRWT commodity index.

c) CTA improvement of Adj. R^2 and AIC are rather significant. Adj. R^2 increased from 26.26% to 32.93%, and AIC decreased from -3.3592 to -3.4504. As CTA is a commodity-related strategy, according to APT theory, the fund performance can be better explained when the model includes the instruments included in the model. Fama and French (SMB, HML, and MOM), Gold and Silver prices, and liquidity LIQ and OCMDRWT commodity index factors significantly impact the CTA model. As discussed in the case of the Equity+ model, Elasticity at Means shall also present how significantly these factors impact the performance of the CTA hedge funds.

As the Adj. R^2 and AIC improvement of Equity and Equity+ models are relatively fractional, but the number of factors used in the research is substantial. Chen et al. (2018), Gibilaro et al. (2018), Jame (2018), Stafylas et al. (2018), Asensio (2019), Racicot and Theoret (2019), Shaikh (2019), Li et al. (2020), Mensi et al. (2020) and others had identified the connection between hedge fund performance and some of the additional factors. The dissertation concludes that hedge fund pricing models are reaching their absolute level of statistical significance. The unexplained return shall comprise the hedge fund manager's contribution (i.e., *alpha*) and accidental return (i.e., *error* – *ε*).

Table 11 presents the summary of the "Fung-Hsieh 8-factor enhanced models" statistically significant additional factors (based on Table 1, which presents all factors of the research).

Table 11. Other factors Fung-Hsieh 8-factor enhanced model

Factors \ Strategy	**Equity**	**Equity+**	**Fixed income**	**CTA**
SMB‡		-0.0369** (0.0158)		-0.2865*** (0.0467)
HML‡		0.0683*** (0.0151)		0.1910*** (0.0449)
MoM‡		0.0332*** (0.0095)		0.1252*** (0.0271)
GOLD‡		0.0289*** (0.0098)		0.0976*** (0.0307)
COPPER‡		0.0156** (0.0069)		
SILVER‡				0.0675*** (0.0156)
BROIL‡				
NGAS‡		0.0086*** (0.0029)		
COCOA‡				
OCMDRWT‡	0.0609*** (0.0186)	0.0714*** (0.0159)	0.1240*** (0.0224)	0.1710*** (0.0449)
LIQ‡	-0.0333** (0.0154)	-0.0538*** (0.0125)	-0.1148*** (0.0191)	-0.1533*** (0.0365)
VIX‡				

Note. Standard errors in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

‡ variables in the Fung-Hsieh 8-factor enhances model selected using the Stepwise model with 0.05 stopping p-value criteria forward and backward.

The base model used for further research will include at least the following models' enhancements:

1) The national factors, i.e., Equity-oriented (Main stock index and Small Cap minus Large Cap factor) and Bond-oriented factors (10-year Governmental bond yield change in each country) will replace the US-based factors originally used in Fung and Hsieh's 8-factor model.

2) All Nordic hedge funds' strategy models significantly depend on liquidity LIQ and OCMDRWT commodity index factors (p-value<0.01). Therefore, the base models shall also rely of them.

Adding the liquidity LIQ factor, which has negative coefficients in all cases, confirms the conclusions of Cao et al. (2018) and Liang and Qiu (2019). However, such ratios do not indicate significant low liquidity or distressed assets held in Nordic hedge funds. Table 12 presents the Elasticity at Means method summary, which determines the selected factors' significance.

Table 12. Other factors Fung-Hsieh 8-factor Elasticity at Means

Factors \ Strategy	Equity	Equity+	Fixed income	CTA
SMB		-0.44%		-7.22%
HML		-6.32%		-28.72%
MoM		1.27%		4.45%
GOLD		5.72%		33.09%
COPPER		1.90%		
SILVER				27.71%
BROIL				
NGAS		-0.06%		
COCOA				
OCMDRWT	1.17%	2.30%	1.18%	10.39%
LIQ	-0.28%	-0.72%	0.06%	-3.92%
VIX				

In Equity model Elasticity at Means of LIQ factor (η_{LIQ}) is -0.28%, Equity+ -0.72%, Fixed income – 0.06% and CTA – 3.92%. In all models, except the CTA liquidity factor is not significant from the scaled impact perspective. Whereas, in Equity $\eta_{OCMDRWT}$ is 1.17%, Equity+ 2.30%, Fixed income 1.18% and CTA 10.37%. It is somewhat more significant from the scaled impact perspective in all strategies; however, it only significantly impacts the CTA funds model.

The models show that CTA strategy hedge funds also significantly depend on Gold (η_{Gold} is 33.09%) and Silver (η_{Silver} is 27.71%) commodity prices. While Stafylas et al. (2018), Swartz and Emami-Langroodi (2018), Racicot and Theoret (2019), Shrydeh et al. (2019), Mensi et al. (2020), Chirwa and Odhiambo (2020), Lambert and Platania (2020) found the dependence of the hedge fund performance on Gold prices, no researchers used Silver before this research. A significant statistical and scaled dependence on Silver shows how important Silver is in industrial consumption and hedge fund performance. Therefore, the dissertation also tests regional CTA hedge funds against the commodity prices and include the most statistically significant into the base model for further analysis. Tables 45 and 46 in Annex 6 present the entire "Fung-Hsieh's 8-factor enhanced models" and their corresponding Elasticity at Means.

The creation of the base model also represents the **defensive statements 1** of the dissertation. Adding the region-specific and other "hidden" risk factors hedge funds' alpha into the hedge fund pricing models shall lead to a decrease in *alpha,* proving that hedge fund managers tend to limit the disclosure of the systemic risks taken by the hedge funds.

The statement has been proven, however, with some inconsistency. Adding the local market representing national Stock and Bond market variables has significantly increased the statistical soundness of the models except for CTA, which was not as impressive as in all other strategies (models). As a result of the model improvements, alpha coefficients and their Elasticity at Means have changed. This statement may have different outcomes (scenarios) with respective explanations:

A. The additional risk reduces the alpha and the error (by increasing the Adj. R^2), proving the defensive statement 1.

B. The additional risk factor does not impact the *alpha* but reduces the error (by increasing the Adj. R^2). In this case, the additional factors reduce the amount of random return (or luck of the fund manager) but do not constitute *alpha*.

C. The additional risk factor redistributes the weights between *beta* factors but does not impact *alpha*. In this case, the new factor replaces the previous factor(s).

D. The additional risk factor increases the *alpha* and reduces the error (by increasing the Adj. R^2). In that case, the increased *alpha* takes the merit of random returns (or luck of the fund manager).

E. There is a possibility that increased *alpha* shows a possible hedge fund manager's contribution if he/she would not use the investment strategy related to the specific additional risk. Nevertheless, these scenarios shall not be conclusive without an additional in-depth analysis of the hedge fund composition.

Table 13 presents the dynamics of the *alpha* and corresponding Elasticity at Means through the change of the models. For reference, Table 10 shows the change in the statistical significance (Adj. R^2 and AIC).

Table 13. Modeled alpha analysis

Alpha **Elasticity at Means**	**Equity**	**Equity+**	**Fixed income**	**CTA**
Fung-Hsieh 8-factor model	0.0010* 0.2571	0.0001 0.0347	0.0028*** 0.6178	0.0004 0.1851
CAPM national model	0.0027 0.3155	0.0017*** 0.5529	0.0029*** 0.6514	0.0010 0.5032
Fama-French 4-factor national model	0.0028*** 0.7112	0.0019*** 0.6084	0.0032*** 0.7094	0.0011 0.5921
Fung-Hsieh 8-factor national model	0.0025*** 0.6342	0.0014*** 0.4361	0.0044*** 0.9795	0.0008 0.4340
Fung-Hsieh 8-factor enhanced model	0.0026*** 0.6549	0.0015*** 0.4777	0.0044*** 0.9818	0.0009 0.4791

Note. Alpha coefficients: *** p<0.01, ** p<0.05, * p<0.1.

There are two groups of models CAPM national and Fama-French 4-factor models and Fung-Hsieh 8-factor national and Fung-Hsieh 8-factor enhanced models. Within each group, there are additional factors added on top of the previous group model: Fama-French 4-factor model enhanced the CAPM model by adding factors SMB, HML, and MOM; whereas the "Fung-Hsieh 8-factor enhanced model" enhances the predecessor with SMB, HML, MOM, Commodity prices, Liquidity, and some other factors.

When comparing CAPM national and Fama-French 4-factor models adding additional factors, the increase of *alpha* coheres with a slight increase in Adj. R^2. When comparing the Fung-Hsieh 8-factor national model and Fung-Hsieh 8-factor enhanced model, which are all constructed using National Stock and Bond factors and adding the additional factors, in Equity, Equity+, and Fixed income, there is a trend of a slight increase of *alpha* supplemented with a slight increase in Adj. R^2. In both cases, this corresponds to explanation D (above) and cannot be conclusive to prove the 1st statement. However, the opposite situation of the 1st statement derives from comparing the 1st group with the 2nd. Adding the Fung and Hsieh trend following factor makes the essential difference in the improvement of the models and decrease of the *alpha* as presented in scenario A.

The situation with the CTA strategy is similar; however, as in all models, *alpha* is not statistically significant (based on p-value), and the results are inconclusive. Nordic CTA (or Commodity Trading Advisors) are usually considered odd to other hedge funds. The European Union legislation categorizes them as an Alternative Investments group consisting of conventional funds focusing on commodity futures and other non-linear return generating (option-like) assets instead of hedge funds aiming to receive an absolute return. Based on the BarclayHedge (2020b) Fund Indices categorization, CTA is also known as Managed Futures funds, which invest in listed financial and commodity futures markets and currency markets worldwide. Elaut and Erdős (2019) also analyzed various CTA portfolios claiming they exhibit positive alpha compared with other new risk factors.

Some variables negatively contribute to the dependent return variable. These variables, however, are not consistent through all strategies (e.g., Equity size spread, 10-year bond yield, and corporate bond spread Baa over 10-Year bond represented by Δ(BAATY), Liquidity index). Such inconsistency can be explained by various strategies dominant in various Nordic hedge funds; however, this needs more investigation before a further conclusion.

Besides the provided explanation, there are several data-related biases or limitations which might have had an impact on the analysis of *alpha* and corresponding Elasticity at Means:

1. Elasticity at Means of alpha presents a difference of 100% (or 1.00) less Elasticity at Means of all variables used by the model; therefore, there are limitations to calculating Elasticity at Means of some risk factors.

2. Not all Nordic hedge funds have data for the whole analysis period of 2005 M1 – 2020 M6 (i.e., reporting less than 186 returns); therefore, the mean value of the same variable in different strategies may vary.

3. Hedge fund returns and stock and bond market-related factors are calculated in national currency and converted into USD in this research. The analysis of currency exchange rate fluctuations significantly impacts the NHX indices returns. Different currencies used in the Nordic hedge funds increase the error, including the correctness of calculating the mean of the risk factors.

To conclude, in the given sample of hedge funds, it is not possible to prove the statement that adding commodities-related factors, Fama-French factors, liquidity, or VIX would significantly improve the statistical soundness of the models and would result in a decreased *alpha* considering hedge funds managers may be overstating the *alpha* indicator. However, this does not reject the statement, as there is a noticeable increase in the base model accuracy (through the improvement of Adj. R^2 and AIC criteria) when adding the trend following factors to Stock, Bond, and other asset-based factors, which would prove the statement.

However, the overall conclusions of this chapter representing the creation of the base model for the further development of the regional hedge funds' performance measurement models are:

1. The base model for Equity and Fixed income strategy hedge funds is statistically significant and conclusive when introducing the national factors, i.e., Equity-oriented (Main stock index and Small Cap minus Large Cap factor) and Bond-oriented factors (10-year Governmental bond yield change in each country).

2. Adding the additional factors, including the commodities prices, commodity index, or liquidity, may present an additional determinant of the hedge fund performance. In the case of the Nordic hedge funds analyzed in this dissertation, liquidity and OCMDRWT commodity significantly impact all Nordic hedge fund performance. Commodity factors were significant for CTA hedge funds.

The other modeling in this dissertation will encounter the determinants identified in this phase, and other researchers are also encouraged to use the approach in constructing the regional hedge funds' asset pricing models.

3.2. Introduction of crisis and regulation factors into regional hedge funds' performance measurement models

The dissertation addresses the investment environment's impact on hedge fund performance using two main approaches:

1. Combining the crisis or regulation periods into single time series and the other (non-affected) periods into the other.

2. Using the Dummy variable to define the crisis or regulatory constrained period and null for the other (non-affected) periods, using the long-term entire research horizon time series as presented in equation [11].

As proved by Hypotheses 1 and 2, the most suitable model for further analysis is Fung-Hsieh's 8-factor enhanced model presented in equation [10]. The analysis of the Dummy crisis variables resulted in the following:

– Global crisis – statistically significant for Equity, Equity+, Fixed income panel data models.
– Global hedge fund drawdown – statistically significant for CTA panel data models.
– Banking crisis and NHX drawdown – not statistically significant for any models.

Figure 9 presents the Global crisis and the Global hedge fund drawdown timeline.

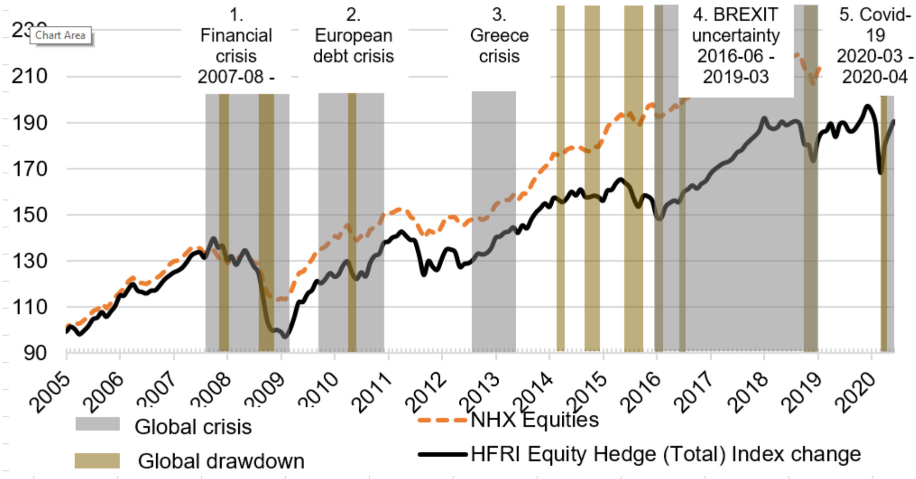

Figure 9. Global crisis and Global hedge fund drawdown timeline

Note. for Global drawdown, refer to Annex 4 Table 43.

Source: Prepared by the author based on: Hespeler and Loiacono (2015), eVestment (2018), Eurekahedge (2020), https://hedgenordic.com/., https://www.hedgefundresearch.com/?fuse=indices-str, https://faculty.chicagobooth.edu/-/media/faculty/lubos-pastor/data/liq_data_1962_2019.txt.

The analysis of the Dummy regulation variables resulted in the following results:

– AIFMD impact – statistically significant for all models.
– Regulation index impact – not statistically significant for any models.

Annex 5 Table 44 presents the AIFMD implementation timeline. Although the individual derivative and leverage indicators are supposed to have a slightly different possible impact on hedge funds' investment process, the AIFMD effect is set as follows: in Sweden and Denmark – as of 2014-01, and Norway and Finland – 2015-01.

Table 14 presents the *crisis* models' statistical characteristics Adj. R^2 and AIC.

Table 14. "Crisis" factor model statistics

Strategy	Indicator	Base model	Crisis periods	No Crisis periods	Dummy Crisis
Equity	Adj. R^2	60.44%	**63.96%**	54.94%	60.49%
	AIC	-4.1266	-4.0513	-4.2451	-4.1278
Equity+	Adj. R^2	58.87%	**61.61%**	55.99%	58.96%
	AIC	-4.1899	-4.0284	-4.4825	-4.1919
Fixed income	Adj. R^2	62.04%	64.99%	**65.40%**	62.85%
	AIC	-4.7024	-4.5783	-5.0776	-4.7227
CTA	Adj. R^2	32.93%	**40.65%**	34.96%	33.86%
	AIC	-3.4504	-3.5110	-3.4833	-3.4638

Note. Adj. R^2 indicators in **bold** represent the most statistically sound model.

Looking into the results at a glance, elaborating on the *crisis* variable in the models proves the defensive statement 2 providing there is an impact on the models. The dissertation aims to define which variables are most affected by the new *crisis* factor. The analysis of Adjusted R^2 of all models with *crisis* factors resulted in the following:

- In Equity and Equity+ models, *crisis* periods only resulted in higher Adj. R^2 compared with the base model, while *no crisis* period Adj. R^2 decreased. Such difference in Adj. R^2 provides the information for the further assumption that performance measurement measuring of Equity related hedge funds can be more precise during *crisis* periods but less precise in *no crisis* periods.
- Adj. R^2 of Fixed income and CTA models based on specified periods of *crisis* and *no crisis* exceeded Adj. R^2 of respected base models. For CTA as Equity funds, *crisis* periods produce more precise models, whereas for Fixed income – it is *no crisis* periods models.
- Regardless of the strategy, all models with the Dummy crisis variable are coherent with corresponding Base models.
- Analysis of beta factors structure of the Base model and Dummy *crisis* model provides the same set of *beta* factors. The main difference appears in the *alpha* and *crisis* period specific *alpha* (Dummy). To confirm *hypothesis 3 – Changes in the investment environment impact the hedge fund performance is reflected on alpha rather than on the beta indicators.*

Considering the above observations, the Base and Dummy *crisis* models are analyzed as a pair. Table 15 provides a more in-depth analysis of *alpha* variables of all crisis models with their respective Elasticity at Means. It complements the conclusion that Base and Dummy crisis models are coherent.

Table 15. "Crisis" alpha analysis

Strategy	Indicator	Base model	Crisis periods	No Crisis periods	Dummy Crisis
Equity	Alpha	0.0026*** (0.0005) 65.49%	0.0039*** (0.0007) 294.64%	0.0012* (0.0007) 16.39%	0.0012* (0.0007) 30.90%
	Crisis factor				0.0025*** (0.0010) 34.65%
Equity+	Alpha	0.0015*** (0.0003) 47.77%	0.0035*** (0.0005) 457.10%	-0.0002 (0.0005) -2.79%	0.0000 (0.0005) 0.93%
	Crisis factor				0.0029*** (0.0007) 49.23%
Fixed income	Alpha	0.0044*** (0.0006) 98.18%	0.0076*** (0.0009) 182.07%	-0.0001 (0.0008) -3.04%	0.0004 (0.0009) 8.31%
	Crisis factor				0.0068*** (0.0012) 83.03%
CTA	Alpha	0.0009 (0.0010) 47.91%	0.0310*** (0.0057) 1089.16%	-0.0015 (0.0011) -86.16%	-0.0013 (0.0011) -70.05%
	Crisis factor				0.0180*** (0.0034) 121.67%

Note. Standard errors in parenthesis.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$.

The analysis of *beta* indicators when comparing the Base model and Dummy crisis models provide a small impact on *beta* indicators (see also the explanation in Annex 7). However, *alpha* indicators underwent more significant changes. As provided in Table 15, the introduction of the crisis factors significantly impacted the *alpha* of all strategies, **proving hypothesis 3**.

As provided above, Equity hedge funds' Base model alpha increased from 0.0026 to 0.0039 when compared with the Crisis period model and decreased to 0.0012 in the No Crisis period model. That corresponds to *Hypothesis 4* of this dissertation – *Hedge fund managers adjust the investment strategies during the crisis to prevent drawdowns and generate positive alpha*. Furthermore, all strategies hedge funds generated alpha indicators exceed the *alpha* of non-crisis periods. Alpha in the Crisis periods model is 0.0039 and statistically significant. In contrast, the alpha in the Dummy crisis model during the crisis period is 0.0012+0.0025=0.0037, which is also statistically significant, proving the above assumption that the crisis can be adequately analyzed by comparing the Base and Dummy crisis models. As Equity+ almost replicates Equity strategy, the results of models are somewhat similar. Fixed income strategy models also provide identical results to Equity strategy models. CTA strategy Crisis periods model and Dummy Crisis model produce very high positive crisis alpha. However, considering the low level of CTA Mean return the positive alpha during the crisis is still within a similar range as in other models. The results presented in this paragraph **prove Hypothesis 4** in all models. Annex 7 presents a comprehensive Elasticity at Means data proving Hypothesis 3 and 4 for all models.

Table 16 present the *regulation* models' Adj. R^2 and AIC indicators.

Table 16. "Regulation" factor model statistics

Strategy	**Indicator**	**Base model**	**Regulation period**	**Prior regulation period**	**Dummy Regulation**
Equity	Adj. R^2	60.44%	45.58%	**67.38%**	60.64%
	AIC	-4.1266	-4.0762	-4.1826	-4.1316
Equity+	Adj. R^2	58.87%	46.35%	**64.85%**	59.05%
	AIC	-4.1899	-4.3064	-4.1713	-4.1940
Fixed income	Adj. R^2	62.04%	60.86%	**66.43%**	62.96%
	AIC	-4.7024	-4.9982	-4.6406	-4.7257
CTA	Adj. R^2	32.93%	24.66%	**42.50%**	33.46%
	AIC	-3.4504	-3.5587	-3.4891	-3.4578

Note. Adj. R^2 indicators in **bold** represent the most statistically sound model.

Elaborating the regulation variable into the models also proves defensive statement 2, as in the case of *crisis* models above. The analysis of Adjusted R^2 of all models with *regulation* factors resulted in the following:

- In all strategies, the models prior to AIFMD have higher adjusted R^2 providing the hedge fund performance can be better explained than analysis of the overall period, however
- In all models conducted when AIFMD was in place, the adjusted R^2 is lower than in the base mode.
- All models with the Dummy regulation variable are coherent with corresponding Base models.
- Analysis of beta factors structure of the base model and Dummy *regulation* model provides the same set of *beta* factors. The main difference appears in the *alpha* and *regulation* period specific *alpha* (Dummy).

The base model and Dummy *regulation* models are analyzed as a pair. Table 17 analyzes *alpha* variables of all *regulation* models with their respective Elasticity at Means.

Table 17. "Regulation" alpha analysis

Strategy	**Indicator**	**Base model**	**Regulation period**	**Prior regulation period**	**Dummy Regulation**
Equity	Alpha	0.0026*** (0.0005) 65.49%	-0.0008 (0.0008) -52.27%	0.0045*** (0.0006) 82.91%	0.0044*** (0.0006) 111.93%
	Regulation factor				-0.0047*** (0.0010) -45.59%
Equity+	Alpha	0.0015*** (0.0003) 47.77%	-0.0028*** (0.0006) -362.42%	0.0038*** (0.0005) 84.02%	0.0031*** (0.0004) 98.17%
	Regulation factor				-0.0042*** (0.0007) -49.96%
Fixed income	Alpha	0.0044*** (0.0006) 98.18%	-0.0017** (0.0008) -104.05%	0.0081*** (0.0008) 125.31%	0.0072*** (0.0008) 162.29%
	Regulation factor				-0.0073*** (0.0012) -67.04%

CTA	Alpha	0.0009 (0.0010) 47.91%	-0.0074*** (0.0016) 259.00%	0.0060*** (0.0013) 127.01%	0.0040*** (0.0013) 208.57%
	Regulation factor				-0.0083*** (0.0021) -160.08%

Note. Standard errors in parenthesis.
*** p<0.01, ** p<0.05, * p<0.1.

The impact of the regulation factor on the *beta* indicators is somewhat insignificant. Annex 7 presents this analysis in more detail. However, the analysis of *alpha* indicators also provides more significant changes, like in the case of crisis models. As provided in Table 17, the introduction of the crisis factors significantly impacted the *alpha* of all strategies, **proving hypothesis 3**.

In opposition to crisis models, regulation models provide an opposite outcome. E.g., in the Equity hedge funds' Base model, alpha decreased from 0.0026 to -0.0008 when compared with the Regulation period model and increased to 0.0045 in the no Regulation period model. That corresponds to *Hypothesis 5* of this dissertation – *Regulation constraints applied to the hedge fund industry negatively impact the hedge fund's alpha*. Furthermore, hedge funds (all strategies) generated alpha indicators are inferior to periods before the regulation. Alpha in the Regulated periods model is -0.0008, whereas alpha in the models with Dummy regulation factors during the regulation period is 0.0044-0.0047=-0.0003. Similar to the crisis models, the effect of the regulation factor can adequately be analyzed by comparing the Base model and the Dummy regulation model (identical to crisis models). These models **prove Hypothesis 5** in all Nordic hedge funds' strategies. Annex 7 presents a comprehensive Elasticity at Means data proving Hypothesis 3 and 4 for all models.

The dissertation also addresses the defensive statement 1 – *Adding the region-specific and other "hidden" risk factors into the hedge fund pricing models shall lead to a decrease in alpha, proving that hedge fund managers tend to limit the disclosure of the systemic risks taken by the hedge funds* in this section. However, in this case, *alpha* ratios cannot be compared since the model timeline changed. However, it is possible to compare the Elasticity at Means of cumulative beta indicators of Base models and Dummy crisis and Dummy regulation models.

In opposition to the defensive statement providing that *alpha* shall decrease, the cumulative *beta* shall increase. The effect of *beta* can be negative compared with the hedge fund return; therefore, this defensive statement shall be analyzed using the standardized coefficients or the Elasticity at Means. Hence, the primary assumption here should be – the cumulative Elasticity at Means of *beta* shall increase. Table 18 provides the comparison of cumulative beta for all models. However, in the case of Equity, Equity+, and CTA models, the outcome of the analysis is opposite to the assumption. Therefore, this test does not prove this statement. However, the Elasticity at Means deviations is also comparatively insignificant, denying entire rejecting the defensive statement.

Table 18. Cumulative beta analysis in crisis and regulation models, Elasticity at Means

Strategy	**Indicator**	**Base model**	**Dummy model**
Equity	Cumulative beta (crisis analysis)	34.51%	34.45%
	Cumulative beta (regulation analysis)		33.66%
Equity+	Cumulative beta (crisis analysis)	52.23%	49.84%
	Cumulative beta (regulation analysis)		51.79%
Fixed income	Cumulative beta (crisis analysis)	1.82%	8.66%
	Cumulative beta (regulation analysis)		4.75%
CTA	Cumulative beta (crisis analysis)	52.09%	48.38%
	Cumulative beta (regulation analysis)		51.51%

The dissertation analyzed the investment environment analysis based on the assumption that all crisis periods follow the same characteristics and that the models are consistent through the different crisis periods. As Figure 9 presents, returns or the trend of the hedge fund index returns is not consistent through the different crisis periods.

Concluding remarks. Introduction of Crisis alpha and Regulation alpha as Dummy variables provided the following results:

- Crisis periods have higher than the average alpha return, **proving hypothesis 4**. The experience of the hedge fund manager in preventing the value of the hedge fund from dropping can explain such higher *alpha*. This experience usually comes from previous crisis management, as analyzed by Carhart (1997), Berglund et al. (2018), and Berglund et al. (2020). Second, skills can explain (and private information outlined by Bargeron and Bonaime, 2020), find opportunities, and employ short strategies. However, Siegel (2005) claims that this additional *alpha* during the crisis could be nothing but additional liquidity premia or opacity of other risk factors.

– The opposite direction of the Regulation impact on alpha (i.e., regulated periods produce significantly lower alpha than the less regulated ones) **proves hypothesis 5**. Joenväärä and Kosowski (2020), Sullivan (2019), and other researchers came to similar conclusions. I.e., regulation reduces the risk appetite of the investors, which reduces the most uncertain part of the return – *alpha*. Secondly, reduced alpha makes hedge funds more looking like mutual funds. However, regulators also consider the contribution of Hedge funds to market liquidity; therefore, the regulation is not overly strict, and hedge funds can still generate alpha in the regulated period.

3.3. Model improvement and result interpretation

3.3.1. Asset pricing modeling in narrow coherent pools of hedge funds

Due to the limited number of hedge funds in different strategies, only Nordic equity can undergo more in-depth analysis to prove the defensive statement 2, seeing the crisis's impact and regulation factors on the hedge funds' asset pricing models. Following Teo (2009), Edelman et al. (2012), Hespeler and Loiacono (2015), Ardia and Boudt (2018), Almeida et al. (2019), Lee and Kim (2018), and Canepa et al. (2020) the Equity strategy hedge funds are split into the following pools:

– Outperforming.
– Underperforming.
– Correlated.
– Neutral.

The pools were further analyzed using the proven concept of Dummy Crisis and Dummy Regulation models. Due to hedge fund reporting biases and the small number of hedge funds in the other strategies, splitting into the pools of Fixed income and CTA hedge funds will only widen the confidence intervals presented in Table 8.

Splitting the Equity strategy hedge funds into pools positively impacted the models' statistical significance. Table 19 presents the model statistics of the models compiled based on pools of hedge funds.

Table 19. Equity pooled models' statistics

Investment environment	Indicator	Base model	Out-per-forming	Un-der-per-forming	Correlated	Neutral
Crisis (dummy)	Adj. R^2	60.44%	62.93%	71.32%	68.63%	59.77%
	AIC	-4.1266	-3.8789	-4.7383	-4.2255	-4.4927
Regulation (dummy)	Adj. R^2	60.44%	63.03%	71.48%	68.83%	59.67%
	AIC	-4.1266	-3.8815	-4.7437	-4.2318	-4.4903

The model statistics improve significantly in the pools of outperforming and underperforming hedge funds. The latter assumes the hedge funds with lower performance figures are more coherent with the market, and therefore their performance may be better explained by the market risk factors. Elasticity at Means analysis presents quite a specific view. E.g., the Stock index within each model presents a considerable variation. Table 20 presents all models' Stock index coefficients with main statistics and corresponding Elasticity at means values.

Table 20. Equity pooled models' Stock index analysis

Investment environ-ment	Indicator	Base model	Ou t-per-forming	Under-per-forming	Correlated	Neutral
Crisis (dum-my)	Stock index	0.4356*** (0.0131)	0.4932*** (0.0214)	0.4279*** (0.0140)	0.5106*** (0.0145)	0.3473*** (0.0221)
	Elasticity at means	0.2567	0.2073	0.5869	0.2619	0.3945
Regulation (dummy)	Stock index	0.4339*** (0.0130)	0.4928*** (0.0214)	0.4239*** (0.0140)	0.5055*** (0.0145)	0.3443*** (0.0221)
	Elasticity at means	0.2557	0.2075	0.5815	0.2593	0.3911

Note: Standard errors in parenthesis.

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

However, those fluctuation decrease when analyzing the absolute risk factor contributing to the hedge fund performance using factor (as presented in equation [6]). Figures 10-13 present the absolute return of the Stock index factor on the (mean Return of the hedge funds).

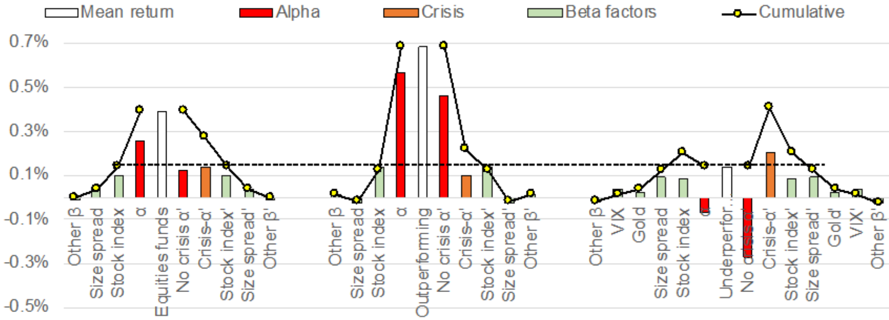

Figure 10. Absolute return contribution to the crisis performance model mean return
Note. The dashed line reflects all weighted cumulative *beta* variables of the initial model.

The relationship of the cumulative *beta* indices based on the dashed line of all models indicates the proof of H_3: *Changes in the investment environment impact the hedge fund performance is reflected on alpha rather than on the beta indicators*. This coherence of the dashed line between this and the following charts presented in Figures 11-13 also raises the point that the main distinctive factor, which changes significantly with the change of the investment environment, is *alpha*, but not the *beta* factors. Cumulative beta only increases in the case of an underperforming hedge funds model, but this is still less material compared to *"Crisis α"* or *"AIFMD-α."* I.e., while absolute cumulative *beta* in the case of underperforming models increases by 0.07% in the Crisis model and by 0.08% in the Regulation model; *"Crisis α"* and *"AIFMD-α"* are 0.20% and -0.20%, disregarding the fact that the impact is negative in the last case.

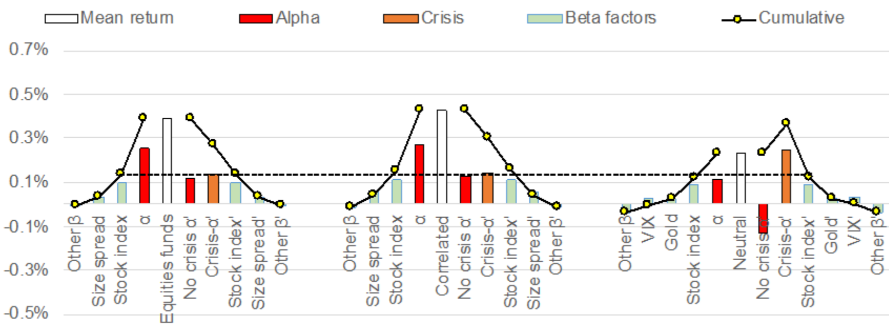

Figure 11. Absolute return contribution to the crisis correlation model mean return
Note. The dashed line reflects all weighted cumulative *beta* variables of the initial model.

Figures 10 and 11 also prove hypothesis 4 – *Hedge fund managers adjust the investment strategies during the crisis to prevent drawdowns and generate positive alpha*. The only exception is the pool of underperforming hedge funds, which overall alpha during the crisis is negative; however, the crisis alpha exceeds one of outperforming hedge funds model.

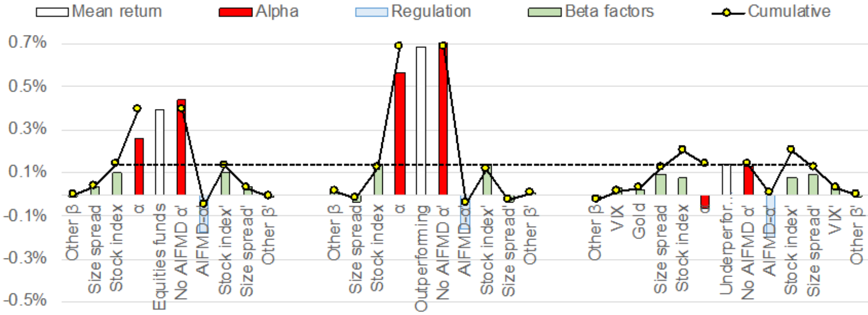

Figure 12. Absolute return contribution to the regulation performance model mean return
Note. The dashed line reflects all weighted cumulative *beta* variables of the initial model.

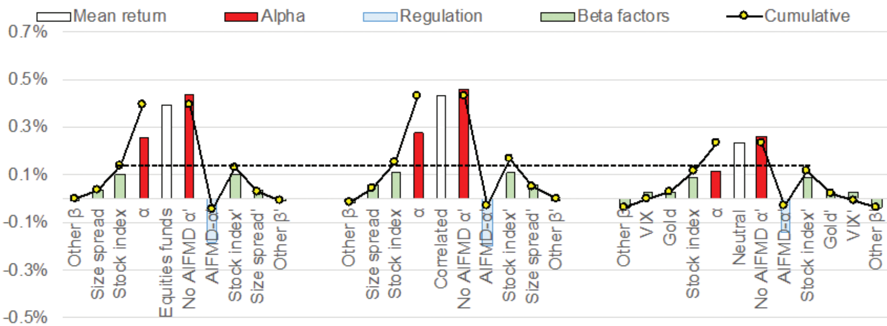

Figure 13. Absolute return contribution to the regulation correlation model mean return
Note. The dashed line reflects all weighted cumulative *beta* variables of the initial model.

Figures 12 and 13 also prove hypothesis 5 – *Regulation constraints applied to the hedge fund industry negatively impact the hedge fund's alpha*.

The dissertation also aimed to discover whether created models can prove the defensive statement 3 – *The alpha factor variation primarily explains the performance differences of the regional hedge funds, besides the variation of the systemic market risks (represented* *by beta factors).* When analyzing the absolute return contribution of outperforming equity hedge fund models, the most significant impact on exceptional performance derives from the *alpha* absolute contribution columns.

Concluding remarks: Splitting and analyzing of different pools/groups of hedge funds, as suggested by Hespeler and Loiacono (2015), Ardia and Boudt (2018), Lee and Kim (2018), and Canepa et al. (2020) showed that such modeling is more precise than the entire database, which was used in building the regional hedge fund pricing models. More in-depth analysis of the Nordic equity hedge funds also proves the defensive statement 2 providing the investment environment factors (crisis and regulation) impact the pricing models and the hypotheses 3-5 related to the impact of the investment environment affecting the alpha indicators in more in-depth models as well.

However, the in-depth analysis provided in this section has limitations, and models based on small databases cannot produce coherent pools. Therefore, such an analysis was not performed with other Nordic hedge fund strategy funds (i.e., Fixed income or CTA).

3.3.2. Assessment of the Nordic hedge fund managers' contribution

The hedge funds' asset pricing models reveal main determinants of the hedge funds' performance. The practical applicability depends on the quality and robustness of the models and how unbiased the results are. The applicability of the model increases with:

- Achieved high-level Adj. R^2 of the models when replacing the global risk factors with national.
- Consistency of the risk factors added to the Fung-Hsieh 8-factor model.
- The general trend of hedge fund managers' contribution to the performance of the Nordic hedge fund during the crisis and regulatory constrained periods, and
- Applied the cross-sectional Fixed Effect in Nordic Equity and Fixed income models.

Harvey and Liu (2018) used panel data models with random and fixed effects to reduce the noise, which does not predict the hedge fund alpha. They also concluded that effect methods outperform other alternative methods at the population (pooled data) and individual fund levels. In the end, they claim – applying the random and fixed effect methods improved the alpha forecast.

The author conducted panel data models using Common Effect presented in equation [4], Fixed effect – [12], or Random Effect – [13]. Applying the cross-section dependence with fixed effects allows estimating the individual effect on the model intercept, i.e., estimates the individual hedge fund *alpha*. The methodology to perform the panel data model effect tests is presented in section 2.3 (i.e., Random effects LM test of Breusch-Pagan, 1980; Hausman's selection between fixed or random effects, 1978; and Cross Section Dependence diagnostic test of Breusch-Pagan, 1980). After performing these tests in the order provided above, the hedge funds' performance measurement models allowed the use of the following effects (Table 21).

Table 21. Panel data models with different effects

	Common effect	**Random effect**	**Fixed effect**
Equity (All funds)	Adj. R^2 60.44% AIC -4.1266	Adj. R^2 60.69% AIC –	Adj. R^2 60.95% AIC -4.1336
- Outperforming	Adj. R^2 62.93% AIC -3.8792		
- Underperforming	Adj. R^2 71.16% AIC -4.7328		
- Correlated	Adj. R^2 68.61% AIC -4.2248	Adj. R^2 68.85% AIC –	Adj. R^2 69.12% AIC -4.2352
- Neutral	Adj. R^2 59.52% AIC -4.4874		
Equity+	Adj. R^2 58.87% AIC -4.1899	Adj. R^2 59.06% AIC –	Adj. R^2 59.28% AIC -4.1938
Fixed income	Adj. R^2 62.04% AIC -4.7024		Adj. R^2 62.83% AIC -4.7179
CTA	0AIC -3.4504		

Note. Empty cells represent failed tests and consequently the effect representing the blank cell cannot be applied.

Applying effects does not increase the models' statistical significance. It is also important to note that only Equity and Fixed income hedge funds' models were able to apply the effects. In the equity pool of hedge funds, the most statistically significant is the Correlated pool, which as an example, is analyzed further down with the Fixed income strategy. The fixed effect allows for assessing the effect on each hedge fund alpha individually and comparing how the fixed effects variate between models, i.e., Base model, Dummy Crisis, and Dummy Regulation models. E.g., a hedge fund whose fixed effect in the Dummy Crisis model is increasing compared with the Base model and is decreasing in the Dummy Regulation model would mean:

– this particular hedge fund increased its alpha more substantially than the market during the crisis and
– dropped down the alpha more than the market did.

Tables 22-23 present this logic.

Table 22. Fixed effect analysis. Equity correlated panel models

Fund number (alphabetic)	**Fund name†**	**Fixed effect of the Base model↓**	**Fixed effect of Crisis dummy model**	**Fixed effect of Regulation dummy model**
13	<…>	0.009682	0.009646	0.009806
17	<…>	0.00902	0.008895	0.009566*
20	<…>	0.005888	0.005869	0.006562*
6	<…>	0.001145	0.001374	0.000585**
…	…	…	…	…
19	<…>	-0.001401	-0.001571	-0.001879**
…	<…>	…	…	…

Note. † The author has not obtained consent to use the fund names, anonymizing them.

* an increased Fixed effect of funds #17 and #20 in the model with Regulation dummy variable shows the positive shift of modeled alpha compared with the other funds in the same panel.

** decreased Fixed effect of funds #6 and #19 in the model with Regulation dummy variable show the negative shift of modeled alpha compared with the other funds in the same panel.

Table 23. Fixed effect analysis. Fixed income panel models

Fund number (alphabetic)	**Fund name†**	**Fixed effect of the Base model↓**	**Fixed effect of Crisis dummy model**	**Fixed effect of Regulation dummy model**
1	<…>	0.005359	0.00564	0.004951**
9	<…>	0.003642	0.00337	0.004307*
…	<…>	…	…	…
2	<…>	0.00105	0.00079	0.001804*
…	<…>	…	…	…

Note. † The author has not obtained consent to use the fund names, anonymizing them.

* an increased Fixed effect of funds #9 and #2 in the model with Regulation dummy variable shows the positive shift of modeled alpha compared with the other funds in the same panel.

** decreased Fixed effect of fund #1 in the model with Regulation dummy variable show the negative shift of modeled alpha compared with the other funds in the same panel.

The provided sample allows assessing how sensitive hedge fund managers' performance and alpha are to change the investment environment conditions.

Applying fixed effects can also provide the benchmarking possibilities of the hedge funds' performance and the *alpha* part of it. Below are presented Equity "All funds" (Figure 14) and Fixed income (Figure 15) charts, which provide the comparison between Mean fund return, modeled alpha, and individually modeled alpha using the fixed effect model.

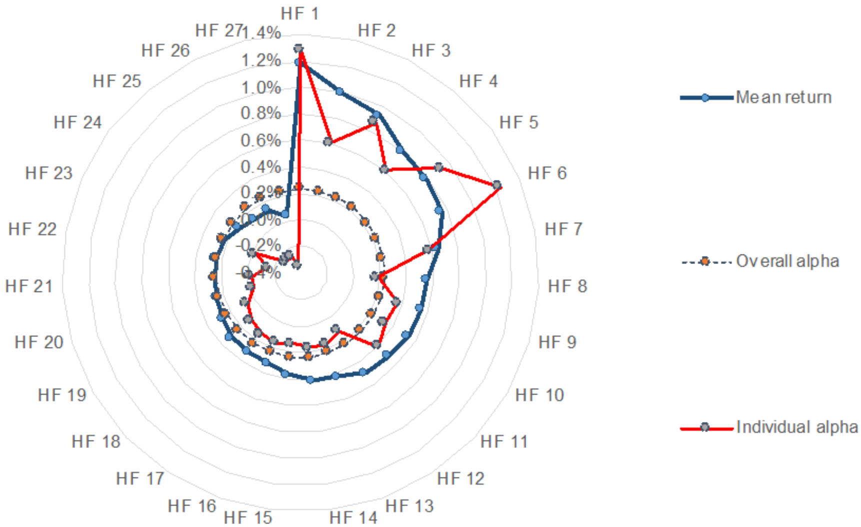

Figure 14. Equity "All funds" modeled alpha with fixed effects

Note. The numbering in the chart does not correspond to table 22, as hedge funds are put in order by decreasing performance here as in table 24 (but not in the alphabetic order).

Nordic Hedge Nordic Business Media promotes the award set to distinguish outstanding hedge fund managers from and active in the Nordic region. Analyzed hedge funds are eligible for participating in the Nordic Hedge Award. The rules for the Nordic Hedge Award provide the following categories: Absolute performance of the year, Relative performance over the NHX strategy index, Sharpe ratio, Absolute 3-year performance, and Skewness of 3 years. Alpha or the information ratio (alpha divided by the standard deviation of these excess alpha returns) would provide more fund managers' performance-focused assessment tools – i.e., performance measurement of the fund manager regardless of the risk appetite of the hedge fund investors. However, the models developed in this dissertation reflect the long-term performance measurement results, while the Nordic Hedge Award focuses more on the performance of the hedge funds over the last three years. Such a long-term analysis horizon allowed the models to assess the long-term hedge funds' performance peculiarities in different investment environment conditions. Therefore, the models can represent a long-term crisis and regulation *alpha*, which should be combined with the other one to three-year performance indicators as currently used by Nordic Business Media.

Table 24 below presents the long-term hedge fund managers' performance assessment and the ranks at Nordic Hedge Award from 2016 till 2019.

Table 24. Ranking of top 10 Nordic Equity hedge funds (long-term).

Mean return rank†	**Mean**	**Alpha**	**Std. Dev.**	**Sharpe**	**Sharpe rank**	**Inf. ratio**	**Inf. rank**	**Equity award rank by year**			
								2019	2018	2017	2016
1	1.18%	1.28%	5.26%	22.5%	6	24.4%	4	1		1	
2	0.99%	0.61%	4.61%	21.5%	8	13.3%	10		1		2
3	0.93%	0.87%	4.63%	20.1%	10	18.8%	5	2		2	3
4	0.80%	0.61%	4.58%	17.5%	14	13.4%	9	3	2		
5	0.79%	0.92%	2.48%	31.7%	3	37.2%	2				1
6	0.76%	1.24%	3.32%	22.9%	5	37.4%	1				
7	0.65%	0.58%	3.94%	16.6%	16	14.8%	8				
8	0.55%	0.19%	4.45%	12.5%	22	4.2%	17				
9	0.55%	0.37%	3.48%	15.8%	18	10.5%	11				
10	0.54%	0.34%	1.21%	44.6%	2	28.2%	3		3		

Note. † The author has not obtained consent to use the fund names, anonymizing them.

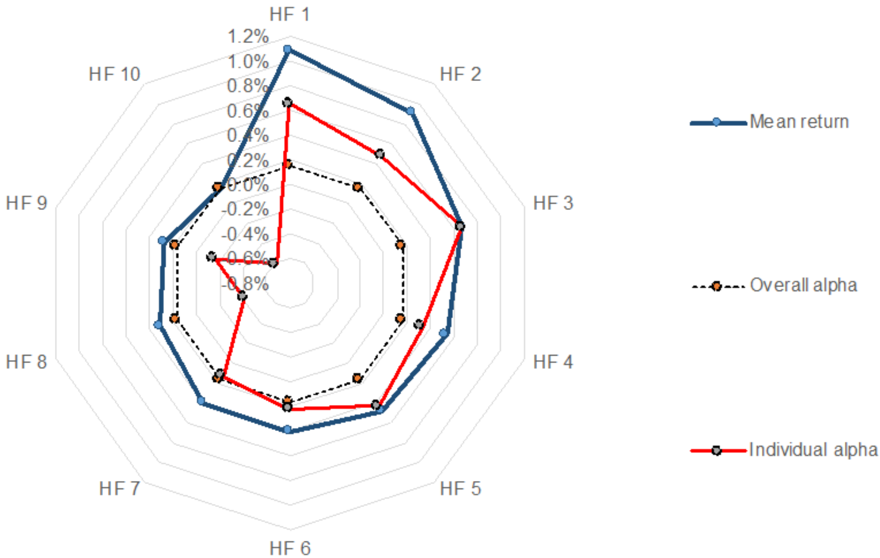

Figure 15. Fixed income modeled alpha with fixed effects

Unlike Equities, Fixed-income hedge funds' *alpha* with fixed effect does not exceed the funds' mean return. The smaller number of Fixed-income hedge funds also reveals that most hedge funds look differently from the others, grouping those funds by performance or correlation less effective than Equities hedge funds. Such viewpoints on the limitations of panel data models are also affected by data biases related to the dependent and independent variables and a small number of funds-related issues discussed in section 2.4. Research limitations and Nordic hedge funds' data biases.

Table 25 presents the performance assessment with embedded long-term alpha and Information ratio of the Nordic fixed income hedge fund.

Table 25. Ranking of top 6 Nordic fixed income hedge funds (long-term).

Mean return rank†	Mean	Alpha	Std. Dev.	Sharpe	Sharpe rank	Inf. ratio	Inf. rank	Fixed income award rank by year			
								2019	2018	2017	2016
1	1.10%	0.66%	1.88%	58.3%	1	34.9%	2	1	3	2	1
2	0.91%	0.48%	2.32%	39.2%	2	20.5%	3			1	3
3	0.67%	0.68%	1.79%	37.5%	3	37.7%	1				
4	0.54%	0.33%	2.03%	26.6%	6	16.2%	5		2		
5	0.48%	0.43%	2.66%	18.0%	9	16.3%	4				
6	0.41%	0.22%	2.13%	19.1%	8	10.3%	7			3	2
…											

Note. † The author has not obtained consent to use the fund names, anonymizing them.

Although there is less inconsistency between Nordic fixed income mean return rating and Information ratio ranking, the top-ranked Nordic fixed income hedge fund had only been ranked twice 2nd over ten years. These results propose that alpha-based performance measurement and including modeled alpha and Information ratio into the award criteria would increase the soundness and transparency of the evaluation.

Despite the minor hedge funds' database limitations, proposed splitting the hedge funds into pools by their risk and performance factors (e.g., standard deviation, Sharpe ratio, information ratio) shall take place. They may produce more suggestions on how to rate the hedge fund managers' performance by applying the Fixed effect.

3.4. Model robustness analysis

Several robustness tests were performed to assess whether conducted modes of this dissertation are robust. The first robustness tests – comparing the panel data models with corresponding linear regression models based on the NHX indices, including:

- Comparing risk and performance indicators between Nordic Equity, Fixed income, and CTA hedge funds pools with NHX Equity, NHX Fixed income, and NHX CTA.
- Comparing the above-stated pairs of model factors and Elasticity at Means of each pair.

As NHX investment strategies are unavailable at the country level, therefore Fung-Hsieh 8-factor model using Global risk factors was only used for comparison purposes.

Table 26 presents the analysis of risk and performance indicators of Nordic Equity, Fixed income, and CTA hedge fund return pools with corresponding NHX index return data.

Table 26. Summary statistics of Nordic hedge funds and NHX indices

Model	**Mean**	**Std. Dev.**	**Sharpe**	**Skew**	**Kurtosis**
Equities hedge funds	0.39%	4.88%	7.99%	-0.49	4.85
NHX Equities	*0.44%*	*1.61%*	*27.44%*	*-0.78*	*5.14*
Fixed income hedge funds	0.45%	3.72%	12.10%	-2.11	16.67
NHX Fixed income	*0.42%*	*1.41%*	*29.44%*	*-3.65*	*23.91*
CTA hedge funds	0.19%	5.24%	3.63%	0.18	3.12
NHX CTA	*0.40%*	*1.90%*	*21.33%*	*0.26*	*3.38*

Both Equity and Fixed income hedge funds pooled data mean returns are close to the respective mean returns of the index. As presented in the research limitations, there is a *Survivorship bias* characteristic of the hedge funds. As outlined by Fung and Hsieh (2004b) as well as in newer research (Hespeler and Loiacono (2015), Bunnenberg et al. (2019), Kanuri (2020), Stafylas and Andrikopoulos (2020)), usually hedge fund indexes do not include those hedge funds, which discontinued reporting due to poor results. However, selected for the analysis, hedge funds represent only limited *Survivorship bias*. These selected hedge funds' returns also represent significantly higher Standard Deviation presuming the NHX indices compensate for the significant return deviations of single funds.

The opposite situation is with the CTA strategy, where the NHX CTA index performs over two times better than pooled CTA hedge funds data. Baltas and Kosowski (2013) also obtained relatively low Adj. R^2 for the CTA strategy (0.49 for equal-weighted return and 0.41 for value-weighted return, compared with 0.21 for the Fung-Hsieh 8-factor model and 0.33 for the Fung-Hsieh 8-factor enhanced model). Very diverse CTA strategies can explain low R^2 for CTA strategy; therefore, very odd returns explain low Adj. R^2 for CTA strategy. This inconsistency is also persistent when comparing separate CTA hedge funds with each other and with NHX CTA index returns.

The selected factors are also scattered, which best illustrates Figures 16-18 below, where on the left-hand side Panel data model scaled return determinants' high-level distribution, and on the right-hand side – the corresponding NHX index model.

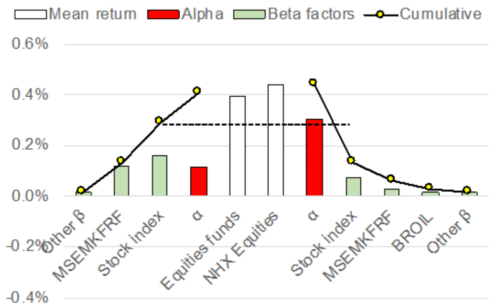

Figure 16. Nordic Equity panel data and NHX Equity absolute return contribution
Note. The dashed line reflects all weighted cumulative *beta* variables of the panel data model.

The inconsistency between Nordic Equity panel data and NHX Equity Elasticity at Means firstly derives from the big difference in *alpha* indicators. While panel data models significantly depend on the S&P500 and MSEMKFRF indices, the NHX Equity model primarily depends on *alpha* with dependency on Brent Oil (Broil) price change.

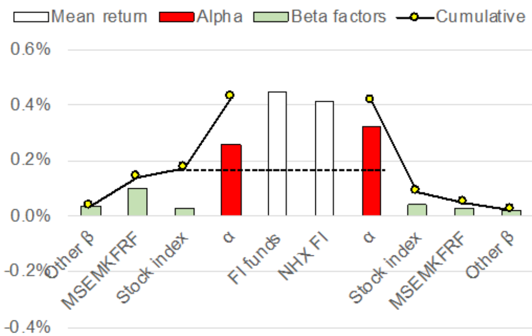

Figure 17. Nordic Fixed income panel data and NHX Fixed income absolute return contribution
Note. The dashed line reflects all weighted cumulative *beta* variables of the panel data model.

In contrast to the Equity strategy, the Fixed income panel data and corresponding NHX index-based models are not that different. Fixed income hedge funds have less dependence on the stock index S&P500 but more on the MSEMKFRF index. *Alpha* is also higher in the case of the NHX Fixed income model.

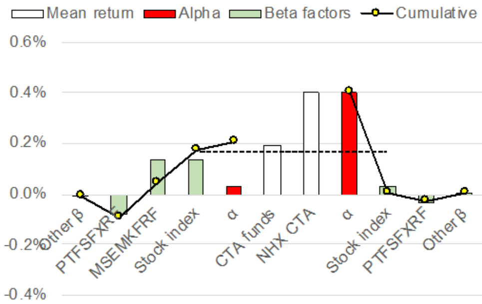

Figure 18. Nordic CTA panel data and NHX CTA absolute return contribution
Note. The dashed line reflects all weighted cumulative *beta* variables of the panel data model.

The absolute contrast to previous models is CTA. CTA index return is an *alpha-only* return. In other words, *beta* risk factors have nearly no impact on the NHX CTA index performance. At the same time, the Nordic CTA panel data model presents the opposite. There are significant dependencies on S&P500, MSEMKFRF, and PTFSFXRF (representing currency trend) and almost nil *alpha*. The comparison between panel data models with corresponding NHX indices has not revealed significant coherence. Therefore, NHX strategy index models cannot be used to prove the robustness of panel data models.

The second robustness test – comparing models built in different periods. The Dummy crisis model proved it can replace two models: the model using crisis periods and the model using non-crisis periods, which merge all periods into one. However, a more in-depth look into Global crisis periods can provide that crises are not coherent. Table 27 presents the summary of Equity crisis models.

Table 27. Equity crisis periods models

Factors	Crisis 1	Crisis 2	Crisis 3	Crisis 4	Crisis 5	All crisis
α	0.0086***	0.0046***	0.0123***	-0.0014	0.0102	0.0039***
η_α	-0.7137	0.9470	0.9049	-0.9652	-0.5997	2.9464
Mean return	-0.0121	0.0049	0.0136	0.0014	-0.0170	0.0013
Adj. R^2	0.6601	0.7368	0.3931	0.4600	0.6537	0.6396

Note. Standard errors in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

Crisis 1, 2, and 3 models present statistically significant *alphas* exceeding all crisis periods' long-term alpha. It is also important to note that although Crisis 1 resulted in a negative mean return , the Elasticity at Means is also negative, and therefore the total alpha contribution of the hedge fund managers is positive 0.0086 monthly or 10.32% annually. Crisis 4 and 5 result in either negative alpha or the alpha is statistically insignificant. On the one hand, Crisis 5 also has not produced the full Fung and Hsieh 8-factor model due to the panel data model limitations. On the other hand, only the Stock index determines *alpha*; therefore, considering Hypothesis 1 and 2 and Defensive statement 1, further analysis of Crisis 5 alpha is irrelevant.

AIFM directive overlaps the Crisis 4 period, and the impact of AIFM directive implementation on the alpha was negative, raising the conclusion – the regulation's negative impact on the alpha dominates over the positive impact of the crisis *alpha*. This observation requires additional modeling and analysis to define the hedge fund performance determinants in the post-AIFM directive implementation phase considering crisis and other investment environment changes over this period. The dissertation, however, aims to create the methodology for creating the region-specific hedge funds' performance assessment models. Annex 8 presents the full Fung and Hsieh 8-factor National Enhanced models of different Global crisis periods.

The other robustness test used in this dissertation – adding the lagged dependent variable for residual autocorrelation as proposed by Racicot and Théoret (2016) and Ardia and Boudt (2018) in their hedge funds' performance measurement research. The main finding of the robustness analysis is that including the extra control variable has not removed the statistical significance of the factors included in the models.

3.5. Scientific discussion of the constructed regional models

The objective of this dissertation was, based on the Nordic hedge fund market example, to develop the methodology of adapting the hedge funds' performance measurement models to specific regions taking into account different investment environment conditions (i.e., determined by the effect of crisis and changes in the regulatory regime) resulting in robust models and transparently presenting the contribution of the hedge fund managers (i.e., providing the *alpha* net of undisclosed risk factors).

Hedge funds usually are analyzed using the models able to analyze the non-linear payoffs and high-risk strategies characteristic of hedge funds (of which the most widely used is the Fung-Hsieh's 8-factor model of Edelman et al. (2012), claiming to cover up to 80 percent of the monthly hedge fund return). However, the likes of Agarwal et al. (2018), Stutzer (2018), and Knif et al. (2020) claim that hedge funds *alpha* can be well defined using traditional models, such as CAPM or APT.

This dissertation aims to create the methodology for assessing regional hedge fund performance, while researchers in this field usually analyze the global hedge fund databases and use US market-based risk factors. As Christoffersen et al. (2014) outlined – the US asset markets strongly drive the hedge fund industry and commodities market. There are only a few research papers focusing on the local hedge funds, i.e., Do et al. (2005) Australian hedge funds; Van Dyk et al. (2014) European and Asian hedge funds; Gibilaro et al. (2018) Cypriot hedge funds; Oueslati and Hammami (2018) Saudi Arabian and Malaysian hedge funds; Huang et al. (2018) Chinese hedge funds; Kanuri (2020) Japanese hedge funds. However, these research papers have not aimed to build region-specific hedge funds' performance assessment models but instead focused on the differences in the performance and the market development trends. More importantly, what role do regional peculiarities play in the performance of the regional hedge funds, and is it possible to determine which categories of the factors are impacted by and represent the region most?

Building CAPM, Fama-French 4-factor, and Fung-Hsieh's 8-factor models using international (US-based) market risk factors and aligned to the Nordic countries' factors (i.e., Equity and Bond market risk factors) increased the model statistical significance in various ways. Adjusted R^2 increased by 15-20 percent, and AIC dropped by 0.3-0.4. This trend, however, has not been achieved in the case of Nordic CTA funds. In mutual funds, similar results were achieved by Vrontos et al. (2008) or Østlyngen (2017), considering hedge fund managers are also more focused on the local equity and bond market. However, the research in this dissertation followed a slightly different approach, as there are no reliable hedge fund trend-following factors available for the local (e.g., Nordic) hedge fund trends. Therefore, all return and local market risk factor data were translated USD compatible variables performed to match with Global trend following factors. In general, all "exotic" risk factors and non-local risk factors (e.g., commodities, liquidity, other assets) are not adjustable for "localization" in the hedge funds' performance measurement models. Regardless, *Hypothesis 1* was fully proven with Nordic equity and Nordic Fixed income hedge funds.

For the CTA strategy, the methodology uses a different modeling approach.

When testing *Hypothesis 2*, i.e., additional factors representing some of the assets present in the hedge funds can generate statistically more significant models. However, the Equity and Fixed income funds' models' statistical improvement was relatively modest – from 0.6033 to 0.6044 and from 0.6077 to 0.6204, respectively. By adding new factors, Dewaele et al. (2015) achieved an increase in R^2 from 0.73 to 0.79, and Edelman et al. (2012) from 0.59 to 0.73 when adding emerging market factors. However, adding Fama and French (SMB, HML, and MOM), Gold and Silver prices, and liquidity LIQ and OCMDRWT commodity index factors significantly impacted the CTA model. Adjusted R^2 increased from 26.26% to 32.93%, and AIC decreased from -3.3592 to -3.4504. Considering their little consistency, as provided by Stafylas et al. (2018) and others, this still shall be considered a substantial model improvement. Gold, Silver, LIQ, and OCMDRWT factors are fundamental for the Nordic CTA hedge funds' performance.

Including the additional risk factors is somewhat new and common practice in recent research (e.g., Chen et al., 2018; Gibilaro et al., 2018; Jame, 2018; Stafylas et al., 2018; Asensio, 2019; Racicot and Theoret, 2019; Shaikh, 2019; Li et al., 2020; Mensi et al., 2020). Adding of those new risk factors has not had an impact on Equity and Fixed income hedge funds' models. Equity and Fixed income hedge funds only depend on the liquidity index of Pástor and Stambaugh (2003) and the OCMDRWT commodity index.

The combination of methods used to prove *Hypothesis 1* (i.e., national market risk factors) and *Hypothesis 2* (i.e., additional risk factors) provides the region-specific hedge funds' performance assessment modeling methodology. To add to *defensive statement 1*, the models are reaching their absolute level of statistical significance, although not as high as Adj. R^2 reached 80% by Edelman et al. (2012). However, based on Almeida et al. (2019), lower Adj. R^2 is characteristic of panel data models, whereas NHX index-based multiple linear regression models used in robustness analysis generated Adj. R^2 0.8269 and 0.6812 and AIC -7.1291 and -6.7862 for NHX Equities and NHX Fixed income models respectively[31].

This higher unexplained return depends on the dispersion of hedge fund manager *alpha*, presented as regression intercept, which does not change over time, and

31 The models were conducted using Fung-Hsieh's 8-factor extended model with only one factor representing the local stock market – OMXN40RF, i.e., monthly OMX Nordic 40 Index (SE0001809476) minus Risk-free rate

accidental return (i.e., *error* – *ε*). However, Berk and Green (2004) claim "that active management is a complete waste of time." They brought the idea that investment performance *alpha* is not just skill but, in most cases, shall be dedicated to luck. The central hypothesis they address states that fund managers' performance has little persistence. They stated that the positive result in one period negatively impacts the next or few coming periods as the successful fund manager will face burdens by increased funds and, therefore, will not achieve that high level of return on the additional capital compared to the results achieved with less capital. The dissertation proves the existence of the *alpha* regardless of the focus on the long-term *alpha*. The dissertation analyzes monthly return data; therefore, frequent fund adjustments and algorithmic (especially time and arbitrage targeting) trading cannot be analyzed here. Shin et al. (2019) presented that frequent hedge fund adjustments and algorithmic trading are significant and need to be tracked more frequently.

Defensive statement 1 also assumes *alpha* shall decrease each time the model adds a new statistically significant risk factor, although Agarwal et al. (2018) and other researchers claim this is not true in many cases. The dissertation proves the statement when adding the systemic national (i.e., equity and bond) factors and achieving a significant statistic improvement of the hedge fund pricing model. However, in cases when the additional risk factors supplement systemic and those "exotic" trend-following risk factors, the decrease of the *error* – *ε* is insignificant (i.e., Adj. R^2 does not change), and *alpha* changes are not conclusive. In the case of Equity and Fixed income hedge fund strategies, Fung-Hsieh's 8-factor model with national equity and bond risk factors shall be sufficient to estimate the *alpha* net of undisclosed risk factors, whereas in the case of CTA, Fung-Hsieh's 8-factor model is not sufficient and enhancement of the model with additional risk factors is needed.

The other important focus of this dissertation outlined in *defensive statement 2* was to incorporate the investment environment into the modeling, making the models fit various market conditions (e.g., distressing of the crisis or regulatory environment). While initially (right after the 2007-2008 crisis), hedge funds were analyzed in the context of crisis as significantly exposed to the crisis based on their credit risk concentration or liquidity risk exposure (Spiegel, 2009; David et al., 2010; Boyson et al., 2011; Aiken et al., 2012; Gropp, 2014; Costa, 2014). The newest research in this area focuses on analyzing how any specific factor impacts the performance or what factors can distinguish hedge funds from other investments that may be more successful during the crisis or regulation-constrained period. Cao et al. (2018), Zhao et al. (2018), Liang and Qiu (2019), and Gregoriou et al. (2020) analyzed this phenomenon of hedge funds. In contrast, Metzger and Shenai (2019), Sung et al. (2020), and Denk et al. (2020) look rather specifically at those distinctive hedge funds. The impact of the regulation is not as common as the analysis of the performance past the global financial crisis of 2007-2008, e.g., Sullivan (2019) concluded that the decline of alpha past financial crisis was related to reducing the investors' risk due to a better understanding of the hedge fund-specific risk factors. Joenväärä and Kosowski (2020) concluded that the regulation diminishes the alpha due to a reduction of liquidity exposure or leverage ratio, characteristic of mutual funds. However, the dissertation aimed to define how the investment environment factors impact the model and which determinants are most impacted by them.

The method of using dummy variables for Crisis and Regulation and adapting them to the specific region or country was unique for the dissertation. Analysis performed based on these variables cannot be directly compared with Hespeler and Loiacono (2015), Joenväärä and Kosowski (2020), Sullivan (2019), Berglund et al. (2018 and 2020), Maloney and Moskowitz (2020), and other researchers, who addressed either just one part of the environment or were only looking into the hedge funds' indices.

Using different crisis factors embedded into the model methods (e.g., Dummy crisis models as well as building the models separately for crisis and non-crisis periods), all models presented a relatively stable composition of beta factors proving *hypothesis 3* and the consistently positive impact on alpha during the crisis – proving the *hypothesis 4*. However, neither of the researchers who specifically analyzed the impact of the crisis on the hedge funds, i.e., Hespeler and Loiacono (2015), Pástor and Vorsatz (2020), Maloney and Moskowitz (2020), concluded that crisis periods have a positive impact on *alpha*. However, even though hedge funds can generate negative returns during a crisis, hedge fund managers can still prevent the value of the hedge fund from dropping to the level of market declines. Brandt et al. (2019), Franzoni and Giannetti (2019), Liang and Qiu (2019), and Chen et al. (2020) analyzed various aspects of hedge fund performance during the crisis and only concluded that hedge funds' managers with special skills could produce the positive alpha during the crisis.

However, the positive crisis alpha contradicts the research by Metzger and Shenai (2019), who compiled separate models using the financial crisis of 06/2007 – 03/2009 and the non-crisis period after the crisis until 01/2017. While the alpha of the

9,500 hedge funds collected in Credit Suisse's Hedge Index database calculated using the Fama-French 4-factor model (Carhart, 1997) is dominantly negative during the crisis, it remains negative in some strategies even after the crisis: i.e., *crisis alpha* -0.0004 and -0.0008 after the *crisis*.

Hypothesis 4 was tested assuming that various crisis periods are coherent and no crisis-specific factors exist. The results were quite surprising when building equity hedge fund models for each of the five selected Global crisis risk factors. The 2007-2008 crisis model (before the AIFMD) provided significantly higher *alpha* than the long-term modeled *crisis alpha*: i.e., 0.0086***[32], 0.0046***, and 0.0123*** against 0.0039***. At the same time, the *crisis alpha* of the Brexit crisis is negative and less statistically significant -0.0014. Due to panel data modeling limitations Covid-19 crisis model could not be concluded using Fung-Hsieh's 8-factor enhanced model.

The author analyzed Covid-19 Nordic equity hedge funds' performance phenomenon in the separate research and concluded that Covid-19 represents the second best favorable period for Nordic equity hedge funds. However, it was not as good as the long-only equity mutual fund performance. Regardless of some controversy between the models' estimated *alpha*, there is a consensus among researchers (e.g., Sung et al., 2020; and Denk et al., 2020, among the latest) who agree that hedge funds have better results than other types of investment during the crisis period. This exceptional performance during the crisis suggests the hedge fund managers' skills are well executed and conclude the *crisis alpha* factors.

The impact of the Regulation alpha, though, corresponds to the observations made by Chan et al. (2007), Brown et al. (2012), Cerutti et al. (2010), Joenväärä and Kosowski (2020), Sullivan (2019), and Berglund et al. (2018 and 2020). All the papers point to the increased costs of hedge fund management and borrowing and the limitation of the risk, consequently impacting the total return. However, as Berglund et al. (2020) pointed out, the systemic beta risk factors do not impact this decrease in the return; therefore, alpha shall be the main factor that impacts the total hedge fund return. The assessment of the regulation impact in all models resulted in the decrease of *alpha,* proving *hypothesis 5,* and relatively insignificant variations of *beta* factors proving *hypothesis 3*.

As proposed by Teo (2009), Edelman et al. (2012), Hespeler and Loiacono (2015), Ardia and Boudt (2018), Lee and Kim (2018), and Canepa et al. (2020), nar-

32 Where *** p<0.01, ** p<0.05, * p<0.1 and "no asterisk" p>0.1

rowing the hedge fund strategy to sub-strategy level reduces the dependent variable scattering and makes asset pricing models more robust. Splitting Equity hedge funds into pools of Correlated with the NHX index and Neutral to the NHX index (following Hespeler and Loiacono, 2015); Outperforming the NHX index and Underperforming the NHX index (following Canepa et al., 2020). On the one hand, correlated and underperforming models provided the improvement of R^2. On the other hand, comparing Total, Outperforming, and Underperforming panel data models, the main difference derives from different *alpha* contributions (Figures 10 and 12), which all obtain comparatively similar returns from beta risk factors. Such high *alpha* returns correspond to the observation of Fung and Hsieh (2004a), Kosowski et al. (2007), and others that the primary performance measurement of the hedge funds is *alpha* rather than the market risk factors (*beta*). This conclusion also contributes to proving the *defensive statement 3*.

The analysis of absolute alpha and beta factors contribution analysis also supported the successful proof of the dissertation hypothesis and defensive statements. Used Elasticity at Means η_k and Absolute return of factor *k* measures allowed analyzing the scaled impact on mean return as Gelman (2008) proposed. In the case of Equities and Fixed income, the definite leading weighted factor is alpha, while in the case of CTA, *alpha* is relatively modest. As Equities and Fixed income panel data models could apply the Fixed Effect, Figures 14 and 15 show that the individual hedge fund Mean return in many cases is coherent with individual *alpha*, estimated using the Fixed Effect.

Considering hedge fund return reporting data biases widely presented by Hespeler and Loiacono (2015), Bunnenberg et al. (2019), Kanuri (2020), Stafylas, and Andrikopoulos (2020), inherent to hedge funds' indices (NHX in the Nordics), the panel data models used in this dissertation have eliminated them as only hedge funds which reported the return over the whole research horizon were analyzed. Adding significantly high (for the hedge funds) determination coefficients (R^2) and the lagged return variables Y_{t-1} also used by Racicot and Théoret (2016), Ardia and Boudt (2018) prove the models are robust.

CONCLUSIONS AND RECOMMENDATIONS

The dissertation examined adjusting the hedge funds' performance measurement models to the specific region hedge funds. Testing the hypothesis and comprehensive examination of the defensive statements were performed by analyzing Nordic hedge funds representing four countries and reported in 5 different currencies. Such diversity makes Nordic countries a suitable environment for achieving the goals of the dissertation. A comprehensive analysis of the capital asset pricing models enabled the identification of the most suitable and robust models to assess the performance of the Nordic hedge funds. The outcomes of analyzing the hedge fund investment phenomenon, model selection, and risk factor selection with in-depth cohesion with other researchers lead the author to the following conclusions:

1. Due to the unique hedge fund investment techniques, including applying leverage, short-selling, or frequent trading, some part of the return becomes merit of applying "exotic" investment strategies or a unique skill of the hedge funds manager known as alpha. The review of the theoretical aspects of the hedge funds' performance measurement models highlighted the primary distinction of hedge funds being focused on the absolute return, which derives from an abnormal result of skilled investments regardless of the general market trend. As the high absolute return is subject to the high management and success fees claimed by the hedge fund managers, fair estimation of alpha is a primary subject for many researchers.

2. Decomposing the hedge fund performance into various factors allows hedge fund investors and analysts to differentiate which part of the return derives from the market and which belongs to the hedge fund managers. Researchers argue whether asset pricing models enhanced with "exotic" risk factors and tailored for hedge funds (such as Fung and Hsieh's 8-factor model) can better explain the alpha than the conventional ones like CAPM or the more sophisticated Fama-French 4-factor model. Therefore, the author selected a wider variety of factors with more focus on the regional specifics and the alternative hedge fund investment strategies (e.g., frequent trading or certain commodities).

3. The analysis revealed that region-specific hedge funds usually report their returns and execute strategies using local currency. Eliminating the FX effect deriving

from the reporting of the hedge funds and the local market indices by recalculating everything into the USD gave a substantial improvement to the models, making the models more conclusive compared with other Global or region-specific hedge funds and their performance measurement models.

4. Following the APT theory, portfolio performance can be best explained by conducting the model using the factors representing the investment instruments used in the portfolio. Although this idea has not been widely researched, the local stock and bond market indices shall prevail when building the regional hedge funds' performance measurement models. Replacing the US dominant factors in Fung-Hsieh's 8-factor model (S&P500 and 10 US Gov. bond yield) with corresponding local factors increased adjusted R^2 in equity and fixed income strategies by 17-19 percent. The same APT logic, however, pointed more toward using a wider variety of Commodity and financial derivatives applicable to CTA funds. Additional commodity factors resulted in the increase of adjusted R^2 by almost 7 percent. Building the regional hedge funds' performance measurement models combining local risk factors and additional investment-specific factors allowed proving hypotheses 1 and 2.

5. Although adding the new risk factors to the models increased their statistical significance, reduced the statistical noise level, and proved hypotheses 1 and 2 as presented above. The general idea of defensive statement 1, alpha being overvalued by not disclosing some risk factors (e.g., liquidity factor), has been proven, however, with some inconsistency. On the one hand, when comparing Fama-French's 4-factor national model's *alpha* with coherent Fung-Hsieh's 8-factor national model's *alpha*, there is a decrease in *alpha* (e.g., in the case of Equity strategy from 0.0028 to 0.0025). However, the alpha change in proving hypotheses 1 and 2 had an opposite direction (i.e., in the case of Equity strategy increased from 0.0025 to 0.0026). Therefore, the proposed models do not fully support the defensive statement 1.

The analysis of the hedge funds' performance measurement modeling revealed many hedge funds' performance measurement methods and models. Testing them allowed examining raised hypotheses and achieving a high level of robustness of the models. The evidence of the Nordic market with its investment peculiarities allowed achieving the following conclusive results:

6. The panel data model selected for the analysis also allows incorporation into the model of country-specific, fund-specific, strategy-specific, and time-specific factors. Considering those factors have a linear dependency on hedge fund returns, the

models are more explanatory than those based on non-linear dependence. Adding the various investment environment changes representing time-specific factors – Dummy variables, in the models was a unique research attempt. The models were able to select Global crisis and AIFMD implementation timelines proving the defensive statement 2.

7. Models used Elasticity at Means (dependent variable) to graphically present and analyze the risk factor contributing to the long-term performance of the hedge fund. Using Elasticity at Means in asset pricing models is not common; however, this allows for comparing various risk factors among different strategies and sub-indices. Proposed by the author method of comparing the cumulative beta factors of related models allowed to determine how alpha and beta factors variable between outperforming and underperforming or correlated over neutral models. In most cases, *beta* factors are responsible for quite a similar part of the return, whereas *alpha* varies depending on the overall performance of the hedge funds. Using the Elasticity at Means method allowed proving hypothesis 3.

8. Analyzing the local hedge funds' performance peculiarities revealed some of the models' discoveries. The average lifespan of the hedge funds is five years, whereas over 50 percent of Nordic hedge funds reported returns of over ten years, making Nordic a long-living region. This quality of the hedge funds supposes the hedge fund managers have a long successful experience and have withstood at least two crisis periods. On the same note – Nordic hedge funds outperformed Global hedge funds by 8 percent during the severe hedge fund drawdown caused by the financial crisis of 2007-2008. All these qualities raise the assumption that Nordic hedge funds shall have some positive determinant of the performance during the crisis, attributable to the Nordic market or Nordic hedge fund managers, which may not be a case in other regions.

9. Based on the other researchers, the author selected crisis periods that represent the market conditions, which limit the borrowing possibilities, cause higher depreciation of some of the exposures due to the currency exchange rates, and cause panic in the market with consequent sell-offs. The selected crisis and regulation periods disconnected from the stock or bond market indices allowed for avoiding the problems of autocorrelation. The selected Global crisis periods and AIFM directive implementation timeline were statistically significant when embedded into the models.

10. Analyzing the impact of crisis or regulation in the long run resulted in coherent results between analyzing either of the periods separately and analyzing them together using the time-specific Dummy variable methods. This result allowed simpli-

fying the models using a single model for both crisis and non-crisis or regulation and prior-regulation periods. However, this conclusion is invalid when analyzing hedge fund performance using short-term periods.

11. Applied panel data effects (fixed effect and random effect) allowed finding the hedge fund-specific *alphas*, which can be used when comparing hedge funds' performance. Fund-specific alpha factor can have a practical use if models contain coherent hedge funds and models achieve a significant level of adjusted R^2.

The dissertation's methodology provided a sound background for building the region-specific hedge funds' performance measurement models. The methodology also allowed conforming the hypotheses 4 and 5, which have a solid background to consider are Nordic region-specific:

12. Many researchers agree that the Crisis event significantly impacts the hedge fund performance and management, dramatically changing the portfolio's market risk factors (their combination). Regardless of the overall possible negative return of hedge funds during the crisis, hedge fund managers focus their efforts during the crisis to compensate for the market's losses. Considering that Long-living hedge funds represent the Nordic hedge funds' universe, the positive *alpha* "premium" during the crisis has a connection with longevity. Although hypothesis 4 was proven using various models and approaches, there are still possibilities using a different research approach, and in different regions, a crisis will reduce the *alpha*.

13. The impact on the hedge fund alpha by the Regulation factor is negative. Concluding that the limitations imposed by the regulators are impacting the overall investment environment, as well as on the hedge funds or hedge fund managers directly, this all results in increased cost of operations and limited possibilities to accept more risk into the hedge fund. Analysis of the hedge fund performance *beta* also pointed out that this factor has no long-term impact deriving from the regulation. Therefore, the decreased *alpha* explains the negative impact of the regulation on the return and proves hypothesis 5.

14. The decomposition of the Nordic Equity hedge funds into coherent pools by the performance and the result correlation with the index return also revealed that the primary source of the differences between the funds derives from the *alpha* rather than *beta* factors variation. While the differences between *beta* factors were evident when comparing different strategies (e.g., Equities vs. Fixed income). Such an outcome of the research supports defensive statement 3 and proves how vital the *alpha* factor is in

selecting the right hedge fund for the investment.

The regionality dimension also requires additional focus from the researchers to provide which factors have more tendencies of being region-specific and shall be tested and included in the regional hedge funds' performance measurement models. The main observations and recommendations in that respect are as follows:

1. In the case of other regions (e.g., Gulf countries, Australia, and European regions), the hedge fund strategies can be more focused on the dominant local commodities. Furthermore, the commodities prices are considered Global, and there is a possibility to find a significant impact of these commodities on the performance and the models.

2. It would also be advisable to reconsider the base model in different regions, as the other regions' hedge funds may not be as strongly dependent on the local financial markets (i.e., stock, bond, IR, FX instruments). Instead, they could be more focused on the previously mentioned commodity instruments or even by more considerable dependency on the credit risk or liquidity risk premiums (in the case of the emerging market).

In order to promote the development of hedge fund pricing models and a more in-depth analysis of how Crisis and Regulation impact asset pricing models, the following research actions or areas are recommended:

3. Hedge funds are claimed to generate the absolute return; therefore, the hedge funds' performance measurement models, especially on a regional basis, aim to estimate the *alpha* net of undisclosed risk factors. To provide more robust proof, the models shall also include the comparison of the performance determinants of the mutual funds using the same investment environment factors and respective periods.

4. To compile models on shorter and more precise periods, which, on the one hand, should further remove the heteroscedasticity problems and, on the other hand, would also orient the model to analyze the same fund manager with the same style (long horizons assume there could be some changes over the time either in strategy or in changing the fund manager). The comparison with other studies shows that the long-term models are more determined by the asset-based risk factors rather than those more "exotic," which tend to change over time, especially in the changeover periods using the short-term analysis horizons.

5. The model assumes that different crisis periods follow the same pattern and depend on the same pricing model when analyzing the crises. The separate crisis pe-

riods analysis test showed that models differ when comparing different crisis periods against each other. More in-depth analysis of various crisis periods (as already mentioned Covid-19 period) shall provide a different view on how causes of crisis may fundamentally differ.

6. Since Homogeneous Panel data models do not suggest any possible relations with lagged variables, panel data models should use the Vector Autoregression method. After applying the Granger causality test to transfer significant lagged variables into Homogeneous Panel data for the final analysis model. These lagged variables should also identify the luck part of achieving the high alpha; shall this luck be a short-term effect?

7. Various researchers defined the connection between the performance of the hedge funds and consequently their produced alpha with the size of the fund. Although the Nordic hedge fund database could not present the AUM of the hedge funds and, more importantly, could not present the dynamics of AUM growth in the case of analyzing different regions. The author recommends retrieving such data and modeling with the hedge fund AUM and the growth rate.

8. Hedge fund performance analysis needs to include "dead" hedge funds. While long-living hedge funds characteristically have more stable returns and lower volatilities, "dead" funds may represent those sensation-seeking funds, which only succeeded in generating the absolute return during a single economic cycle.

When analyzing the practical applicability of the models and sorting the hedge funds by their long-term alpha, the results were somewhat coherent with the Nordic Hedge Nordic Business Media promoted award. However, these awards are mainly based on one to three years of hedge fund performance. The recommendations for the practical application of the models in the Nordic regions are as follows:

9. Long-term hedge funds' performance measurement models present a long-term crisis and regulation *alpha*, which should be combined with the current one to three years performance indicators used by Nordic Business Media.

10. Short-term hedge funds' performance measurement models would not reflect the hedge fund managers' contribution to the performance during the crisis or other changes in the investment environment. However, using the panel data models with fixed effects in the short-term models can provide the tool for ranking the hedge funds between each other based on *alpha* or specific *beta* indicators.

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ANNEXES

Annex 1. Hedge funds' indexes descriptive statistics

Table 28 below shows descriptive statistics and ADF one-sided p-values (MacKinnon, 1996) of the models based on NHX strategy, Country indices, and HFRI index.

Table 28. Summary statistics of NHX indices (monthly).

Strategy index	Mean	Std. Dev.	Sharpe	Skew	Kurto-sis	ADF-p
NHX Equities	0.44%	1.61%	27.44%	-0.78	5.14	0.0000
NHX Fixed income	0.42%	1.41%	29.44%	-3.65	23.91	0.0000
NHX Multi-strategy	0.37%	1.18%	31.53%	-0.77	4.70	0.0000
NHX CTA	0.40%	1.90%	21.33%	0.26	3.38	0.0000
NHX Fund of funds	0.12%	0.96%	13.03%	-1.48	9.00	0.0000
NHX Composite	0.36%	1.18%	30.41%	-1.04	6.75	0.0000
HFRI	0.36%	1.83%	19.73%	-1.30	7.62	0.0000

Figure 19 below displays the differences in NHX country index dynamics, where the starting point of 100 levels all NHX country indices and the HFRI index.

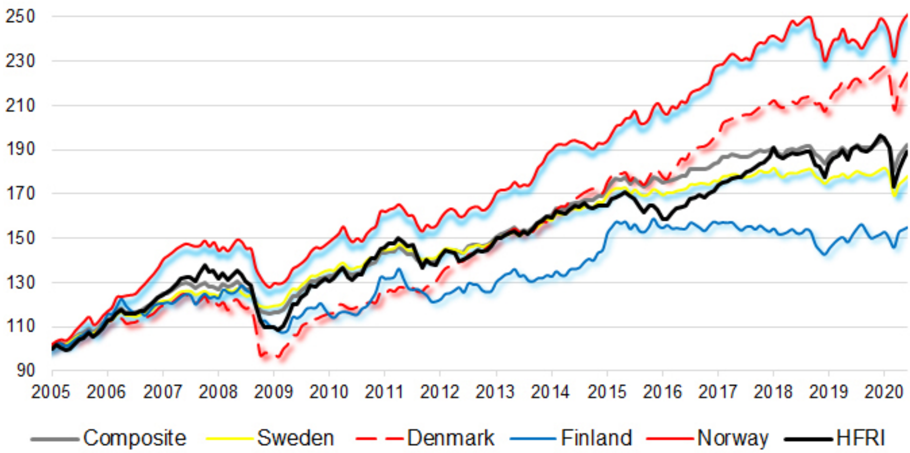

Figure 19. NHX country indices dynamics

Although NHX country indices' dynamic looks relatively coherent, compared to the HNX strategy indices lines in Figure 7, there are some insignificant differences in index movement directions. These differences lead to the premise that national peculiarities arise due to differences in stock prices, interest rates, currency exchange, or other factors. Panel data models of this dissertation further address these differences. Table 29 below presents descriptive statistics of the NHX indices by countries together with ADF one-sided p-values.

Table 29. Summary statistics of NHX by Country (monthly).

NHX country index	**Mean**	**Std. Dev.**	**Sharpe**	**Skew**	**Kurto-sis**	**ADF-p**
Sweden	0.32%	1.03%	30.71%	-0.90	6.86	0.0000
Denmark	0.45%	1.72%	26.24%	-2.56	17.20	0.0000
Finland	0.25%	1.72%	14.52%	0.02	3.77	0.0000
Norway	0.51%	1.56%	32.65%	-0.83	4.75	0.0000
NHX Composite	0.36%	1.18%	30.41%	-1.04	6.75	0.0000
HFRI	0.36%	1.83%	19.73%	-1.30	7.62	0.0000

Annex 2. Nordic hedge funds data and statistics

Summary statistics of the different strategy Nordic hedge funds with risk-return scatter plots of each strategy hedge funds are presented below.

Table 30. Summary statistics of Nordic Equity hedge funds (monthly).

Hedge fund strategy	Mean	Std. Dev.	Sharpe	Skew	Kurto-sis	ADF-p
Rhenman Healthcare Equity EUR	1.18%	5.26%	22.49%	-0.48	4.97	0.0000
Gladiator Fond	0.99%	4.61%	21.49%	-1.27	10.23	0.0000
Accendo Capital Sicav SIF	0.93%	4.63%	20.12%	0.95	8.02	0.0000
Priornilsson Idea	0.80%	4.58%	17.46%	-0.83	9.27	0.0000
Taiga Fund	0.79%	2.48%	31.70%	-1.83	14.89	0.0000
Mjeltevik Invest IS	0.76%	3.32%	22.88%	1.47	7.38	0.0000
Sector ZEN Fund	0.65%	3.94%	16.55%	-0.05	4.28	0.0017
Atlant Edge	0.55%	4.45%	12.47%	-0.57	3.92	0.0002
AAM Absolute Return Fund Class B NOK	0.55%	3.48%	15.81%	0.15	5.73	0.0000
Sector Healthcare Fund	0.54%	1.21%	44.59%	0.45	3.45	0.0186
Carnegie Worldwide Long-Short	0.51%	2.66%	19.11%	-0.78	5.70	0.0000
Ram One	0.50%	2.60%	19.23%	0.71	17.02	0.0000
Thyra Hedge	0.43%	1.93%	22.20%	-0.24	10.01	0.0000
Coeli Norrsken	0.42%	2.30%	18.18%	-0.86	11.04	0.0000
Alcur	0.37%	0.73%	51.12%	0.88	7.06	0.0000
KLP Alfa Global Energi	0.32%	1.89%	17.06%	-0.13	4.55	0.0001
Inside Hedge	0.31%	2.86%	10.81%	0.32	5.42	0.0000
Atlant Sharp	0.31%	3.78%	8.15%	-0.97	5.77	0.0000
Solidar Smartbeta Trend	0.27%	2.76%	9.90%	0.34	4.16	0.0009
QQM Equity Hedge	0.26%	2.05%	12.49%	-0.32	5.50	0.0000
Adrigo Fund	0.25%	1.70%	14.47%	-1.62	18.65	0.0000
Priornilsson Yield	0.25%	1.00%	24.55%	-0.53	12.22	0.0000
Foghorn	0.23%	1.08%	21.16%	-0.03	4.80	0.0000
Handelsbanken Global Hedge	0.17%	1.07%	16.01%	-0.24	5.05	0.0000
Graal	0.14%	1.06%	13.10%	-2.07	12.32	0.0000

Graal Aktiehedge	0.13%	1.09%	11.76%	-2.37	15.70	0.0000
Graal Offensiv	0.04%	1.89%	2.37%	-1.20	6.09	0.0000
NHX Equities	0.44%	1.61%	27.40%	-0.78	5.14	0.0000

Many hedge funds have higher standard deviations than NHX Equities index's, which present extreme monthly returns from as low as -25.03% in Gladiator Fond to as much as 26.31% in Accendo Capital Sicav SIF[33].

The risk-return scatter plot presented in Figure 20 presents that most Nordic Equity hedge funds lay "South-East" from the NHX Equity index line.

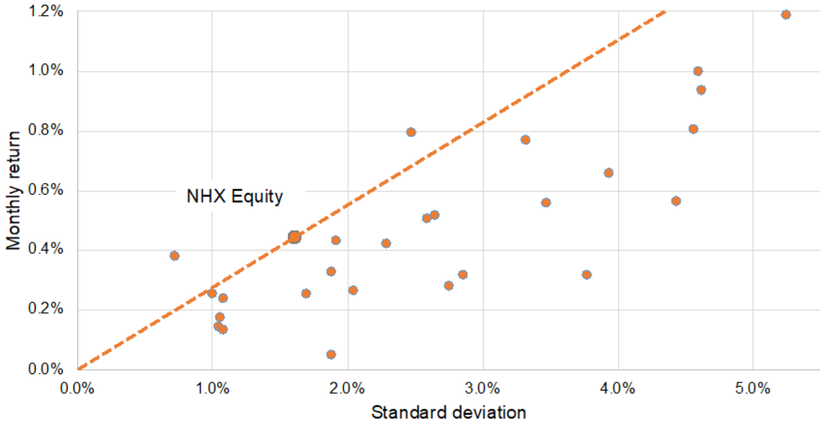

Figure 20. Monthly return and Standard deviation for Nordic Equity hedge funds
Note. the slope of the diagonal line represents the Sharpe ratio. All marks in the North-west direction represent the higher Sharpe ratio.

Table 31. Summary statistics of Nordic Fixed Income hedge funds (monthly).

Hedge fund strategy	**Mean**	**Std. Dev.**	**Sharpe**	**Skew**	**Kurto-sis**	**ADF-p**
Asgard Fixed Income Fund	1.10%	1.88%	58.31%	-0.39	7.46	0.0000
Danske Invest Hedge FI	0.91%	2.32%	39.21%	-2.32	28.24	0.0000
Midgard Fixed Income Fund	0.67%	1.79%	37.51%	0.60	5.99	0.0000
HP Hedge	0.54%	2.03%	26.57%	-2.55	19.35	0.0000

33 https://nhx.hedgenordic.com/ProgramSearch.aspx

Capital Four Credit Opport. Fund	0.48%	2.66%	18.03%	-6.88	80.12	0.0000
Nykredit Mira Hedge Fund	0.41%	2.13%	19.13%	-2.42	19.39	0.0000
KLP Alfa Global Rente	0.40%	1.22%	32.50%	1.70	11.66	0.0000
Excalibur	0.30%	1.04%	29.25%	1.03	9.56	0.0000
Danske Invest Hedge Mort. Arb.	0.27%	1.75%	15.41%	-2.78	23.15	0.0000
Carlsson Nor N Macro Fund	0.16%	0.65%	24.16%	0.90	5.13	0.0000
NHX Fixed Income	0.42%	1.41%	29.51%	-3.65	23.91	0.0000

As presented in Table 31, the mean Fixed Income hedge funds' return varies from 0.16% for Carlsson Nor N Macro Fund to 1.10% for Asgard Fixed Income Fund. However, standard deviations comparing to Equities hedge funds from Table 30 are sizably lower and do not exceed 2.66%.

Figure 21 presents the risk-return scatter plot. The Nordic Fixed Income hedge funds split evenly from the NHX Fixed Income index line, making NHX Fixed Income index and Nordic Fixed income hedge funds average index very similar.

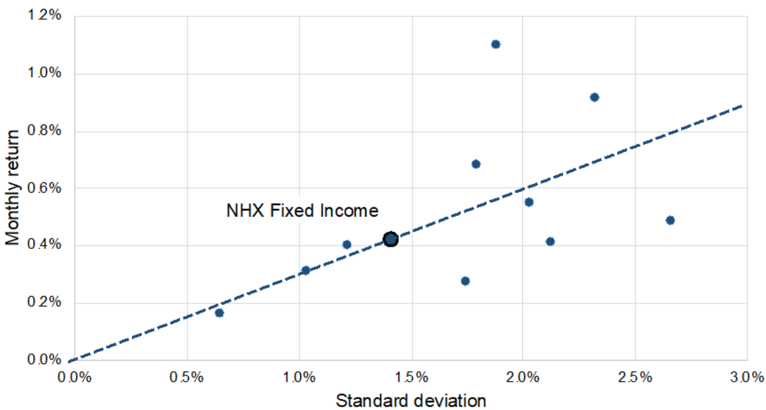

Figure 21. Monthly return and Standard deviation for Nordic Fixed Income hedge funds
Note. the slope of the diagonal line represents the Sharpe ratio. All marks in the North-west direction represent the higher Sharpe ratio.

Table 32 below presents descriptive statistics of Multi-Strategy hedge funds together with ADF one-sided p-values.

Table 32. Summary statistics of Nordic Multi-strategy hedge funds (monthly).

Hedge fund strategy	**Mean**	**Std. Dev.**	**Sharpe**	**Skew**	**Kurto-sis**	**ADF-p**
Formuepleje Safe	0.84%	5.74%	14.68%	-1.65	19.16	0.0000
Formuepleje Penta	0.79%	7.88%	10.07%	-3.11	23.83	0.0000
Nektar	0.55%	1.73%	31.71%	1.00	6.53	0.0000
Aktie Ansvar Kvanthedge	0.48%	3.38%	14.15%	-0.33	5.90	0.0000
WH Index	0.42%	2.55%	16.36%	-1.92	10.26	0.0000
Nordea Alpha 15 Fund	0.38%	3.23%	11.60%	0.06	3.47	0.4058
Atlant Stability Offensiv	0.30%	1.60%	18.55%	-2.56	15.28	0.0002
Catella Hedgefond	0.27%	1.47%	18.54%	-5.46	54.44	0.0000
HCP Black Fund	0.21%	1.42%	14.52%	0.53	6.26	0.0000
Atlant Stability	0.18%	0.63%	29.29%	-3.59	29.72	0.0000
Nordea 1 Multi Asset Fund	0.14%	1.71%	8.48%	0.10	3.75	0.0000
NHX Multi Strategy	0.37%	1.18%	31.44%	-0.77	4.70	0.0964

Figure 22 presents the risk-return scatter plot. Most of the Nordic Multi-Strategy hedge funds lie South-East from NHX Multi-Strategy index line.

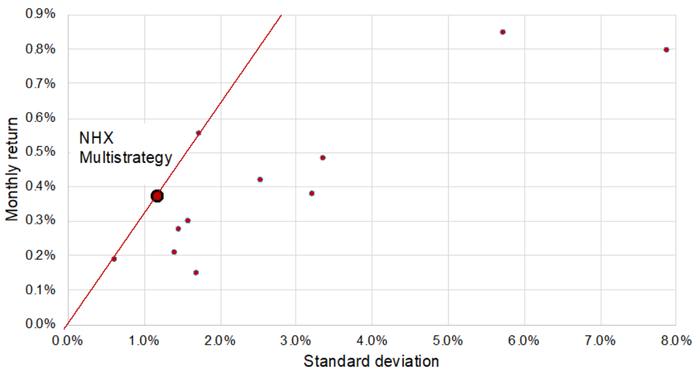

Figure 22. Monthly return and Standard deviation for Nordic Multi-strategy hedge funds
Note. the slope of the diagonal line represents the Sharpe ratio. All marks in the North-west direction represent the higher Sharpe ratio.

Table 33 presents descriptive statistics of CTA hedge funds together with ADF one-sided p-values.

Table 33. Summary statistics of Nordic CTA hedge funds (monthly).

Hedge fund strategy	Mean	Std. Dev.	Sharpe	Skew	Kurto-sis	ADF-p
Aktie Ansvar Trendhedge	0.63%	3.09%	20.45%	0.23	4.26	0.0009
Lynx	0.54%	4.35%	12.48%	0.03	3.28	0.7259
IPM Systematic Macro Fund	0.47%	2.95%	15.96%	0.26	4.39	0.0002
Estlander Partners Alpha Trend	0.36%	3.63%	9.91%	0.36	3.38	0.0778
IPM Systematic Currency Fund	0.35%	2.73%	12.98%	0.40	4.25	0.0002
Estlander Partners Freedom	0.35%	3.79%	9.16%	0.18	3.30	0.4177
Shepherd Energy Portfolio	0.26%	2.19%	11.90%	0.04	8.20	0.0000
SEB Asset Selection	0.26%	2.28%	11.34%	0.32	3.68	0.0355
SEB Asset Selection Op-port. SEK	0.13%	3.78%	3.54%	0.13	3.89	0.0347
RPM Galaxy	0.07%	4.68%	1.58%	-0.18	4.84	0.0000
Nordea 1 Heracles Long Short MI	0.04%	2.16%	2.02%	-0.35	5.58	0.0000
Estlander Partners Alpha Trend II	0.00%	8.41%	0.01%	0.40	5.30	0.0000
NHX CTA	0.40%	1.89%	21.33%	0.26	3.38	0.0000

Figure 23 presents the risk-return scatter plot. Most Nordic CTA hedge funds lie South-East from the NHX CTA index line, the same as in two previous cases.

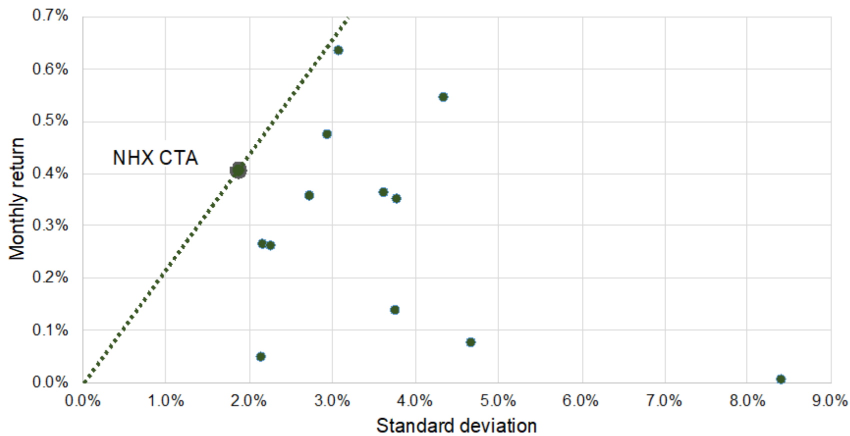

Figure 23. Monthly return and Standard deviation for Nordic CTA hedge funds
Note. the slope of the diagonal line represents the Sharpe ratio. All marks in the North-west direction represent the higher Sharpe ratio.

Table 34 presents descriptive statistics of Fund of funds together with ADF one-sided p-values.

Table 34. Summary statistics of Nordic Fund of funds hedge funds (monthly).

Hedge fund strategy	Mean	Std. Dev.	Sharpe	Skew	Kurto-sis	ADF-p
Aktie Ansvar Multistrategi 2XL	0.47%	2.44%	19.30%	0.06	3.58	0.2570
Brummer Multi Strategy	0.42%	1.30%	32.16%	-0.42	3.47	0.0288
Aktie Ansvar Multistrategi	0.26%	1.43%	18.09%	-1.10	9.93	0.0000
AIM Credit Strategies Fund	0.26%	0.71%	36.06%	-0.36	7.46	0.0000
Merrant Alpha Select USD	0.21%	0.37%	55.72%	1.00	5.93	0.0000
AIM Diversified Strategies Fund	0.21%	0.79%	26.12%	-0.25	3.76	0.0403
Agenta Multi-Strategy	0.17%	1.51%	10.95%	-5.03	50.41	0.0000
Danske Invest Eliksir FoHF	0.16%	1.34%	11.83%	-1.95	14.30	0.0000
Coeli Multistrategi	0.15%	0.89%	16.48%	-1.39	11.07	0.0000
OPM Vega A	0.14%	0.99%	14.49%	-0.58	4.61	0.0000
SEB True Market Neutral	0.13%	0.40%	32.23%	0.86	6.13	0.0000
Caram Systematic Alpha A	0.05%	1.02%	4.83%	-0.98	6.66	0.0000
NHX Fund of Funds	0.12%	0.96%	12.95%	-1.48	9.00	0.0000

Comparing with other tables, Nordic Fund of funds returns are the lowest, with the top-performing fund at 0.47%, when other Nordic strategies possess higher returns.

Figure 24 presents the risk-return scatter plot. The Nordic Fund of funds are predominantly above the NHX Fund of funds index line.

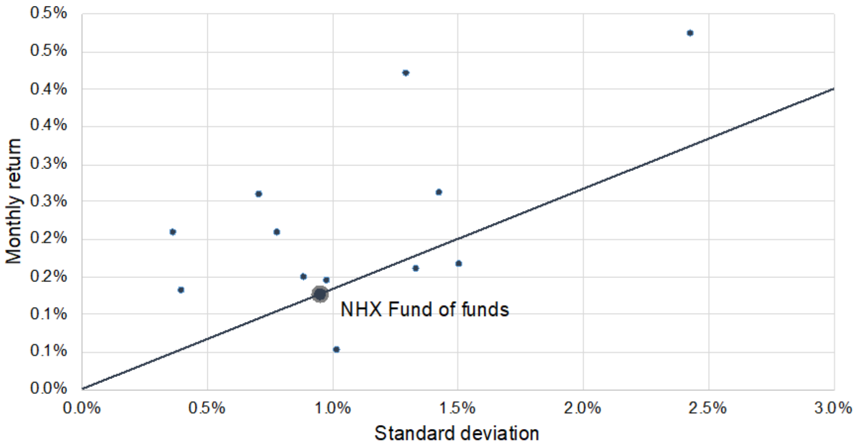

Figure 24. Monthly return and Standard deviation for Nordic Fund of Funds hedge funds
Note. the slope of the diagonal line represents the Sharpe ratio. All marks in the North-west direction represent the higher Sharpe ratio.

Table 35. Summary statistics of Equity hedge funds by correlation and performance.

Hedge fund portfolio	Mean	Std. Dev.	Sharpe	Skew	Kurtosis
Total	0.47%	1.39%	33.59%	-0.49	4.85
Correlated	0.51%	1.82%	27.84%	-0.60	4.99
Neutral	0.36%	0.82%	**43.70%**	-0.20	5.61
Outperforming	**0.75%**	2.23%	33.54%	-0.45	5.19
Underperforming	0.26%	0.95%	27.22%	-0.59	5.12
NHX Equities	*0.44%*	*1.61%*	*27.44%*	*-0.78*	*5.14*

Note. Statistic figures in **bold** represent the top figure of either the mean return or Sharpe ratio within the same hedge fund strategy.

Annex 3. Summary statistics of risk factors

Tables 36-38 present summary statistics of Fung and Hsieh 8-factors David A. Hsieh's Data Library[34] with replaced factors, other risk factors and Commodity risk factors together with augmented Dickey-Fuller (ADF) one-sided p-values test of MacKinnon (1996).

Table 36. Summary statistics of Table 11 and supplemented risk factors (monthly).

Risk factor	Mean	Std. Dev.	Sharpe	Skew	Kurtosis	ADF-p
OMXCRF	0.53%	6.16%	8.67%	-1.12	5.98	0.0000
OMXHRF	0.30%	6.40%	4.68%	-0.51	4.94	0.0000
OMXSRF	0.22%	6.31%	3.43%	-0.59	5.60	0.0000
OSEBXRF	0.34%	7.91%	4.29%	-1.16	7.21	0.0000
SPRF	0.49%	4.21%	11.68%	-0.71	4.93	0.0000
SIZESPRC	-0.55%	3.91%	-14.00%	-0.17	3.96	0.0000
SIZESPRH	0.26%	4.68%	5.61%	0.95	7.62	0.0000
SIZESPRO	-0.39%	4.74%	-8.31%	-0.17	4.71	0.0000
SIZESPRS	0.36%	5.08%	7.11%	0.12	2.65	0.0000
RLSP	0.00%	2.51%	-0.16%	0.00	3.61	0.0000
Δ(TYRF)*	-0.0008%	0.03%	-2.75%	0.73	5.20	0.0000
Δ(10YDen)*	0.0011%	0.02%	4.89%	2.19	12.51	0.0000
Δ(10YFin)*	-0.0007%	0.02%	-3.82%	2.58	17.36	0.0000
Δ(10YNor)*	-0.0018%	0.03%	-6.67%	1.95	16.64	0.0000
Δ(10YSwed)*	-0.0016%	0.03%	-5.86%	1.65	12.06	0.0000
Δ(BAATY)*	0.00%	0.02%	2.06%	2.45	19.18	0.0000
MSEMKFRF	0.42%	6.24%	6.73%	-0.51	4.92	0.0000
PTFSBDRF	-1.80%	17.58%	-10.22%	2.09	10.37	0.0000
PTFSCOMRF	-0.02%	15.80%	-0.10%	1.25	5.40	0.0000
PTFSFXRF	-1.12%	20.30%	-5.50%	1.71	7.12	0.0000

* For the risk factors TYRF, 10YSwed, 10YDen, 10YFin, 10YNor, and BAATY, the ADF-p value is above 0.05, and therefore, the Null Hypothesis is valid – the variable has a unit root; therefore, these variables are not stationary. The values were transposed into the 1st level difference (Δ), satisfying the unit root test and proving the stationary variables. The table presents summary statistics and ADF-p values of corresponding 1st level difference.

34 David A. Hsieh's Data Library available at: https://faculty.fuqua.duke.edu/~dah7/HFRFData.htm

Table 37. Summary statistics of other risk factors (monthly).

Risk factor*	**Mean**	**Std. Dev.**	**Sharpe**	**Skew**	**Kurtosis**	**ADF-p**
HML	-0.29%	2.81%	-10.19%	-0.50	6.97	0.0000
SMB	0.03%	2.31%	1.09%	0.19	2.67	0.0000
LIQ	0.13%	3.35%	3.92%	-0.36	4.90	0.0000
VIX	0.03%	0.25%	11.99%	1.79	8.80	0.0000
RX	-0.01%	1.82%	-0.63%	-0.35	4.31	0.0000
FXDDK	-0.10%	2.78%	-3.67%	-0.36	4.91	0.0000
FXEUR	-0.06%	2.78%	-2.13%	-0.22	4.85	0.0000
FXNOK	-0.25%	3.36%	-7.34%	-0.33	4.16	0.0000
FXSEK	-0.18%	3.30%	-5.48%	-0.08	3.64	0.0000

* The research disregards risk factors VAL, TMOM, Carry, ATM Call, OTM Call, ATM Put, OTM Put due to the high volume of missing data (i.e., some variables are reported till 2014, while others - till 2010).

Table 38. Summary statistics of commodity risk factors (monthly).

Risk factor	Mean	Std. Dev.	Sharpe	Skew	Kurtosis	ADF-p
OCMDRWT	0.19%	3.95%	4.83%	-0.90	5.83	0.0000
BROIL	0.82%	12.87%	6.36%	0.72	18.48	0.0000
COCOA	0.55%	7.81%	7.06%	0.02	2.88	0.0000
COPPER	0.52%	7.72%	6.67%	-0.14	6.99	0.0000
GOLD	0.73%	3.90%	18.76%	0.06	3.50	0.0000
NGAS	0.08%	13.31%	0.57%	0.75	6.10	0.0000
SILVER	0.87%	9.18%	9.53%	0.15	3.46	0.0000

Annex 4. Crisis risk factors

I. Following the crisis timeline over the last 20 year, there are the following crises (also as stated by Hespeler and Loiacono, 2015):

1. The global financial crisis of 2007-2008. Based on the different observations represented 2007-08 till 2009-03 timeline.

2. European debt crisis 2009-2011 – first wave leading to the banking crisis taking the impact of the global financial crisis and raising the public funds for bailout procedures. The timeline is as follows: 2009-10 – 2011-12.

3. After some ease and Greece governmental tensions, the other crisis took place. The timeline is 2012-07 – 2013-05.

4. The following somewhat controversial crisis with outcomes not finalized yet is a Brexit crisis, which began after the UK's historic vote on June 23, 2016, to leave the EU. Although the Brexit process is still in its transition period, based on the Brexit timeline, the crisis ends when Britain left the EU on March 29, 2019. The timeline is 2016-06 – 2019-03.

5. The last rather significant crisis is related to Covid-19. The crisis began with a deep drawdown in all financial markets in mid-March 2020 to recover the stock indexes (DOW Jones, S&P 500)[35] at the beginning of November 2020. As Pástor and Vorsatz (2020) outlined, the Covid-19 crisis takes ten weeks, from February 20 till April 30, 2020. However, uncertainty about whether the Covid-19 second wave would impact the economy and the investment business in particular; for research purposes, the end of the crisis corresponds to the end of the research horizon. The timeline for the analysis is 2020-03 – 2020-04.

II. Following Babecký J. et al. (2014), only banking crisis events were identified and only in two Nordic countries: Sweden 2008 January – 2008 December and Denmark 2008 January – 2010 December. Berglund and Mäkinen (2016) proved that most Nordic banks learned from the 1990 crisis and adjusted their business models accordingly. As explained in theory, the banking crisis disrupts the credit supply process leading to losses. They should restrain hedge fund's ability to borrow money in the financial markets in these countries. Following Babecký J. et al. (2014).

III. Based on the drawdowns reported by the HedgeNordic database[36], there

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35 Based on publicly broadly used in the dissertation www.investing.com
36 HedgeNordic database available at: https://hedgenordic.com/.

were the following drawdowns registered for the NHX indices by country:

Table 39. Drawdown report for Sweden

#	Begins	Ends	Length (negative), Month	Depth. %
1	2008 June	2009 July	6	-6.71
2	2010 May	2010 September	2	-1.96
3	2011 May	2012 December	5	-4.68
4	2015 June	2016 July	4	-2.07
5	2018 February	2018 September	2	-2.22
6	2018 October	2020 January	3	-3.80
7	2020 February	2020 July	2	-6.86
Overall negative months			24	

Table 40. Drawdown report for Denmark

#	Begins	Ends	Length (negative), month	Depth. %
1	2007 July	2012 December	20	-22.71
2	2015 June	2015 November	4	-3.04
3	2015 December	2016 March	3	-2.44
4	2018 October	2019 February	3	-3.20
5	2020 February	2020 July	2	-8.59
Overall negative months			32	

Table 41. Drawdown report for Finland

#	Begins	Ends	Length (negative), month	Depth. %
1	2006 May	2007 May	3	-6.07
2	2007 July	2008 February	2	-5.11
3	2008 July	2010 December	9	-16.41
4	2011 May	2014 July	7	-10.85
5	2015 June	2015 November	4	-4.04
6	2015 December	2016 December	11	-1.03
7	2017 April	2019 August	21	-9.07

8	2019 September	2020 July	7	-7.04
Overall negative months			64	

Table 42. Drawdown report for Norway

#	Begins	Ends	Length (negative), month	Depth. %
1	2007 November	2008 May	5	-3.02
2	2008 June	2010 February	7	-14.29
3	2010 May	2010 November	4	-4.42
4	2011 May	2012 December	5	-7.35
5	2018 September	2019 December	4	-7.85
6	2020 February	2020 July	2	7.09
Overall negative months			27	

Tables (from 39 to 42) present continuous negative results (drawdowns) in all four countries. All of them face similar periods of market turmoil of financial crisis 2007-2008 and debt crises of 2011 and 2013. However, individually NHX countries' indexes vary, especially in the last four years, as shown in Figure 19. NHX country indices dynamics.

IV. Hedge fund Exposure & Tail Risk Industry Report published by eVestment (2018) presented the historical scenarios that have made the highest impact on the 30 large-size reporting hedge funds. Complemented with Eurekahedge (2020) Q1 report, the Global Hedge Funds' Industry Drawdown looks as follows:

Table 43. Global Hedge Fund Industry Drawdown periods

Historical scenario	Drawdown period	Drawdown variable period
1987 Black Monday	10/1/87 - 10/26/87	1987 October
WTC Attack	8/2/01 - 9/21/01	2001 August – 2001 September
2002 Market Downturn	5/17/02 - 10/9/02	2002 May – 2002 September
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
2018 Q4 Drawdown	2018 Q4	2018 October – 2018 December
2020 Covid-19	2020 March	2020 March

Annex 5. AIFMD analysis

Table 44. Analysis of AIFMD in the Nordic countries

Country	Regulation related indicator	"Reaction" point
Sweden	There is no clearly reported information on the derivative asset or derivative liability position during the sufficient time horizon in FSI reports. A significant decrease in derivative investments is reported in 2013, which raises the assumption, that in 2013 banks and investors significantly reduced derivatives volumes. The FSI report does not present the leverage ratio; therefore, figures represent the Swedish FSI report that states the increase of leverage ratio from 2014, Sveriges Riksbank (2020).	With different information sources, the reaction point on the AIMFD directive is 2014-01 for dummy value creation purposes.
Finland	Based on the derivative position of IMF indicators "Gross Asset Position in Financial Derivatives to Capital" and "Gross Liability Position in Financial Derivatives to Capital," there was a significant increase of both indicators in 2014 Q4. Then indicator ratios went back to long-term averages.	With derivative indicators ratios, the reaction point is 2015-01 for the dummy value creation purposes.
Denmark	Based on the derivative position indicators "Gross Asset Position in Financial Derivatives to Capital" and "Gross Liability Position in Financial Derivatives to Capital" reported by IMF, there was a significant decrease of both indicators from 2014 Q1. Then they remained at nearly the same level.	With derivative indicators ratios, the reaction point is 2014-01 for the dummy value creation purposes.
Norway	There is no reflection of AIFMD; therefore, the effect of AIFMD regulation is the starting date of enforcement – 2015-01-01	According to the description, the reaction point is 2015-01 for the dummy value creation purposes.

Annex 6. Panel data regressions models

Table 45. Fung-Hsieh 8-factor national enhances models

Factors \ Models	Equity	Equity+	Fixed income	CTA
α (monthly)	0.0026*** (0.0005)	0.0015*** (0.0003)	0.0044*** (0.0006)	0.0009 (0.0010)
Stock index†	0.4338*** (0.0131)	0.3840*** (0.0095)	0.2237*** (0.0154)	0.3570*** (0.0287)
Size spread†	0.2898*** (0.0111)	0.2508*** (0.0078)	0.3079*** (0.0147)	0.1510*** (0.0210)
Δ(TYRF) †	1.6099 (1.8624)	5.1963*** (1.3875)	17.954*** (2.4830)	-2.4780 (4.1889)
Δ(BAATY)	0.5167** (0.2494)	0.7531*** (0.1853)	0.2061 (0.3039)	1.3241** (0.5316)
MSEMKFRF	0.0284* (0.0152)	0.0877*** (0.0111)	0.0941*** (0.0175)	0.0295 (0.0333)
PTFSBDRF	0.0052 (0.0035)	0.0093*** (0.0026)	0.0033 (0.0041)	0.0227*** (0.0075)
PTFSCOMRF	0.0069** (0.0034)	0.0080*** (0.0025)	0.0083** (0.0042)	0.0205*** (0.0072)
PTFSFXRF	0.0034 (0.0030)	0.0007 (0.0022)	-0.0056 (0.0037)	0.0563*** (0.0064)
SMB‡		-0.0369** (0.0158)		-0.2865*** (0.0467)
HML‡		0.0683*** (0.0151)		0.1910*** (0.0449)
MoM‡		0.0332*** (0.0095)		0.1252*** (0.0271)
GOLD‡		0.0289*** (0.0098)		0.0976*** (0.0307)
COPPER‡		0.0156** (0.0069)		
SILVER‡				0.0675*** (0.0156)
BROIL‡				
NGAS‡		0.0086*** (0.0029)		

COCOA‡				
OCMDRWT‡	0.0609*** (0.0186)	0.0714*** (0.0159)	0.1240*** (0.0224)	0.1710*** (0.0449)
LIQ‡	-0.0333** (0.0154)	-0.0538*** (0.0125)	-0.1148*** (0.0191)	-0.1533*** (0.0365)
VIX‡				
Mean return	0.0039	0.0031	0.0045	0.0019
Return S.D.	0.0488	0.0464	0.0373	0.0524
Sharpe ratio	7.99%	6.68%	12.06%	3.63%
Adj. R^2	0.6044	0.5887	0.6204	0.3293
AIC	-4.1266	-4.1899	-4.7024	-3.4504
F-statistic	655.22	711.79	262.32	64.041

Note: Standard errors in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

† replaced variables as shown in Table 6, "Substituted risk factors".

‡ variables in the Fung-Hsieh 8-factor Enhanced model are selected using Stepwise model with 0.05 stopping p-value criteria forward and backwards.

Table 46. Fung-Hsieh 8-factor national enhances models Elasticity at Means

Factors \ Models	Equity	Equity+	Fixed income	CTA
α (monthly)	0.6549	0.4777	0.9818	0.4791
Stock index	0.2557	0.3375	0.2057	0.5527
Size spread	0.0971	0.1237	-0.2909	0.2658
Δ(TYRF)	-0.0052	-0.0188	0.0215	0.0161
Δ(BAATY)	0.0026	0.0035	0.0010	-0.0095
MSEMKFRF	0.0241	0.1013	0.0602	0.0653
PTFSBDRF	-0.0218	-0.0525	-0.0091	-0.2206
PTFSCOMRF	-0.0029	-0.0054	-0.0016	-0.0303
PTFSFXRF	-0.0133	-0.0034	0.0189	-0.4764
SMB		-0.0044		-0.0722
HML		-0.0632		-0.2872
MoM		0.0127		0.0445
GOLD		0.0572		0.3309
COPPER		0.0190		
SILVER				0.2771

BROIL				
NGAS		-0.0006		
COCOA				
OCMDRWT	0.0117	0.0230	0.0118	0.1039
LIQ	-0.0028	-0.0072	0.0006	-0.0392
VIX				

Annex 7. Absolute return contribution of crisis and regulation models

Provided below are Absolute return contribution based on Elasticity at Means models which also prove the Hypothesis 3, 4 and 5.

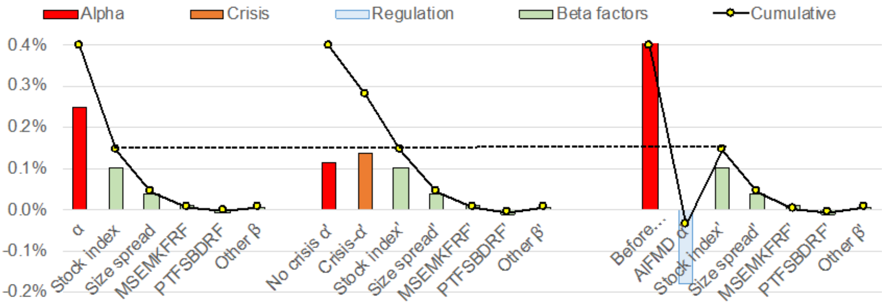

Figure 25. Absolute return contribution of Equity Base, Dummy crisis, and Dummy regulation models

Note: Dashed line crossed the cumulative level of all beta factors in all models proving crisis and regulation factors had no significant impact on the *beta*, whereas main impact is reflected on *alphas*.

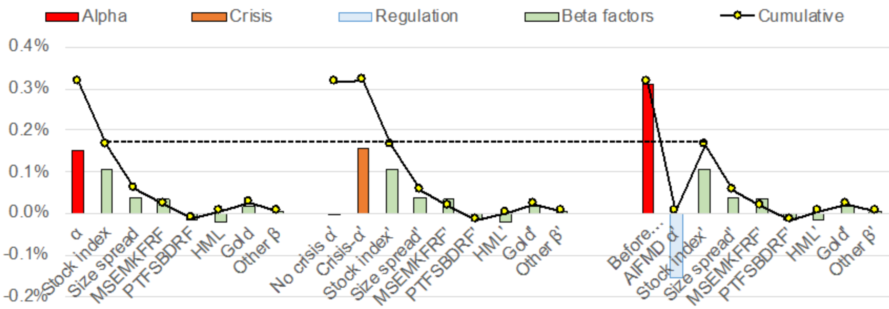

Figure 26. Absolute return contribution of Equity+ Base, Dummy crisis, and Dummy regulation models

Note: Dashed line crossed the cumulative level of all beta factors in all models proving crisis and regulation factors had no significant impact on the *beta*, whereas main impact is reflected on *alphas*.

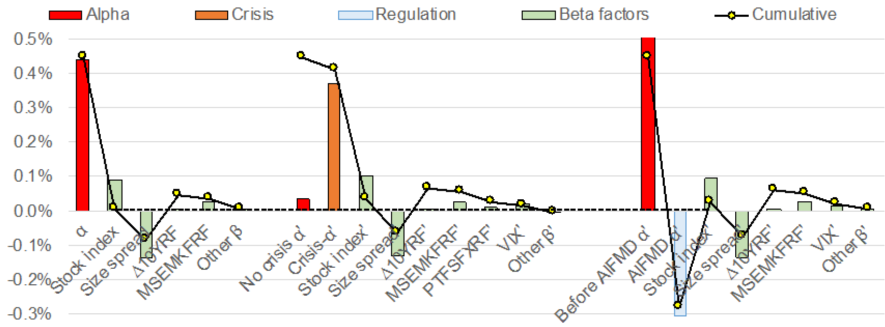

Figure 27. Absolute return contribution of Fixed income Base, Dummy crisis, and Dummy regulation models

Note: Dashed line crossed the cumulative level of all beta factors in all models proving crisis and regulation factors had no significant impact on the *beta*, whereas main impact is reflected on *alphas*.

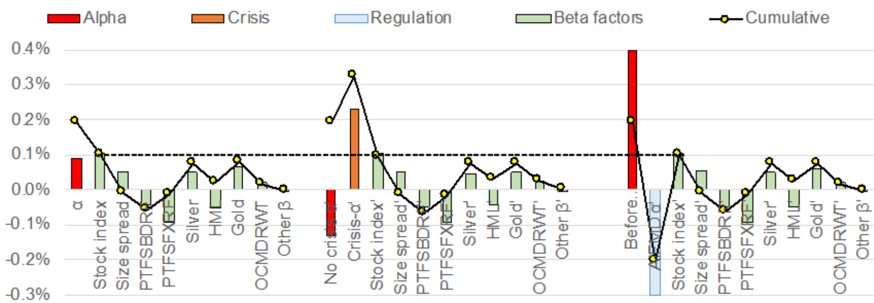

Figure 28. Absolute return contribution of CTA Base, Dummy crisis, and Dummy regulation models

Note: Dashed line crossed the cumulative level of all beta factors in all models proving crisis and regulation factors had no significant impact on the *beta*, whereas main impact is reflected on *alphas*.

Annex 8. Equity crisis models

Table 47. Equity crisis periods models

Factors \ Models	Crisis 1	Crisis 2	Crisis 3	Crisis 4	Crisis 5†	All crisis
α (monthly)	0.0086*** (0.0023)	0.0046*** (0.0015)	0.0123*** (0.0034)	-0.0014 (0.0011)	0.0102 (0.0102)	0.0039*** (0.0007)
Stock index	0.3570*** (0.0493)	0.4937*** (0.0358)	0.1345 (0.1317)	0.3927*** (0.0396)	0.6704*** (0.0757)	0.4314*** (0.0200)
Size spread	0.3361*** (0.0341)	0.3112*** (0.0289)	0.2486*** (0.0635)	0.3234*** (0.0276)		0.2973*** (0.0150)
Δ(TYRF)	-2.6701 (3.9670)	1.3672 (7.3358)	13.554 (10.992)	8.3566 (5.4496)		3.7373 (2.3323)
Δ(BAATY)	1.6559*** (0.6237)	-0.7672 (0.7975)	-6.2038** (2.5892)	1.2500 (1.0559)		1.5034*** (0.3302)
MSEMK-FRF	0.1376*** (0.0517)	0.0302 (0.0448)	-0.2646 (0.1751)	0.0878** (0.0349)		0.0512** (0.0225)
PTFSBDRF	0.0512*** (0.0171)	0.0258*** (0.0087)	-0.0476 (0.0331)	-0.0022 (0.0083)		0.0110** (0.0050)
PTFSCOM-RF	-0.0095 (0.0179)	0.0287*** (0.0100)	0.0702*** (0.0247)	-0.0087 (0.0098)		0.0126** (0.0052)
PTFSFXRF	-0.0017 (0.0142)	-0.0050 (0.0087)	0.0311 (0.0286)	0.0045 (0.0063)		-0.0070 (0.0043)
SMB‡						
HML‡						0.1182*** (0.0262)
MoM‡						
GOLD‡						0.0492** (0.0207)
COPPER‡						
SILVER‡						
BROIL‡						
NGAS‡						
COCOA‡						0.0166** (0.0083)
OCM-DRWT‡			0.4964*** (0.1804)			
LIQ‡						

VIX‡			-5.2165 (2.4339)			-0.9425** (0.4285)
Mean return	-0.0121	0.0049	0.0136	0.0014	-0.0170	0.0013
Return S.D.	0.0680	0.0594	0.0298	0.0378	0.1070	0.0530
Sharpe ratio	-17.79%	8.25%	45.64%	3.70%	-15.89%	2.45%
Adj. R^2	0.6601	0.7368	0.3931	0.4600	0.6537	0.6396
AIC	-3.5961	-4.1301	-4.6495	-4.3171	-2.6454	-4.0513
F-statistic	100.53	254.37	20.169	92.258	78.391	345.88

Note: Standard errors in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

† the full Hung-Hsieh's 8-factor model cannot be conducted due to limitations of panel data model related with very short period.

‡ variables in the Fung-Hsieh 8-factor Extended model are selected using Stepwise model with 0.05 stopping p-value criteria forward and backwards.

MYKOLAS ROMERIS UNIVERSITY

Danielius KOLISOVAS

DETERMINANTS OF THE REGIONAL HEDGE FUND PERFORMANCE: EVIDENCE FROM NORDIC COUNTRIES

Summary of Doctoral Dissertation

Social Sciences, Economics (S 004)

Vilnius, 2022

The doctoral dissertation was prepared at Mykolas Romeris University during the period of 2014-2022 under the right to organize doctoral studies granted to Vytautas Magnus University, ISM University of Management and Economics, Mykolas Romeris University and Vilnius University by the order of the Minister of Education, Science and Sport of the Republic of Lithuania No. V-160 dated on February 22, 2019.

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The doctoral dissertation is available at the Martynas Mažvydas National Library of Lithuania and the libraries of Vytautas Magnus University, ISM University of Management and Economics, Mykolas Romeris University and Vilnius University Šiauliai Academy.

DISSERTATION SUMMARY

Relevance of the topic. Researchers mentioned hedge funds and their investments for the first time in the 1950s. In the 1960s, it became common for investors to apply long and short equity investment strategies. Initially, the purpose of hedge funds was to reduce the market risk for investments in traditional assets (capital market instruments). In the 1990s, hedge funds became an independent investment instrument for investors looking for total maximum return. Hedge funds are also known for their severe losses in 1998 when Long Term Capital Management Fund suffered a loss of 1.8 billion USD because of a severe decrease in bond prices and a high level of leverage. The sharp declines of the asset prices during the sell-offs of the financial instruments, which even further lost their value due to low liquidity, shrank the hedge fund AUM by 25 percent in the 2nd half of 2008 (BarclayHedge, 2020a). The Financial Crisis Inquiry Report (FCIC, 2011) claimed the sharp drop in the asset prices of the trading portfolios due to several hedge funds' activity was the reason for Lehman Brothers Bank's bankruptcy. Lately, the market crash of Covid-19 caused a decrease in hedge fund AUM from 3 194 billion USD in 2019 to 2 857 billion USD, reporting losses of almost 13 percent in Q1 2020 with a nearly complete recovery of AUM to 3 113 billion USD and bounce back with 15 percent gain by the end of Q3 2020 (eVestment, 2020; BarclayHedge, 2020a).

The outstanding hedge funds' performance lies in their investment phenomenon. On the one hand, hedge fund managers seek the maximum returns, trying to beat the market indices by employing skilled strategies and not being constrained by regulation. On the other hand – they achieved rather impressive diversification results and generated higher risk-adjusted returns in the class of alternative investments measured by the Sharpe ratio. Besides the high Sharpe ratio, hedge fund investors and managers seek high alpha, an excess return over the market-generated return. *Alpha* is also a primary driver of the hedge fund manager's remuneration presented as the management and success fee. However, some studies are talking about alpha trends decline post the Global financial crisis of 2007-2008.

Presenting the right alpha level and, even more importantly, disclosing the risks hedge fund managers undertake and shall allocate to beta indicators is still undergoing discussions between researchers. Over 20 years, the understanding of the risks the hedge funds have grown. The traditional risks expanded with new risks representing the size of the fund, growth momentum, or even more "exotic" so-called non-linear risks, which do not linearly depend on the market and have option-like features. The model of Fung and Hsieh introduced in 1997 addressed those non-linear risk criteria, and now the currently 8-factor model presented in 2012 is used as the benchmark and starting point in many types of research. Non-linear risks, however, are still undergoing a cognitive stage. Many researchers claim hedge fund *alpha* can be estimated precisely using conventional performance measurement tools like CAPM or Fama-French model.

Most models defined to determine the hedge funds' performance factors are based on Global hedge fund industry trends and represent core hedge fund industries such as the US, UK, central regions (i.e., North America, Europe, or Asia), or in Tax Havens. US dominance is evident as the models mentioned above use the US indices and other financial instruments reported in the US Dollar. The entire hedge fund industry is spinning around the five most prominent data suppliers: BarclayHedge, EurekaHedge, Hedge Fund Research (HFR), Morningstar, and Lipper Hedge Fund Database (TASS).

Even though Nordic hedge funds outperformed the global hedge fund industry represented by HFRI and MSCI indices during the severe drawdown of 2008 Q3-Q4 by nearly 10 percent[37], there is minimal research on the Nordic and other regional hedge funds. Such limited research raises the concern whether analysis of the hedge fund performance in small regions represented by possibly very biased return data may be too complex an assignment. Those rare cases of the regional hedge funds research papers are more focused on comparing the absolute return figures rather than discussing the hedge funds' performance assessment models and their performance determining factors. Adapted to the local market, hedge funds' performance measurement models can present how much of this outstanding performance depends on the local hedge fund managers' alpha and what comes as a market premium. Furthermore, can exploring the Nordic hedge fund performance contribute to the Baltic hedge fund development? Nordic Business Media anticipates inducing the Baltic hedge fund index to present Baltic hedge funds in the Nordic universe[38].

Research problem and the level of its investigation. The economic research in

37 Calculated by author based on: https://hedgenordic.com/; https://www.hfr.com/indices

38 Based on the first-hand information obtained from the representatives of the Nordic Business Media when discussing the research findings and publishing the findings in series of Nordic hedge fund reports in 2021.

the hedge funds' performance measurement area has various directions, some of which will be analyzed in this dissertation. The hedge funds' performance measurement models underwent a tremendous evolution: from single factor models like CAPM of Treynor (1961) or multifactor APT of Ross (1976); to models determining the performance of the hedge funds using non-linear dependences analyzing option-like return structure by Glosten and Jagannathan (1994), trend-following factors by Fung & Hsieh (1997a, 2001, 2002 and 2004a), or Fama-French three-factor model (or enhanced by Carhart's (1997) 4-factor model). Other researchers (e.g., Agarwal and Naik, 2004, Capocci et al., 2005, Dewaele et al., 2015, Moskowitz, 2020) also examine hedge funds' non-linear return. However, Fung-Hsieh's 8-factor model of Edelman et al. (2012) is still considered robust, explaining nearly 80 percent of all equity hedge funds by analyzing monthly returns. However, the likes of Agarwal et al. (2018), Stutzer (2018), and Knif et al. (2020) still claim that CAPM and ICAPM models well explain the hedge funds' *alpha*. The idea behind this strong belief derives from the main idea behind the CAPM model explaining the Modern portfolio theory of Markowitz (1952), describing the diversification of the portfolio and the ability of the hedge funds to generate high alpha or absolute return, also known as seeking "north-west" direction introduced by Mossin (1966). Hedge funds are known for applying leverage, which allows reaching further "north-west" positions identifiable by CAPM. However, successful investment ideas are usually limited.

Following the APT theory, the portfolio's performance depends on the portfolio's composition represented by various asset classes and instruments. Hedge funds tend to be focused on equities, fixed income (bond), or CTA (commodity and other financial asset classes). Analysis of various commodities in the hedge funds is prevalent in the CTA vehicles, as presented by Blocher et al. (2017), Elaut and Erdős (2019), and Shaikh (2019). There are many very focused pieces of research on the hedge fund performance dependence on the movement of the Gold or Oil commodities prices: Stafylas et al. (2018), Swartz and Emami-Langroodi (2018), Racicot and Theoret (2019), Shrydeh et al. (2019), Mensi et al. (2020), Chirwa and Odhiambo (2020), Lambert and Platania (2020). Other commodities, such as Copper, Silver, or Natural gas, are somewhat scarcely analyzed.

Besides the asset-based, researchers also widely analyze the hedge funds' performance dependence on specific risk factors. The liquidity factor introduced by Pástor and Stambaugh (2003) made a breakthrough in the hedge funds' performance measurement by determining how much the hedge funds' return depends on the liquidity risk the hedge fund manager undertakes. Underestimated liquidity risk was also a crucial factor in many hedge funds, which underwent significant drawdowns during the financial crisis of 2007-2008. There are many pieces of research covering the liquidity risk factor in the hedge funds' performance measurement area: Sadka (2010), Cao et al. (2018), Chen et al. (2018), Jame (2018), Liang and Qiu (2019), Canepa et al. (2020) and Li et al. (2020).

The other asset non-related widely analyzed factor is volatility as the volatility usually initiates more frequent trade, which is characteristic of hedge funds' investment. Oliva and Reno (2018), Thomson and van Vuuren (2018), Asensio (2019), Racicot and Theoret (2019), and Lee et al. (2020) also considered the VIX factor to impact hedge funds significantly.

In addition to the asset- or risk-based (liquidity and volatility) factors, so-called exogenous factors are also widely analyzed. Investment size introduced and widely used by Fama and French (2004). Freshly established, smaller funds have more freedom in amending their strategies to the changing market conditions; therefore, as outlined by Amman and Moerth (2005), Jones (2007), Teo (2009), Joenväärä et al. (2019), Becam et al. (2019), O'Neill and Warren (2019), Cumming et al. (2020), they have more potential. On the contrary, large-size funds have size-related advantages because the larger-scale fund managers can afford to spend more on analysis and due diligence of each asset or component of the fund. As outlined by Getmansky et al. (2004) and Xiong et al. (2009), the benefit of being well-informed works with large-size hedge funds. Investors' experiences analyzed by Carhart (1997), Pirotte and Tuchschmid (2014), Berglund et al. (2018), Rzakhanov and Jetley (2019), and Berglund et al. (2020) also can be compared with the hedge fund longevity lead the hedge fund managers to more sound decisions. Cui et al. (2019) and Shin et al. (2019) also supplemented the experience with strategy adjustment frequency providing frequent trading can strategically time the tail risk.

Despite the wide range of the hedge funds' performance measurement research focus, researchers such as Savage (2017), Groshens (2018), and Robertson (2018) proposed categorization of the hedge fund performance determining factors by their difficulty to implement and the complexity of the investment instruments and the strategies. Jaeger (2005) introduced the concept of "smart beta" and "strategic beta" (or Alternative beta), categorizing all factors into pure beta, smart beta, alternative beta, and alpha. Investment factor-based Betas (i.e., Value, Carry, Quality, Growth, Momentum, and Size) were defined and analyzed by Asness et al. (2013), Lustig et al. (2011), Moskowitz et al. (2012), Baltas and Kosowski (2013).

The researchers also widely analyze the hedge fund performance during the crisis or changes in the hedge fund performance and risk appetite due to the changes in the regulatory environment. Cao et al. (2018), Zhao et al. (2018), Liang and Qiu (2019), Gregoriou et al. (2020), and others analyze which strategies make hedge funds successful during the crisis. In contrast, Metzger and Shenai (2019), Sung et al. (2020), Denk et al. (2020), and others compare the performance of hedge funds compared to benchmarks or mutual funds. Although there are many explanations of the hedge fund performance during the crisis, adding the crisis factor into the comprehensive hedge funds' performance measurement models is somewhat sparsely attempted. Hespeler and Loiacono (2015) established the dependency of the hedge funds' return indicators on sector return distribution; however, they did not allocate this to the exact performance determinants.

The regulation imposed in response to the financial crisis of 2007-2008, represented by the US Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank) and EU 2011/61 / EU AIFM Directive, had a dual impact on hedge fund performance. According to Barr (2008), Brown et al. (2012), Chan et al. (2007), and Cerutti et al. (2010), hedge funds firstly encountered the limitation of the risk that hedge funds undertake. The requirement to register the hedge fund managers once the AUM of the hedge fund exceeds 100 million USD prevents the potentially very significant impact on the market. The reduced possibility to use higher leverages, increased borrowing costs, or a ban on using short selling reduced the options for earning a higher return by taking higher risk. However, Sullivan (2019) and Joenväärä and Kosowski (2020) also noticed a decrease in the risk appetite of the hedge fund investors, resulting in the more conservative hedge fund managers' approach and reduced *alpha* level. Fairchild (2018) concluded that this puts more pressure on hedge fund managers, as their fees are what they charge for success.

Regardless of the angle from which the hedge fund performance is analyzed, the one essential aspect of the hedge fund performance is the *alpha* factor and the ability of the fund manager to generate it. According to Siegel (2005), by taking the Smart beta approach, investors optimize the different market factors and achieve higher returns while experiencing the same level of risk. He concludes that what was initially considered pure alpha can now be considered premia of liquidity or opacity of other risk factors.

The development of the hedge funds' performance measurement models, selection of the factors, and interpretation of how performance depends on the changes in the investment environment was performed on the Global scale using the global or the US-based hedge funds in a USD dominant environment. Nevertheless, in 1982 Stambaugh proposed the initial idea of analyzing the investment portfolios (mutual funds) using or combining the various non-US-based indices. For the first time, Do et al. (2005) analyzed the Australian hedge funds; however, they found very little dependence on the Australian ASX index. However, they also discovered that a smaller region of hedge funds' return is subject to data biases, especially survivorship bias.

Other regions were also analyzed on an occasional basis: Asia was analyzed by Van Dyk et al. (2014), Japan – by Kanuri (2020), Saudi Arabia and Malaysia – by Oueslati and Hammami (2018), and Islamic countries – by Karim et al. (2020). China's hedge fund market is growing, and more research papers represent this region: Huang and Sun (2018), Huang et al. (2018), Chen et al. (2019), and Zhai and Wang (2020). Gibilaro et al. (2018) analyzed the Cypriot hedge fund market. However, all these research papers are more focused on analyzing the absolute return or quantifying the differences between the regional and global hedge funds.

Despite the impressive performance of the Nordic hedge funds, only a few research papers represent this market with focus on the investment environment itself or on analyzing the mutual hedge funds: Ekberg and Iversen (2018). The Nordic hedge fund industry analysis revealed that the Nordic region could be characterized by longevity and a lower rate of offshoring registration, making this region unique. The Nordic investment market also differs from the US investment market in how the communication between the fund managers and the investors is carried out. Preuss (2019) observed higher risk awareness of the Nordic equity fund managers resulting in lower volatility ratios than the US rivals. Although hedge fund regions have particular features (e.g., Nordics are known for their longevity, and the hedge funds shall have substantial experience in withstanding more than two crises), the methodology created in this dissertation is designed to apply to any smaller region regardless of region's peculiarities.

Scientific problem – what factors determine the results of regional hedge funds, and how do the assessment models and factors depend on the changes in the investment environment.

Research object – regional hedge funds' performance measurement (asset pricing) models.

Research objective – after examining the hedge funds' investment phenomenon and based on the Nordic sample to develop regional hedge funds' performance measurement models adapted to different investment environment conditions.

The following **research tasks** are set to achieve the research objective:

1. After analyzing the scientific literature and based on the theoretical concepts of the hedge fund investment phenomenon, determine the preconditions for developing and applying hedge fund pricing methodology for regional hedge funds.

2. Considering the factors that characterize the region's investment environment and hedge fund investment strategies, define a methodology for creating regional hedge funds' performance measurement models.

3. Following the proposed methodology and based on Nordic hedge funds' return data, Nordic-specific risk factors, and investment environment conditions, identify determinants of the Nordic hedge funds' performance.

4. To assess the contribution of Nordic hedge fund managers (measured by *alpha*) in various investment environment conditions (i.e., crisis or regulatory constrained or unconstrained periods).

Research hypotheses.

H_1: Region-specific risk factors can better explain the regional hedge funds' performance rather than the Global risk factors using both conventional (e.g., CAPM, APT) or non-linear (e.g., Fung-Hsieh 8-factor) models.

H_2: Additional risk factors (e.g., commodity prices, derivatives, ETFs, other assets) and the dummy variables representing various periods of different investment environment conditions improve the statistical significance of the models allowing a more reliable assessment of the hedge fund manager's contribution to the performance of the hedge fund.

H_3: Changes in the investment environment impact the hedge fund performance is reflected on *alpha* rather than on the *beta* indicators.

H_4: Hedge fund managers adjust the investment strategies during the crisis to prevent drawdowns and generate positive *alpha*.

H_5: Regulation constraints applied to the hedge fund industry negatively impact the hedge fund's *alpha*.

Research methods.

The dissertation uses the following research methods in assessing Nordic hedge funds' investment results and in using asset-pricing models:

- Systematic analysis of the literature.
- Analysis of legal documents.
- Graphical data interpretation and analysis.
- Methods of statistical analysis.
- Empirical research.
- Expert evaluation method.

Research limitations. Hedge funds are known for their inconsistency of the return reporting deriving from their legal form, which does not require the comprehensive disclosure of their investment activity. Due to hedge fund managers' possibility to delay or ignore reporting the returns, the data in the hedge fund reporting databases is suffering significant biases, which the majority of the researchers solve by analyzing more generalized hedge fund index data and by validating the indices using various sources of the hedge fund returns. However, when analyzing the hedge funds and their respective indices in the smaller region, additional limitations arise from the market size. Small databases and small sample sizes cause an increase in confidence intervals and, consequently, decrease the accuracy of the models. Even trying to include as many hedge funds in the analysis as possible causes the other limitation – unbalanced panel data. The increasing analysis horizon also plays a crucial role in determining the long-term hedge fund performance factors. On the one hand, the long-term alpha gives a more fundamental view of the region-specific hedge fund investment peculiarities rather than differences observable only in the short run. On the other hand, building long-term models diminishes or even eliminates the factors which tend to change based on the investment environment changes (e.g., changing the long and short strategies or changing the alpha based on the growth of the hedge fund manager's experience with the time).

The non-linear dependence of the hedge funds' returns on the systemic market risks requires advanced research methods based on non-linear dependence models. Researchers use non-linear regressions and other more advanced and complex methods (e.g., dynamic panel data models, panel VAR models, panel ARDL models, and models with non-linear factor dependence). Using linear-only dependency-based models may exclude some of the determinants from the research; however, the explanation of the linear dependencies is more straightforward.

The researchers focusing their analysis on the Global hedge funds' databases have opportunities to group the hedge funds in coherent panels by strategy, age, size, and other characteristics. However, in a smaller region, such grouping may lead to even further inaccuracies. Panel data models are used to include hedge fund-specific factors in the models. However, given the region size and the longevity of the research horizon, panel data models are also limited. E.g., there are no possibilities of using a generalized method of moments designed to solve endogeneity problems.

The scientific novelty of the dissertation and its theoretical importance:

1. The dissertation aims to explore the methodology of creating and adapting the robust model for assessing the performance of the regional hedge funds: what part of the return is attributable to taking on the known market risk, and which is the merit of the hedge fund manager. In the area of holistic hedge fund return, researchers predominantly analyze the Global hedge fund databases, whereas this research seeks various methods and factors which can best represent and determine the performance of the regional hedge funds.

2. The dissertation uses various methods: i.e., models using long-term time horizons with Dummy variables describing the investment environment factors (crisis and regulation); harmonized models analyzing separately periods affected by crisis and regulation against the models of unaffected periods; and finally, models analyzing different crisis periods determining which factors are persistent and which are not in using those different approaches. Such other methods see the alpha deviation from short-term to mid-term and long-term. Long-term alpha makes it possible to distinguish sensation-seeking funds analyzed by Brown et al. (2018) from actual long-term value-generating funds.

3. Calculating long-term *alpha* and long-term *beta* factors also reveal which are more stable in the long run. Most systemic risk factors (e.g., stock or bond market factors) depend on the investment environment. However, hedge fund managers are known for their ability to employ *exotic* strategies – i.e., updating or changing those systemic risk factors based on the effect of the investment environment (i.e., crisis or the regulatory regime).

4. The dissertation also focused on analyzing the hedge funds' performance using asset pricing models using the method with the standardized *beta* coefficients addressing the elasticity of coefficient at dependent variable means. Before that, Gelman (2008) analyzed mutual funds using standardized *beta* coefficients. Considering this research analyzes long-term return data, scaled factors shall diminish the volatility

of the factor value and present its long-term impact on the long-term hedge fund performance. Elasticity at Means also provides graphical of the generated model.

5. No researchers researched Nordic hedge fund pricing determinants before this dissertation. The initial analysis of the Nordic hedge fund return data presents several rather extraordinary observations. Firstly, Nordic hedge funds outperformed by 8% global hedge fund indices throughout the 2007-2008 financial crisis drawdown. Secondly, out of 72 analyzed Nordic hedge funds, 57 survived for more than ten years making Nordic the region of long-livers. McCrum (2014) concluded the series of reports claiming, "Most hedge funds fail: their average life span is about five years." Such a large number of long-living funds implies that Nordic hedge funds' managers withstood more than two crises raising the hypothesis that Nordic hedge fund managers shall be good at investment during the crisis. This hypothesis has not been under the radar of other researchers.

Practical significance of the dissertation:

1. The methodology created in this dissertation shall be adapted to build the hedge fund pricing models in other regions. Although there still can be significant differences between hedge fund regions and consequently between the hedge funds, the methodology presents the model creating sequential flow adjustable to different conditions.

2. The dissertation assesses whether the investment environment, such as crisis or regulation, may **impact** the absolute return of the hedge funds regardless of the direct impact of the market risk factors. Can this specific return be **attributed** to the fund manager's contribution and individual skills, usually awarded by incentive fees? More transparent hedge fund pricing shall reduce the strong asymmetry in the relationship between hedge fund performance and investor sentiment (Zheng and Osmer, 2018) and harmonize long-term growth perspectives.

3. Research in a narrow Nordic hedge fund market, which only comprises 140 active hedge funds, shall motivate other researchers to segment the hedge fund market and analyze the smaller regions. The Nordic region is also very influential for the Baltic states, making the research findings applicable to the Baltic market.

4. The Nordic hedge fund industry presents the results of hedge funds' pricing models. These models can be used by hedge fund managers when showing their results to investors. The Nordic hedge fund award established by Nordic Business Media, besides the absolute return numbers, shall also use the assessment of the hedge fund

manager's contribution to the fund results *(alphas)*.

Defensive statements of the dissertation:

1. Adding the region-specific and other "hidden" risk factors into the hedge fund pricing models shall lead to a decrease in *alpha,* proving that hedge fund managers tend to limit the disclosure of the systemic risks taken by the hedge funds.

2. The hedge funds' investment environment factors (crisis and regulation) impact their asset pricing models and variables.

3. The alpha factor variation primarily explains the performance differences of the regional hedge funds, besides the variation of the systemic market risks (represented by beta factors).

The logical structure of the doctoral dissertation:

The dissertation includes an introduction, three main sections, conclusions and recommendations, references, and annexes. The dissertation comprises 143 pages (with references and annexes of 191 pages). The number of references – is 290. Figure 1 presents the logical dissertation structure.

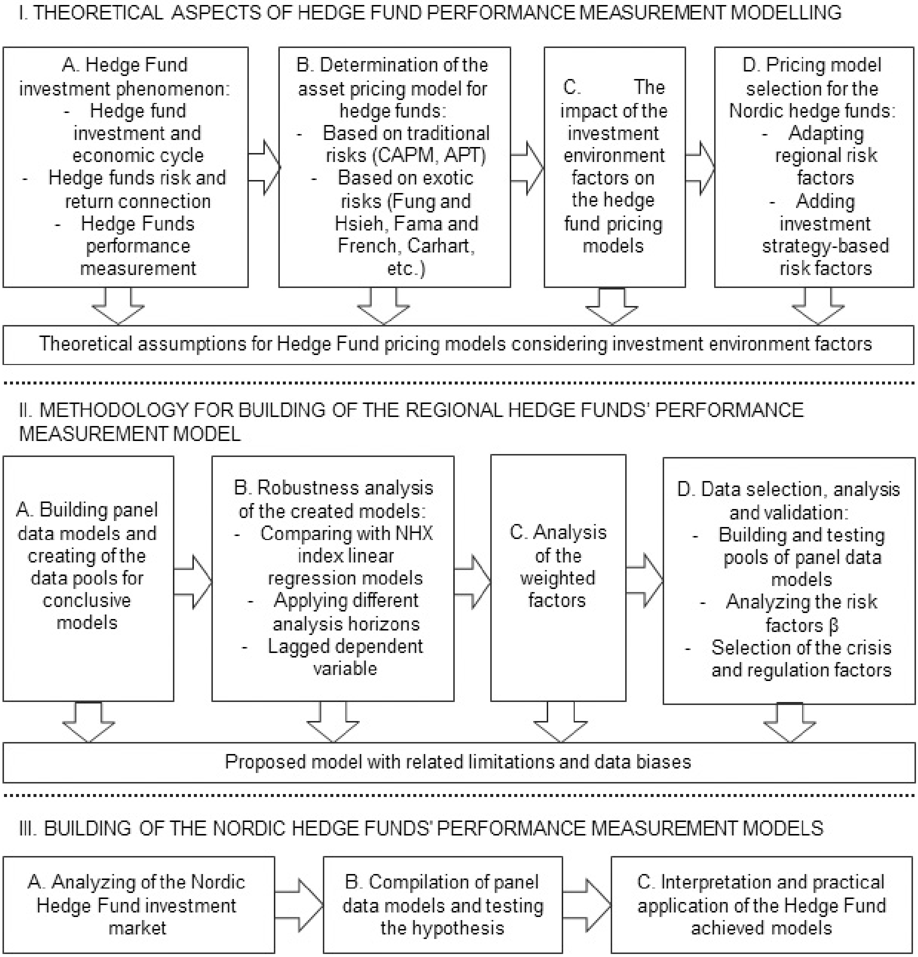

Figure 1. Dissertation logical structure

Theoretical aspects of hedge funds' performance measurement modelling:

The nature of the hedge funds classifies them as high risk and a high return investment undertaking; however, it is not the increased risk but a high absolute return that distinguishes them from the other investment classes. Higher risk strategies depend on the systemic risk channels: credit channels, capital market channels, and liquidity channels, widely presented by Aiken et al. (2012), Brown et al. (2012), Dixon et al. (2012), and others. The frequent aligning of the strategy and frequent trading complements the high-risk channels.

As opposed to mutual funds (also known as regulated CIUs), hedge funds are well known for their unconstrained strategies that lead to somewhat antagonistic interrelations and rumors. Based on various calculations, hedge funds AUM comprises nearly 4% of the entire CIU market; they have that specific attention from the researchers due to the high *alpha* indicators. Achieving the high *alpha* approach gives real portfolio diversification, also known as a neutral market (*zero-beta*). Hedge funds find the proper structure, known as the optimal portfolio (or diversified portfolio), which derives from Markowitz's modern portfolio theory (1952). When comparing hedge funds with mutual funds with the same investment profile (i.e., instruments, duration, directions, regions), hedge funds usually have lower volatility or higher Sharpe ratios, as discussed by Cederburg et al. (2018), Grinblatt et al. (2020) and others. Karehnke and de Roon (2020) estimated that the significant value to investors is delivered by 11% of hedge funds, while similar mutual funds provide an insignificant 4% in the long run. Hartley (2019) compared the performance of liquid alternative mutual funds (LAMF) with hedge funds of similar strategies and discovered at least a 1% on average performance advantage of hedge funds over LAMF.

Although there are few definitions of hedge funds, European Commission (European Commission, 2020) defined them as high-risk funds that aim to achieve an absolute return. However, it is not even the performance level but the strategy complexity that distinguishes hedge funds from the other CIUs. Grinblatt et al. (2020) state that hedge fund strategies are more contrarian and do not follow market trends, while mutual funds are the opposite. Hedge funds strategies comprise four main groups: Directional, Event-driven, Market Neutral, and Fund of funds. The smaller regions may have different hedge fund classifications, which may need a combination of the models and patterns used in the global hedge funds' performance measurement models. E.g., in Nordic countries, Nordic Business Media reports the following five hedge fund strategies: Nordic equities, Nordic fixed income, Nordic commodity trading advisors (CTAs), Nordic multi-strategy, and Nordic fund of funds.

Despite its focus on the absolute return, led by the wrong highlights in the media surrounded by rumors, hedge funds are also known for contributing to the financial system's stability. Hedge funds provide market liquidity (Jame, 2018, Li et al., 2020); hedge funds still act as hedging for some investments and ultimately give some talented investment managers jobs. Despite the upsides and downsides of the hedge fund industry, some hedge funds prosper and live long while others suffer losses or collapse during the market turmoil. The decomposition of the hedge fund performance factors may disclose what part of the performance depends on the manager's success and what part is market-related.

Notably, the information presented about the hedge fund's performance is usually biased and delivered from the best qualities the manager wants to contribute. However, the investors need to see the "correct" or unbiased determinants of the hedge fund performance and the performance indicators themselves.

The fair assessment of the hedge fund's risk-adjusted performance and determination of the performance-based remuneration requires applying various methods, which decompose multiple factors contributing to the final result. Value Research Desk (2020) presents the leading portfolio technical ratios: alpha, beta, R-squared, standard deviation, and the *Sharpe Ratio*. However, Grau-Carles et al. (2017) determined *Sharpe ratio* is biased in the case of non-normally distributed returns characteristic to the hedge funds.

Over more than 20 years, hedge fund asset pricing underwent significant development by Fung and Hsieh (1997, 2001, 2004, 2008), Liang (2000), Agarwal and Naik (2004), Kosowski et al. (2007), Bali et al. (2011), Brown et al. (2012), Edelman et al. (2012), Cao et al. (2018), Joenväärä and Kosowski (2020). These days' the main issues relate to recognizing traditional risks (i.e., the impact of the size or value) and more *"exotic"* risks inherent to the hedge fund investment process (i.e., momentum or various non-linear and option-like return generating investments). Many successful attempts still exist to use traditional asset pricing models for hedge funds. Therefore, these days there are still two main streams of asset pricing models considered by researchers to evaluate the performance of hedge funds:

– Conventional pricing models deriving from leading theories – Capital Asset Pricing Model (CAPM) (Treynor, 1961) and Arbitrage Pricing Theory (APT)

(Ross, 1976), and

– Fung and Hsieh (2004b) elaborated on exotic risks, characteristic of hedge funds aiming for absolute return and employing dynamic styles and high leverage.

Conventional asset pricing models entail the *linear relation* between risk and return. The concept of these asset pricing models, especially those based on APT logic, is based on determining the right asset or investment instrument-based factors which best explain the performance of the investment undertaking. On the one hand, researchers enhance models by adding various equity and debt instruments. On the other hand, hedge funds can also produce a relatively high correlation with specific commodity prices. Stafylas et al. (2018), Swartz and Emami-Langroodi (2018), Racicot and Theoret (2019), Shrydeh et al. (2019), Mensi et al. (2020), Chirwa and Odhiambo (2020), Lambert and Platania (2020) analyzed hedge funds performance dependence on the movement of the Gold, Copper, Oil, and other commodities prices. The leverage strategy attributable to hedge funds can also be explained by the CAPM model, which was in the radar of researchers for many years now (Stattman, 1980, Rosenberg et al., 1985, Bhandari, 1988, Chan et al., 1991, Asness et al., 2013, Frazzini and Pedersen, 2014, Hübner and Lambert, 2019, Bian et al. 2020, and Li J. et al., 2020).

However, conventional asset pricing models have common drawbacks when using them to determine the performance factors of the hedge fund (including equity, fixed income, and CTA strategies). These models rely on linear risk factors, which hedge fund managers can quickly eliminate by using derivatives or option-like strategies. However, based on Agarwal et al. (2018), Stutzer (2018), and Knif et al. (2020), CAPM and ICAPM models still well explain the hedge funds' *alpha*, regardless of hedge funds provide a more comprehensive range of risk exposures deriving from the instruments the fund invests. The main outtake of these models and the conclusion of previous researchers – they provide economically sound provision of using various asset-based factors, especially when seeing regional hedge funds' unusual results compared with the Global rivals.

Since hedge funds contain different financial instruments with linear and non-linear payoffs, they may employ hedging/derivative instruments and very dynamic trading. Therefore, based on Fung and Hsieh (1997a), neither the Fama-French three-factor model (or enhanced by Carhart's (1997) 4-factor model) nor conventional CAPM or APT models may be sufficient to measure Nordic hedge funds' performance. Fung and Hsieh developed a model which assesses the hedge fund investment style-related factors reflected by portfolios of lookback straddles. It is important to note that by that time, Fung and Hsieh could explain nearly 80 percent of all equity hedge funds by analyzing their monthly returns, thus becoming the most efficient tool for observing the hedge fund returns. It further improved the model and contributed the eighth factor to the model – the emerging market index (Edelman et al., 2012). The model is now called Fung and Hsieh's 8-factor model.

Agarwal and Naik (2004) mentioned that hedge funds exhibit non-normal payoffs when applying derivative strategies with an option-like structure. Adding an option-driven risk factor to the linear factor model, Agarwal and Naik (2004) increased its precision in assessing hedge funds' performance by 5-20 percent (measured by adjusted R^2) compared with models without options.

Savage (2017), Groshens (2018), and Robertson (2018) widely used the "smart beta" and "strategic beta" (or Alternative beta) concepts introduced by Jaeger (2005). This concept extends the traditional view on pricing models using four categories of variables: pure beta, smart beta, alternative beta, and alpha. They linked the risk factors with their relative price, considering exotic risk factors are more difficult and expensive to achieve. Therefore, investors and fund managers must choose between the effort to achieve the return and the payoff. Investment factor-based *betas* (i.e., Value, Carry, Quality, Growth, Momentum, and Size) supplement or oppose Fung and Hsieh's 8-factor model.

The other substantial part of the research is on the additional risk-related factors, most of which are related to liquidity or volatility risks. Pástor and Stambaugh (2003) constructed the liquidity index, which many other researchers continuously reported and used. Chen et al. (2018), Jame (2018), and Li et al. (2020) also analyzed the performance of hedge funds, which deal with low liquidity assets (e.g., distressed debt). They identified that high alpha reporting funds underestimate and underreport high liquidity risk held in the fund. Higher liquidity risk represented by low liquidity exposures in the hedge funds provide liquidity cushions to the market, which makes hedge funds extremely important for the market during the turmoil.

Volatility risk is associated with more frequent trade, especially by those fund managers who rely on algorithmic trading and those implying strict control loss and stop loss measures. Asensio (2019) looked for the connections between the slope of the VIX futures term structure and the spread trades characteristic of the hedge funds.

After combining different research papers, the author selected the following factors based on Fung-Hsieh's 8-factor model enhanced with other determinants.

Table1. Hedge fund pricing model factors' summary

Risk factor	**Factor description**
Stock index*	Monthly return of the S&P 500 stock market index (or another main stock index) minus Risk-free rate
D_10YRF*	Monthly return of the FRB 10Y constant maturity bond (or another local Governmental 10-year bond) minus Risk-free rate
Size spread*	Monthly return of the Russell 2000 stock market index (or another Small-Cap index) return minus Monthly return of the S&P 500 stock market index (another main stock index) return
D_Baa10Y*	Monthly return of Moody's Baa bond minus Monthly return of FRB 10Y constant maturity bond
MSEMKFRF*	Monthly return of MSCI Emerging Market index minus Risk-free rate
PTFSBDRF*	Monthly return of the PTFS Bond lookback straddle factor minus Risk-free rate
PTFSFXRF*	Monthly return of the PTFS Currency lookback straddle factor minus Risk-free rate
PTFSCOMRF*	Monthly return of the PTFS Commodity lookback straddle factor minus Risk-free rate
SMB**	A small minus big factor
HML**	A high minus low factor
MOM**	Global Momentum factor
FX	Currency risk factor (Risk factors of Adrien Verdelhan, 2012)
GOLD***	Monthly gold spot price change minus Risk-free rate
COPPER***	Monthly Copper future price change minus Risk-free rate
SILVER***	Monthly Silver Futures price change minus Risk-free rate
BROIL***	Monthly Brent oil spot price change minus Risk-free rate
NGAS***	Monthly Natural Gal future price change minus Risk-free rate
COCOA***	Monthly Cocoa future price change minus Risk-free rate
LIQ	Liquidity risk factor[39]

39 Liquidity risk factor available at: https://faculty.chicagobooth.edu/-/media/faculty/lubos-pastor/data/liq_data_1962_2019.txt

OCMDRWT***	Monthly Risk Weighted Enhanced Commodity TR index[40] change minus Risk-free rate
VIX	30-day expected volatility of the US stock market, derived from real-time, mid-quote prices of S&P 500® Index (SPX^{SM}) call and put options[41].

* Fung and Hsieh factors of Edelman et al. (2012), David A. Hsieh's Data Library available at: https://faculty.fuqua.duke.edu/~dah7/HFRFData.htm

** Fama and French factors of Carhart (1997)

*** Other factors are collected form https://www.investing.com/

Crisis and regulation impact the performance of hedge funds. However, few research papers disseminated embedding the crisis or regulation factors into the hedge funds' asset pricing model. The dissertation does not rely on the factors commonly used to present the crisis and regulation impact (e.g., interest rate, financial asset prices), which will cause autocorrelation with the stock or other indices. Therefore, crisis and regulation periods but not the areas of impact will further represent the investment environment in this dissertation.

Various global and national crisis and regulation periods may impact and reliably contribute to hedge fund performance measurement (asset pricing) models. Crisis – extensively analyzed by Cao et al. (2018), Zhao et al. (2018), Liang and Qiu (2019), Metzger and Shenai (2019), Denk et al. (2020), Gregoriou et al. (2020), Sung et al. (2020). For the crisis periods, the dissertation examines the following determinants: banking crisis, debt crisis, currency crisis, Global crisis, and Global hedge fund drawdowns. Regulation – extensively analyzed by Chan et al. (2007), Barr (2008), Brown et al. (2012), Cerutti et al. (2010), Sullivan (2019), and Berglund et al. (2018 and 2020). For the regulation periods – AIFMD implementation, FSI (of IMF), and WGI (of World bank) were considered.

None of the highlighted models was used in the context of the regional hedge funds. Stambaugh (1982) proposed the initial idea of analyzing the investment portfolios using or combining the various non-US-based indices. Regional hedge funds are

40 Risk Weighted Enhanced Commodity Ex Grain 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

41 It is recognized globally as the primary measure of volatility – used by the researchers and in the media (http://www.cboe.com/vix)

characterized by return data biases, which make regional hedge funds' performance measurement modeling even more complicated. The extensive range of the models and various factors shall provide more opportunities to construct robust models and to test the methodology on Nordic hedge funds. On the other note, Nordic hedge funds have a comparatively longer life span than the Global average of 5 years (McCrum, 2014). Out of 72 Nordic hedge funds analyzed, 57 survived for more than ten years making Nordic the region of long-livers, i.e., having evidence of withstanding more than two crises and raising the hypothesis that Nordic hedge fund managers are advanced in overcoming the crisis.

In developing a regional hedge fund, performance measurement methodology must consider the models and factors listed above and answer the defensive statements and hypotheses raised. Considering smaller hedge fund regions present biased return data, special attention to the model robustness and using of alternative models is considered when building regional hedge funds' performance measurement models. Table 2 below presents the aggregated asset pricing model combining various performance determining factors. Each performance determinant could potentially depend on the specifics of the regional market. The dissertation follows this dependence through the methodology and creation of the model.

Table 2. Hedge fund pricing model aggregated model

Performance determinant / Risk factor	**Category**	**Dependent on region**
Systemic/base risks (stock, bond, IR, FX market)	beta	Yes
Other asset-related (commodities, other assets)	beta	No
"Exotic" / Smart / Alternative (derivatives, leverage, frequent trading, etc.)	beta	No
Individual contribution	alpha	"1"
Investment environment (crisis vs. non-crisis; regulated vs. liberalized)	"2"	Yes

Source: created by the author based on Agarwal et al. (2018) and Groshens (2018).

Other asses-related and "Exotic" / Smart / Alternative factors shall not be region specific as proposed in Table 2. However, based on the APT theory, hedge funds may depend on the factor if such factor reflects the financial instrument in the portfolio/ hedge fund. Therefore, the dissertation analyzes and tests all factors selected with each hedge fund strategy regardless of prejudice.

Methodology for building of the regional hedge funds' performance measurement model.

The methodology comprises three main aspects: selecting the modeling method for validating the hedge fund performance determinants, selecting the determinants themselves, and presenting the methods for performing various modeling robustness testing actions. Figure 2 presents the model building methodology and the expected outcomes (methods), i.e.:

1. Comparing the Panel data models with different factors (global, regional, and "exotic"). Pooled OLS is used to assess the statistical significance of the determinants.

2. Extending the model using the investment environment factors.

3. Model improvement by narrowing the hedge funds pools into coherent pools, selecting the panel data effect, and analyzing and interpreting the model results.

4. Performing various robustness tests.

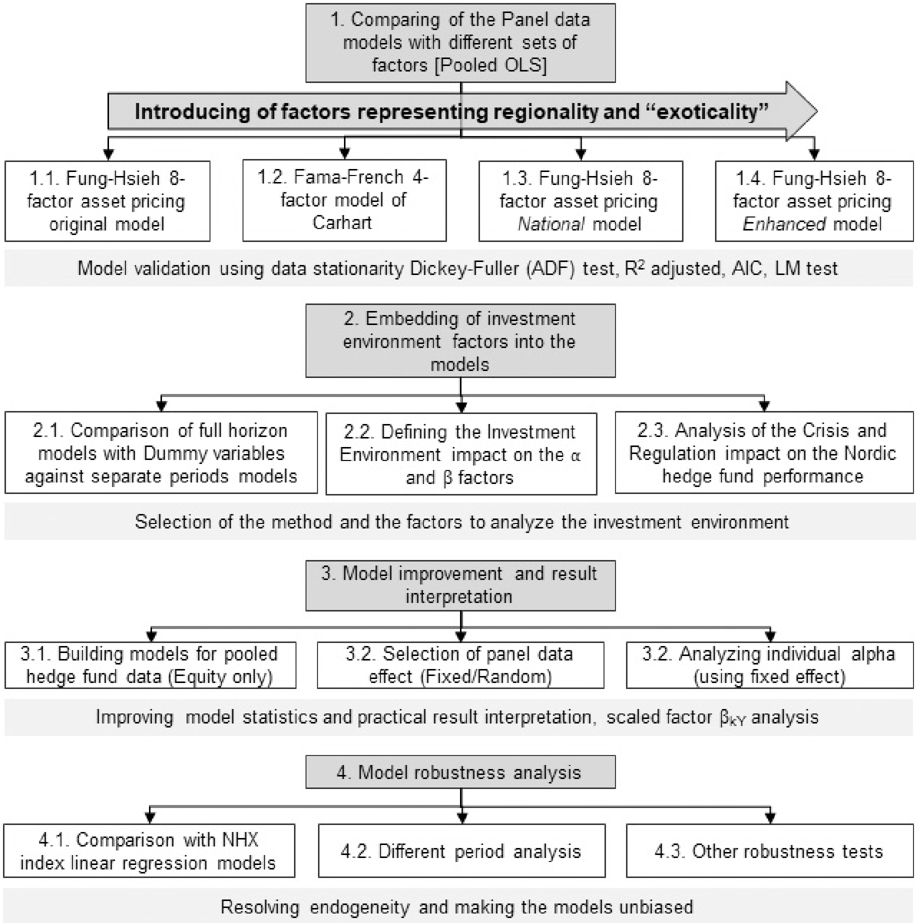

Figure 2. Hedge funds' asset pricing model development and testing steps
Source: Created by the author.

Using panel data models overcomes the heteroscedasticity issue if the data used in the models are stationary. To assure that the values in the regressions are stationary, Moffatt (2019) augmented Dickey-Fuller (ADF) test checking for a unit root in a time series sample was taken for every variable.

The modeling was based on panel data pooled OLS method building Fama-French 4-factor [1] model.

$$R_{i,t} - RF_t = \alpha + \beta_1(RM_t - RF_t) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_{i,t} \qquad 1.$$

Where:

R – the return of hedge fund or NHX index.

RF – the risk-free rate of return.

α – model intercept / Jensen Alpha.

RM – total market return (Each of the Nordic country stock indices replacing the stock-based index of S&P500).

SMB – size premium (small cap index – large-cap index).

HML – value premium (high book-to-market value – small book-to-market value).

MOM – a premium of outperforming positions minus underperforming positions.

β_{1-4} – factor coefficients.

ε – residual or error.

i – the number of cross sections / hedge funds (i = 1,2, ..., N).

t – time periods (t = 1,2, ..., T).

And Fung-Hsieh's 8-factor [2] model based on US-based (Global) factors.

$$R_{i,t} - RF_t = \alpha + \beta_1 SPRF_t + \beta_2 TYRF_t + \beta_3 RLSP_t + \beta_4 BAATY_t + \beta_5 MSEMKFRF_t + \beta_6 PTFSBDRF_t + \beta_7 PTFSFXRF_t + \beta_8 PTFSCOMRF_t + \varepsilon_{i,t} \qquad 2.$$

Where:

Based on [1] specifications with additional terms:

SPRF, TYRF, RLSP, BAATY, MSEMKFRF, PTFSBDRF, PTFSFXRF and PRFSCOMRF – 8 factors of Fung and Hsieh model, presented above and in Table 1.

β_{1-8} – factor coefficients.

Likes of Agarwal et al. (2018), Berglund et al. (2018), and Duanmu et al. (2018) followed the same approach indicating that the linear dependence of the factors is also somewhat convenient to discuss the results from the economic angle.

The models' enhancement is achieved by replacing the Global factors with national substitutes, adding additional commodities or other financial asset-based, and embedding the investment environment representing crisis and regulation factors using the Stepwise regression forward approach.

The methodology also emphasizes the importance of using a single (USD) currency for all calculations. Therefore, the factors are adjusted to USD value change. Panel data models also require selecting the suitable Estimation model, which is determined using three effects (Common effect, Fixed Effect, and Random effect). Choosing the most suitable effect can improve the models and enable more practical use of the model results.

Embedding of the investment environment into the models was performed using two methods. The first method splits the time-dependent panel data into periods depending on which phase of the investment environment is taking place (e.g., in the case of crisis factor – crisis period vs. non-crisis period). The second – introduces the dummy variable representing the affected period and the null valued factor in the unaffected period.

In the end, the panel data models allow applying the fixed or random effect to solve the endogeneity problem, estimate the individual effect for the hedge fund, and increase the practical applicability of the models. There are model limitations deriving from the small size of the regional hedge fund databases, the long-term analysis horizons, and the hedge funds' return data reporting biases. The dissertation is respectively aiming to reduce those limitations where feasible.

Many researchers also seek the connection between the hedge fund return and the anomalies in the short run (e.g., price shocks, drawdowns). They use non-linear regressions and other more advanced and complex methods (e.g., autoregressive vector) here. Other models and methods are also quite widespread in hedge fund performance analysis, including, but not limited to, dynamic panel data models, panel VAR models, panel ARDL models, and models with non-linear factor dependence. The researchers emphasize that those more advanced models and methods allow for greater statistical significance of the selected factors. However, these methods are somewhat less informative when analyzing the results from the economic angle and may lack adaptability when adapting to other regions or conditions.

Following Bernard et al. (2019) and Almeida et al. (2020), the author benefited from using panel data models when splitting the hedge funds into narrower coherent pools by performance or interaction with the benchmark. For better result interpretation and graphical presentations, standardized coefficients are calculated, and the weighted contribution of each of the factors is presented. The elasticity at Means method is used here.

Nordic hedge funds' return data.

Nordic Business Media Aktiebolag supplied Nordic hedge funds' and respective indices' return data. Table 3 presents the composition of the dependent variables comprising Hedge funds' monthly return and Nordic hedge fund indices' monthly return.

Table 3. Dependent variable composition

Variable	Description	Number of variables	Range	Frequency	Parameters
HFR_j	Hedge fund return	72 funds	2005M1-2020M6	monthly	Country. Strategy
$HFIR_k$	Strategy index return	5 strategy indexes	2005M1-2020M6	monthly	-

Nordic hedge funds represent the following strategies: Equities, Fixed income, Multi-Strategy, CTA/Managed Futures, and Fund of funds. Although other hedge fund strategies are also present in the Nordic market, no officially reported hedge fund strategy index exists. The funds representing other known strategies (e.g., market neutral) belong to any of the abovementioned strategies.

Hespeler and Loiacono (2015), Ardia and Boudt (2018), and Canepa et al. (2020) also proposed splitting hedge funds into categories by performance (e.g., Top performance funds to minimum performance funds and four categories in between). Due to the relatively moderate number of hedge funds in the equity strategy, it is reasonable to split funds into two groups: Outperforming the index and Underperforming the NHX strategy index. Due to the low number of hedge funds in other strategies, only Equity strategy hedge funds were split into coherent pools.

Building of the Nordic hedge funds' performance measurement models.

The dissertation examines base models for the following 3 Nordic hedge funds strategies: Equities, Fixed income, and CTA, and the fourth pool of hedge funds combines Equities, Multi-strategy, and Fund of funds strategies based on their Pearson correlation coefficients ranging from 0.79 to 0.84. The modeling provided the following contribution to the raised hypotheses:

H_1*: *Region-specific risk factors can better explain the region-specific hedge funds' performance rather than the Global risk factors using both conventional (e.g., CAPM, APT) or non-linear (e.g., Fung-Hsieh 8-factor) models.

a) CAPM national model in both Equity and Equity+ strategies increased Adj. R^2 from 43.70% to 52.00% and from 44.32% to 49.24%; and decreased AIC from -3.7743 to -3.9355 and from -3.8879 to -3.9815 proving the national stock index alone is the dominant risk factor for equity hedge funds, whereas not for Fixed income and CTA hedge fund strategies.

b) Fama and French 4-factor model of Carhart (1997) based on the national stock index also has similar results to the observation of the CAPM model. So national factors have not increased the statistical significance of Fixed income and CTA strategy hedge funds, **rejecting** the H_1 hypothesis. However, Fung-Hsieh's 8-factor national model was designed to prove hypothesis H_1 **confirmed** in all strategies, including Fixed income and CTA hedge funds.

***H_2*:** *Additional risk factors (e.g., commodity prices, derivatives, ETFs, other assets) and the dummy variables representing various periods of different investment environment conditions improve the statistical significance of the models allowing a more reliable assessment of the hedge fund manager's contribution to the performance of the hedge fund*. Fung-Hsieh 8-factor enhanced model **proves** and **rejects** hypothesis H_2 in the following hedge fund strategies:

a) Equity and Equity+ the improvement of Adj. R^2 and AIC are very fractional, which can be explained by the logic of APT theory assuming Equity representing hedge funds have very little or no exposure in those assets or investment strategies represented by the additional factors. The liquidity risk premium LIQ of Pástor and Stambaugh (2003) and the OCMDRWT commodity index slightly impacted the Equity model. The equity+ performance assessment model has a statistically significant connection to most of the newly proposed factors; however, these factors look relatively insignificant when estimating their Elasticity at Means.

b) Fixed income improvement of Adj. R^2 and AIC are slightly better compared to Equity and Equity+ models. However, as with Equity, there is little connection between the newly proposed factors and the Fixed income strategy, in which funds presumably invest in bonds and other interest-bearing instruments. The Fixed income funds model selected the same factors as the Equity model: liquidity LIQ and OCMDRWT commodity index.

c) CTA improvement of Adj. R^2 and AIC are rather significant. Adj. R^2 increased from 26.26% to 32.93%, and AIC decreased from -3.3592 to -3.4504. As CTA is a commodity-related strategy, according to APT theory, the fund performance can be better explained when the model includes the instruments included in the model. Fama and French (SMB, HML, and MOM), Gold and Silver prices, and liquidity LIQ and OCMDRWT commodity index factors significantly impact the CTA model. As discussed in the case of the Equity+ model, Elasticity at Means shall also present how significantly these factors impact the performance of the CTA hedge funds.

***H_3*: *Changes in the investment environment impact the hedge fund performance is reflected on alpha rather than on the beta indicators*. The analysis of *beta* indicators when comparing the Base model and Dummy crisis and Dummy regulation models provide a small impact on beta indicators. However, alpha indicators underwent more significant changes, which are very close using the Dummy variable models and the models analyzing the specific periods only. Table 4 presents the results of models from the *alpha* indicator perspective in Equities strategy: in the absolute figures and the Elasticity at Means (3rd figure in each cell).

Table 4. "Crisis" and "Regulation" alpha analysis

Strategy	Indicator	Base model	Affected periods	Unaffected periods	Dummy Model
Crisis model	Alpha	0.0026*** (0.0005) 65.49%	0.0039*** (0.0007) 294.64%	0.0012* (0.0007) 16.39%	0.0012* (0.0007) 30.90%
	Crisis factor				0.0025*** (0.0010) 34.65%
Regulation model	Alpha	0.0026*** (0.0005) 65.49%	-0.0008 (0.0008) -52.27%	0.0045*** (0.0006) 82.91%	0.0044*** (0.0006) 111.93%
	Regulation factor				-0.0047*** (0.0010) -45.59%

Note: Standard errors in parenthesis.
*** p<0.01, ** p<0.05, * p<0.1

***H_4*: *Hedge fund managers adjust the investment strategies during the crisis to pre-*

vent drawdowns and generate positive alpha. As provided above, Equity hedge funds' Base model alpha increased from 0.0026 to 0.0039 when compared with the Crisis period model and decreased to 0.0012 in the No Crisis period model. Furthermore, all strategies hedge funds generated alpha indicators exceed the *alpha* of non-crisis periods. Alpha in the Crisis periods model is 0.0039 and statistically significant. In contrast, the alpha in the Dummy crisis model during the crisis period is 0.0012+0.0025=0.0037, which is also statistically significant, proving the above assumption that the crisis can be adequately analyzed by comparing the Base and Dummy crisis models. Similar results were achieved in Fixed income and CTA strategies as well.

***H_5*: *Regulation constraints applied to the hedge fund industry negatively impact the hedge fund's alpha*. In opposition to crisis models, regulation models provide an opposite outcome. E.g., in the Equity hedge funds' Base model, alpha decreased from 0.0026 to -0.0008 when compared with the Regulation period model and increased to 0.0045 in the no Regulation period model. That corresponds to *Hypothesis 5* of this dissertation – *Regulation constraints applied to the hedge fund industry negatively impact the hedge fund's alpha*. Furthermore, hedge funds (all strategies) generated alpha indicators are inferior to periods before the regulation. Alpha in the Regulated periods model is -0.0008, whereas alpha in the models with Dummy regulation factors during the regulation period is 0.0044-0.0047=-0.0003. Similar to the crisis models, the effect of the regulation factor can adequately be analyzed by comparing the Base model and the Dummy regulation model (identical to crisis models).

The **defensive statement 1** *Adding the region-specific and other "hidden" risk factors into the hedge fund pricing models shall lead to a decrease in alpha, proving that hedge fund managers tend to limit the disclosure of the systemic risks taken by the hedge funds*. However, it has been proven while building the base model with some inconsistence. Adding the local market representing national Stock and Bond market variables has significantly increased the statistical soundness of the models except for CTA, which was not as impressive as in all other strategies (models). As a result of the model improvements, alpha coefficients and their Elasticity at Means have changed.

In the case of building the models with Dummy variables, the results shall be reflected in comparing the Elasticity at Means of cumulative beta indicators of Base models and Dummy crisis and Dummy regulation models. Hence, the primary assumption here should be – the cumulative Elasticity at Means of *beta* shall increase. However, in the case of Equity, Equity+, and CTA models, the outcome of the analysis is opposite to the assumption. Therefore, this test does not prove this statement. Therefore, the statement supported by Agarwal et al. (2018), Stutzer (2018), and Knif et al. (2020) about CAPM and ICAPM models' possibility to explain the hedge funds' *alpha* well is feasible.

The **defensive statement 2** *The hedge funds' investment environment factors (crisis and regulation) impact their asset pricing models and variables*. Adding crisis and regulation Dummy variables had a small, but consistent impact on the models:

- There is a consistent impact on alpha factors: in case of crisis – alpha increases; in case of regulation – it decreases.
- The impact on the beta factors is somewhat insignificant, i.e., the sets of beta factors are nearly identical.

The **defensive statement 3** *The alpha factor variation primarily explains the performance differences of the regional hedge funds, besides the variation of the systemic market risks (represented by beta factors)*. Analysis of different Equity strategy hedge funds' coherent pools (gathered by performance and the correlation with the index) revealed that variation of the sets of beta factors between different pools is somewhat insignificant, and the main variation derives from alpha changes. When analyzing factors' contribution to outperforming equity hedge fund models, the most significant impact on exceptional performance derives from the *alpha* absolute contribution columns.

From the **practical perspective,** panel data models can reduce their noise by using random or fixed effects. Harvey and Liu (2018) concluded that effect methods outperform other alternative methods at the population (pooled data) and individual fund levels. In the end, they claim that applying the random and fixed effect methods improved the alpha forecast. Applying the cross-section dependence with fixed effects allows estimating the individual effect on the model intercept, i.e., estimating the individual hedge fund *alpha*. The effect was selected by performing a series of tests (i.e., Random effects LM test of Breusch-Pagan, 1980; Hausman's selection between fixed or random effects, 1978; and Cross Section Dependence diagnostic test of Breusch-Pagan, 1980). Although applying the effect has not increased the models' statistical significance, Equity and Fixed income hedge funds' models were able to apply the effects. The fixed effect allows for assessing the effect on each hedge fund alpha individually and comparing how the fixed effects variate between models, i.e., Base model, Dummy Crisis, and Dummy Regulation models. E.g., hedge funds whose fixed effect in the Dummy Crisis model is increasing compared with the Base model and is decreasing in the Dummy Regulation model would mean:

- this particular hedge fund increased its alpha more substantially than the market during the crisis and
- dropped down the alpha more than the market did.

Nordic Hedge Nordic Business Media promotes the award set to distinguish outstanding hedge fund managers from and active in the Nordic region. The models developed in this dissertation reflect the long-term performance measurement results, while the Nordic Hedge Award focuses more on the performance of the hedge funds over the last three years. The award may consider adding the long-term alpha performance criteria, especially the legacy performance over the crisis, as the other criteria. The models can also be set to analyze the shorter (more recent) horizons and provide more accurate alpha indicators, although losing their long-term and legacy performance peculiarities.

Robustness analysis of the models confirmed one of the **limitations** – extended horizon models represent only long-living funds, which by their long-term reporting resilience cannot be put in the same category as the young and growing hedge funds. The other rather significant limitation of the models appeared to be a diminution of the investment strategy-related beta factors, which include long/short strategy changes, frequent trading, using option-like and other derivatives – also known as "exotic" risk factors. The other inherent limitation derives from the size of the local databases. The sample size of the different hedge fund investment strategies variated between 10 and 27, making the confidence intervals range between 9.75% and 26.27%.

Conclusions and recommendations for future research:

A comprehensive analysis of the capital asset pricing models enabled the identification of the most suitable models to assess the performance of the Nordic hedge funds. The outcomes of analyzing the hedge fund investment phenomenon, model selection, and risk factor selection with in-depth cohesion with other researchers lead the author to the following conclusions:

1. Due to the unique hedge fund investment techniques, the models imply using "exotic" factors, representing fund managers' focus on achieving the absolute return and high *alpha*. A fair estimation of alpha is still an essential subject for many researchers.

2. The researchers argue whether asset pricing models tailored for hedge funds

(such as Fung and Hsieh's 8-factor model) can better explain the *alpha* than the conventional, like CAPM. Therefore, the author selected a wider variety of factors with more focus on the regional specifics and the alternative hedge fund investment strategies (e.g., frequent trading or certain commodities).

3. Eliminating the FX effect deriving from the reporting of the hedge funds and the local market indices by recalculating everything into the USD gave a substantial improvement to the models, making the models more conclusive compared with other Global or region-specific hedge funds and their performance measurement models.

4. Replacing the US dominant factors in Fung-Hsieh's 8-factor model (S&P500 and 10 US Gov. bond yield) with corresponding local factors increased adjusted R^2 in equity and fixed income strategies by 17-19 percent. The improvement of 7 percent of CTA adjusted R^2 was achieved by adding the Commodities and other derivatives into the model, proving hypotheses 1 and 2.

5. Regardless the results of hypotheses 1 and 2, the defensive statement 1, alpha being overvalued by not disclosing some risk factors (e.g., liquidity factor), has been proven, however, with some inconsistency. On the one hand, when comparing Fama-French's 4-factor national model's *alpha* with coherent Fung-Hsieh's 8-factor national model's *alpha*, there is a decrease in *alpha* (e.g., in the case of Equity strategy from 0.0028 to 0.0025). On the other hand, the alpha change while proving hypotheses 1 and 2 had an opposite direction (i.e., in the case of Equity strategy increased from 0.0025 to 0.0026).

Testing various hedge funds' performance measurement models and methods allowed testing raised hypotheses and achieving a high level of robustness of the models. The evidence of the Nordic market with its investment peculiarities allowed achieving somewhat conclusive results:

6. The panel data model allowed incorporation into the model of country-specific, fund-specific, strategy-specific, and time-specific factors. Considering those factors have a linear dependency on hedge fund returns, the models are considered rather explanatory. Adding the various investment environment changes representing time-specific factors – Dummy variables, in the models was a unique research attempt. The models could select Global crisis and AIFMD implementation timelines proving the defensive statement 2.

7. Elasticity at Means used to present and interpret the models allowed to determine how *alpha* and *beta* factors variable between outperforming and underper-

forming or correlated over neutral models. In most cases, *beta* factors are responsible for quite a similar part of the return, whereas *alpha* varies depending on the overall performance of the hedge funds. Using the Elasticity at Means method allowed proving hypothesis 3.

8. The average lifespan of the hedge funds is five years, whereas over 50 percent of Nordic hedge funds reported returns of over ten years, making Nordic a long-living region. This quality of the hedge funds supposes the hedge fund managers have a long successful experience and have withstood at least two crisis periods. On the same note – Nordic hedge funds outperformed Global hedge funds by 8 percent during the severe hedge fund drawdown caused by the financial crisis of 2007-2008.

9. The selection of crisis and regulation periods based on the market conditions defined by the author and other researchers allowed avoiding the problems of autocorrelation. The selected Global crisis periods and AIFM directive implementation timeline were statistically significant when embedded into the models.

10. Analyzing the impact of crisis or regulation in the long run resulted in coherent results between analyzing either of the periods separately and analyzing them together using the time-specific Dummy variable methods. This result allowed simplifying the models using a single model for both crisis and non-crisis or regulation and prior-regulation periods. However, this conclusion is invalid when analyzing hedge fund performance using short-term periods.

11. Applying and analyzing the panel data model effects (fixed effect and random effect) allowed finding the hedge fund-specific *alphas*, which can be used when comparing hedge funds' performance with each other.

The dissertation's methodology provided a sound background for building the region-specific hedge funds' performance measurement models. The methodology also allowed conforming the hypotheses 4 and 5, which have a solid background to consider are Nordic region-specific:

12. Many researchers agree that the Crisis event significantly impacts the hedge fund performance and management, dramatically changing the portfolio's market risk factors (their combination). Considering that Nordic hedge funds' universe is represented by long-living hedge funds, the positive *alpha* "premium" during the crisis is not a surprising conclusion.

13. The impact on the hedge fund alpha by the Regulation factor is negative. Concluding that the limitations imposed by the regulators are impacting the overall in-

vestment environment, as well as on the hedge funds or hedge fund managers directly, this all results in increased cost of operations and limited possibilities to accept more risk into the hedge fund. Analysis of the hedge fund performance beta also pointed out that this factor has no long-term impact deriving from the regulation. Therefore, the decreased *alpha* explains the negative impact of the regulation on the return.

14. The decomposition of the Nordic Equity hedge funds into coherent pools by the performance and the result correlation with the index return also revealed that the primary source of the differences between the funds derives from the *alpha* rather than *beta* factors variation. While the differences between *beta* factors were evident when comparing different strategies (e.g., Equities vs. Fixed income). Such an outcome of the research supports defensive statement 3 and proves how vital the *alpha* factor is in selecting the right hedge fund for the investment.

In conducting the other regional hedge funds' performance measurement modeling, the author makes the following recommendations:

1. In the case of other regions (e.g., Gulf countries, Australia, and European regions), the hedge fund strategies can be more focused on the dominant local commodities. Furthermore, the commodities prices are considered Global, and there is a possibility to find a significant impact of these commodities on the performance and the models.

2. It would also be advisable to reconsider the base model in different regions, as the other regions' hedge funds may not be as strongly dependent on the local financial markets (i.e., stock, bond, IR, FX instruments). Instead, they could be more focused on the previously mentioned commodity instruments or even by more considerable dependency on the credit risk or liquidity risk premiums (in the case of the emerging market).

In order to promote the development of hedge funds' pricing models and a more in-depth analysis of how Crisis and Regulation impact asset pricing models, the following research actions or areas are recommended:

3. Hedge funds are claimed to generate the absolute return; therefore, the hedge funds' performance measurement models, especially on a regional basis, aim to estimate the *alpha* net of undisclosed risk factors. To provide more robust proof, the models shall also include the comparison of the performance determinants of the mutual funds using the same investment environment factors and respective periods.

4. To compile models on shorter and more precise periods, which, on the one

hand, should further remove the heteroscedasticity problems and, on the other hand, would also orient the model to analyze the same fund manager with the fixed style. The comparison with other studies shows that the long-term models are more determined by the asset-based risk factors rather than those more "exotic," which tend to change over time, especially in the changeover periods using the short-term analysis horizons.

5. The models assume that different crisis periods follow the same pattern and depend on the same pricing model when analyzing the crises. The separate crisis periods analysis test showed that models differ when comparing different crisis periods against each other. More in-depth analysis of various crisis periods shall provide a different view on how the root causes of crisis may fundamentally differ.

6. Since Homogeneous Panel data models do not suggest any possible relations with lagged variables, panel data models may use the Vector Autoregression method. After applying the Granger causality test to transfer significant lagged variables into Homogeneous Panel data for the final analysis model. These lagged variables should also identify the luck part of achieving the high alpha; shall this luck be a short-term effect?

7. Various researchers defined the connection between the performance of the hedge funds and consequently their produced alpha with the size of the fund. Although the Nordic hedge fund database could not present the AUM of the hedge funds and, more importantly, could not present the dynamics of AUM growth in the case of analyzing different regions. The author recommends retrieving such data and modeling with the hedge fund AUM and the growth rate.

8. Hedge fund performance analysis needs to include "dead" hedge funds. While long-living hedge funds characteristically have more stable returns and lower volatilities, "dead" funds may represent those sensation-seeking funds, which only succeeded in generating the absolute return during a single economic cycle.

When analyzing the practical applicability of the models and sorting the hedge funds by their long-term alpha, the results were somewhat coherent with the Nordic Hedge Nordic Business Media promoted award. However, these awards are mainly based on one to three years of hedge fund performance. The recommendations for the practical application of the models in the Nordic regions are as follows:

9. Long-term hedge funds' performance measurement models present a long-term crisis and regulation *alpha*, which should be combined with the current one to three years performance indicators used by Nordic Business Media.

10. Short-term hedge funds' performance measurement models would not reflect the hedge fund managers' contribution to the performance during the crisis or other changes in the investment environment. However, using the panel data models with fixed effects in the short-term models can provide a tool for ranking the hedge funds based on *alpha* or specific *beta* indicators.

Dissemination of scientific research results:

Interim and final research results have been disseminated in various national and international papers and presented at scientific conferences.

Publications:

1. Kolisovas, D., Giriūnienė, G., Baležentis, T., Štreimikienė, D. and Morkūnas, M. (2022) "Determinants of Nordic hedge fund performance," *Journal of Business Economics and Management (JBEM)*. Available at: https://doi.org/10.3846/jbem.2022.16170.

2. Škarnulis, A. and Kolisovas, D., (2015) "Pros and cons of inflation-linked sovereign bonds. Initial considerations of the Lithuanian case," *Pinigų studijos*, February 2015, pp. 56-73 [Online]. Available at: https://www.lb.lt/uploads/documents/docs/publications/pinigu_studijos_2015_m_nr_1.pdf

3. Teresienė, D., Kolisovas, D. and Pėstininkas, A. (2014) "2003-2013 published economic indicator's impact on yields of US treasury notes and bonds," *Business Systems & Economics*, Vol 4, No 2, pp. 181-195.

Conference presentations:

1. Kolisovas D. (2019) "Applying Panel Data models for Hedge Fund pricing, '5th International Conference – RAESR 2019. Recent Advances in Economic and Social Research." Romania Academy Institute for Economic Forecasting. May 23-24, Bucharest.

2. Kolisovas D. (2019) "Crypto Perspective: Beyond the 2017 boom," '6th International Scientific Conference Whither our Economies – 2019 WOE'19. September 19-20, Vilnius.

Other publications:

1. Kolisovas, D., (2021) "Secrets of Long Livers: Crisis Alpha," *Nordic Hedge Fund Industry Report 2021*, March 2021, pp. 48-53 [Online]. Available at: https://hedgenordic.com/wp-content/uploads/2021/03/HNIR2021.pdf

2. Kolisovas, D., (2021) "In the Face of COVID-19: Unusual Crisis Performance," *Finding Alpha in Equities*, May 2021, pp. 38-43 [Online]. Available at: https://hedgenordic.com/wp-content/uploads/2021/05/Equities_2021.pdf

AUTHOR'S RESUME

Education

- 2014-2022 – PhD candidate at Mykolas Romeris University, Social sciences, Economics (S 004).
- 2019 March-June – Research internship at Romanian Academy, Institute for Economic Forecasting, Romania in accordance with Erasmus+ program. Internship supervisor – prof. Dr. Mihaela Simionescu.
- 2017 October-2018 June – Research internship at Riga Technical University Department of Investments and Securities in accordance with Erasmus+ program. Internship supervisor – prof. Dr. Natalja Lace.
- 1996-1998 – Master of Science at Kaunas University of Technology, Social sciences, Management.
- 1996-1997 – Master of Science at University of Greenwich (UK), Social sciences, Management.
- 1993-1996 – Bachelor of Science at Kaunas University of Technology, Social sciences, Management.

Working experience

- 2019-current – Various executive Risk Management positions at the Financial Institutions (Lithuania, US, UK).
- 2011-current – Risk Management Consultant providing consulting and training services to Private and Public entities.
- 2016-2019 – Advisor to the Managing Director on Risk Management and Internal Audit functions of Ignalina Nuclear Power Plant.
- 2011-2016 – Lecturer at Mykolas Romeris University.
- 2011-2016 – Head of Risk Management department, Bank Finasta.
- 2008-2010 – Head of Risk Management unit, Bank of Lithuania.
- 2005-2007 – Senior consultant at Ernst & Young Baltic.
- 2000-2005 – Process analyst at Lietuvos draudimas.
- 1998-2000 – Audit assistant at KPMG Lithuania.

Other information

- 2007 – certified Financial Risk Manager (FRM) by the Global Association of Risk Professionals (GARP).

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REGIONINIŲ RIZIKOS FONDŲ VEIKLOS REZULTATĄ LEMIANČIŲ VEIKSNIŲ NUSTATYMAS ŠIAURĖS ŠALYSE

Daktaro disertacijos santrauka

Socialiniai mokslai, ekonomika (S 004)

Vilnius, 2022

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Mokslo daktaro disertacija bus ginama viešame Ekonomikos mokslo krypties tarybos posėdyje 2022 m. gruodžio 1 d. 10 val. Mykolo Romerio universitete, I-414 auditorijoje.
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Su disertacija galima susipažinti Lietuvos nacionalinėje Martyno Mažvydo bibliotekoje, ISM Vadybos ir ekonomikos universiteto, Mykolo Romerio universiteto, Vilniaus universiteto Šiaulių akademijos ir Vytauto Didžiojo universiteto bibliotekose.

DISERTACIJOS SANTRAUKA

Temos aktualumas. Mokslininkai pirmą kartą paminėjo rizikos fondus ir jų investicijas 1950-aisiais. 1960-aisiais jau tapo įprasta investuotojams taikyti ilgas ir trumpas investavimo į akcijas strategijas. Pirminis rizikos fondų tikslas buvo investicijų į tradicinį turtą (kapitalo rinkos priemones) rinkos rizikos mažinimas. 1990-aisiais rizikos fondai tapo nepriklausoma investavimo priemone investuotojams, ieškantiems bendros maksimalios grąžos. Rizikos fondai taip pat žinomi dėl savo didelių nuostolių 1998 m., kai Long Term Capital Management fondas, taikantis aukštą sverto lygį, patyrė 1,8 milijardo JAV dolerių nuostolį dėl didelio obligacijų kainų sumažėjimo. Staigus investicinių priemonių kainų kritimas 2008 m. 2-ajame pusmetyje iššaukė didelį pozicijų išpardavimą, kuris dar labiau paskatino kainų kritimą. To pasėkoje, rizikos fondų valdomas turtas (toliau - AUM) per labai trumpą laiką susitraukė net 25 procentais (BarclayHedge, 2020a). Finansų krizės tyrimo ataskaitoje (FCIC, 2011 m.) Lehman Brothers banko bankroto priežastimi nurodomas staigus prekybos portfelių turto kainų kritimas su banku susijusiuose rizikos fonduose. Pastaruoju metu dėl Covid-19 įvykių 2020 m. I ketvirtį rizikos fondų AUM sumažėjo nuo 3 194 milijardų JAV dolerių iki 2 857 milijardų JAV dolerių. Tačiau per 2020 m. II ketvirtį AUM beveik visiškai atsigavo iki 3 113 milijardų JAV dolerių ir užtikrino 15 procentų prieaugį iki 2020 m. III ketvirčio pabaigos (eVestment, 2020; BarclayHedge, 2020a).

Stulbinantys rizikos fondų veiklos rezultatai glūdi jų investavimo fenomene. Viena vertus, rizikos fondų valdytojai siekia maksimalios grąžos, bandydami aplenkti rinkos indeksus taikydami sumanias strategijas ir nebūdami suvaržyti reguliavimo. Kita vertus, jie pasiekė gana įspūdingų diversifikavimo rezultatų ir sugeneravo didesnę pagal riziką pasvertą grąžą alternatyvių investicijų klasėje, išreiškiamą Sharpe rodikliu. Be didelio Sharpe rodiklio, rizikos fondų investuotojai ir valdytojai siekia aukšto *alfa* rodiklio, kuris parodo grąžą, gaunamą virš rinkos (indeksų) generuojamos grąžos. *Alfa* taip pat yra pagrindinis rizikos fondų valdytojo atlyginimo, nustatomo kaip valdymo ir sėkmės mokestis, variklis. Tačiau kai kuriuose tyrimuose kalbama apie *alfa* rodiklio mažėjimo po pasaulinės finansų krizės 2007–2008 m. tendencijas.

Tyrėjai vis dar daug dėmesio skiria tinkamo *alfa* lygio nustatymui ir, kas yra dar svarbiau, rizikos, kurią prisiima fondas ir kurią parodo *beta* rodikliai, atskleidimui. Pastaruosius 20 metų supratimas apie rizikos fondus ir jų prisiimamą riziką nuolatos didėjo. Tradicines rizikas papildė taip vadinamos „egzotiškos" rizikos, apibūdinančios fondo dydį, augimo pagreitį, o taip pat fondų grąžą atspindinčios į išvestinių priemonių panašios savybės. Mokslininkų Fung ir Hsieh 1997 m. pristatytas modelis, išskyrė šiuos netiesinius rizikos kriterijus, ir iki 2012 m. patobulintas ir šiuo metu laikomas pagrindiniu ir atspirties tašku tarp kitų mokslininkų laikomas 8 veiksnių modelis. Tačiau netiesinės grąžos fondų savybė vis dar išgyvena kognityvinį etapą. Daugelis mokslininkų teigia, kad rizikos fondo *alfą* galima pakankamai tiksliai įvertinti naudojant tradicinius veiklos rezultatų matavimo modelius, tokius kaip CAPM ar Fama-French modelį.

Dauguma modelių siekiančių nustatyti rizikos fondų grąžą lemiančius veiksnius yra sukurti vertinant pasaulinius rizikos fondus, registruotus JAV, JK, apima stambius regionus (Amerika, Europa, Azija) arba registruotus mokestinių lengvatų teritorijose. JAV dominavimas yra akivaizdus, nes aukščiau minėtuose modeliuose naudojami JAV indeksai ir kitos finansinės priemonės, kurių vertė išreiškiama JAV doleriu. Informacija apie rizikos fondų grąžą yra renkama ir skelbiama penkių ryškiausių duomenų tiekėjų: BarclayHedge, EurekaHedge, Hedge Fund Research (toliau - HFR), Morningstar ir Lipper Hedge Fund Database (TASS).

Šiaurės šalių rizikos fondų grąža beveik 10 procentų viršijo pasaulinius rizikos fondų indeksus (HFRI ir MSCI) per pagrindinį 2008 m. 3-4 ketv. rizikos fondų kainų kritimą, tačiau Šiaurės šalių ir kitų regionų rizikos fondų veikla moksliniame pasaulyje mažai tyrinėta. Toks nedidelis ištyrimas kelia klausimą, ar rizikos fondų veiklos rezultatų analizė mažuose regionuose[42], kurių grąžos duomenys gali būti labai šališki, gali būti per daug sudėtinga užduotis. Tais retais regioninių rizikos fondų mokslinių tyrimų atvejais daugiau dėmesio skiriama absoliučios grąžos duomenų palyginimui, o ne rizikos fondų veiklos rezultatų vertinimo modelių ir jų veiklos rezultatus lemiančių veiksnių aptarimui. Pritaikyti vietos rinkai, rizikos fondų veiklos rezultatų vertinimo modeliai gali parodyti, kokia dalis šių išskirtinių rezultatų priklauso nuo vietinių rizikos fondų valdytojų *alfa* ir kas ateina kaip rinkos priemoka *beta*. Be to, Šiaurės šalių rizikos fondų veiklos rezultatų tyrimas gali padidinti susidomėjimą Baltijos šalių rizikos fondų plėtros galimybėmis. Nordic Business Media tikisi paskatinti Baltijos šalių rizikos fondų indeksą ir pristatyti Baltijos šalių rizikos fondus Šiaurės šalių kontekste.[43]

Mokslinių tyrimų problema ir jos ištyrimo lygis. Moksliniuose tyrimuose rizikos fondų veiklos rezultatai nagrinėjami įvairiomis kryptimis, dalis kurių bus paliesta šioje disertacijoje. Rizikos fondų veiklos rezultatų vertinimo modeliai patyrė didžiulę evoliuciją: nuo Treynor 1961 m. sukurto vieno veiksnio CAPM modelio arba Ross 1976 m. sukurto daugiaveiksnio APT modelio; iki modelių, nustatančių rizikos fondų veiklos

42 Apskaičiuota autoriaus pagal: https://hedgenordic.com/; https://www.hfr.com/indices

43 Remiantis informacija gauta aptariant tyrimų rezultatus su Šiaurės šalių verslo žiniasklaidos atstovais.

rezultatus naudojant netiesines priklausomybes, analizuojant į pasirinkimo sandorius panašią Glosteno ir Jagannathano (1994) grąžos struktūrą, Fung ir Hsieh (1997a, 2001, 2002 ir 2004a) tendencijas sekančius veiksnius, arba Fama-French trijų veiksnių modelis (patobulintas Carharto (1997) iki 4 faktorių). Kiti tyrėjai (pvz., Agarwal ir Naik, 2004, Capocci ir kt., 2005, Dewaele ir kt., 2015, Moskowitz, 2020) taip pat tiria rizikos fondų netiesinę grąžą. Tačiau Fung-Hsieh 8 faktorių modelis paskelbtas kartu su Edelman (Edelman ir kt., 2012 m.) vis dar laikomas patikimu, paaiškinančiu beveik 80 procentų visų akcijų rizikos fondų mėnesinių grąžų. Tačiau savo darbuose Agarwal ir kt. (2018), Stutzer (2018) ir Knif ir kt. (2020) vis dar teigia, kad CAPM ir ICAPM modeliai pakankamai tiksliai nustato rizikos fondų *alfa*. Tokio stipraus įsitikinimo idėja kyla iš pagrindinės CAPM modelio idėjos, paaiškinančios 1952 m. Markowitzo šiuolaikinę portfelio teoriją, apibūdinančią portfelio diversifikaciją ir rizikos fondų gebėjimą generuoti didelę *alfa* ar absoliučią grąžą, taip pat žinomą kaip Mossino (1966) pristatytas „šiaurės vakarų“ krypties siekimas. Rizikos fondai taip pat gerai žinomi tuo, kad taiko svertą, kuris leidžia pasiekti aukštesnes „šiaurės vakarų“ pozicijas, nustatomas CAPM modelio. Verta paminėti, kad sėkmingos investavimo idėjos yra gana ribotos.

Vadovaujantis APT teorija, portfelio rezultatai priklauso nuo portfelio sudėties, kurią sudaro įvairios investicinės priemonės priklausančios skirtingoms turto klasėms. Rizikos fondai paprastai orientuojasi į akcijas, fiksuotas pajamas (obligacijas) arba biržos prekių prekybos patarėjai CTA (investuojantys į biržos prekes ir kitą finansinį turtą). Tokie mokslininkai, kaip Blocher ir kt. (2017), Elaut ir Erdős (2019) ir Shaikh (2019) plačiai analizavo įvairių biržos prekių kainų įtaką CTA fondams. Taip pat nemažai tyrimų sieja rizikos fondų kainų svyravimą su aukso ir naftos kainų svyravimu (Stafylas ir kt., 2018, Swartz ir Emami-Langroodi, 2018, Racicot ir Theoret, 2019, Shrydeh ir kt., 2019, Mensi ir kt., 2020, Chirwa ir Odhiambo, 2020, Lambert ir Platania, 2020). Tačiau, kitoms biržos prekėms, tokioms kaip varis, sidabras ar gamtinės dujos, mokslininkai neskiria dėmesio.

Be finansinio turto, tyrėjai taip pat plačiai analizuoja rizikos fondų veiklos priklausomybę nuo kitokių rizikos veiksnių. Pástor ir Stambaugh (2003) įvestas likvidumo veiksnys, parodantis kokią rizikos fondų grąžą uždirba prisiimama likvidumo rizika, padarė proveržį rizikos fondų veiklos rezultatų vertinime. Nepakankamas likvidumo rizikos įvertinimas taip pat buvo labai svarbus veiksnys, lėmęs daugelio rizikos fondų 2007-2008 metų finansų krizės metu patirtus nuostolius. Likvidumo rizikos veiksnį ir jo įtaką rizikos fondų rezultatams plačiai tiria Sadka (2010), Cao ir kt. (2018), Chen ir kt. (2018), Jame (2018), Liang ir Qiu (2019), Canepa ir kt. (2020) ir Li ir kt. (2020) bei kiti mokslininkai.

Kitas su finansinio turto grąža nesusijęs plačiai analizuojamas veiksnys yra kintamumas (toliau - VIX), kuris dažniausiai sąlygoja dažnesnę finansinių priemonių prekybą, kuri yra būdinga rizikos fondams. Oliva ir Reno (2018), Thomson ir van Vuuren (2018), Asensio (2019), Racicot ir Theoret (2019) bei Lee ir kt. (2020) taip pat tyrė VIX veiksnio įtaką rizikos fondų rezultatams.

Be turtu ar rizika pagrįstų (likvidumo ir kintamumo) veiksnių, taip pat mokslininkų plačiai analizuojami vadinamieji egzogeniniai veiksniai, tokie kaip investicijų dydis, kurį pristatė Fama ir French (2004). Naujai įsteigti mažesni fondai turi daugiau laisvės keisti savo strategiją atsižvelgdami į besikeičiančias rinkos sąlygas. Kaip nurodė Amanas ir Moerthas (2005), Jonesas (2007), Teo (2009), Joenväärä ir kt. (2019), Becam ir kt. (2019), O'Neill ir Warrenas (2019), Cummingas ir kt. (2020), mažesni rizikos fondai turi daugiau augimo potencialo. Priešingai, didesni rizikos fondai turi su dydžiu susijusių pranašumų, nes didesnio masto rizikos fondų valdytojai gali sau leisti daugiau išleisti kiekvieno rizikos fondo turto ar komponento analizei ir išsamiam patikrinimui. Kaip nurodė Getmansky ir kt. (2004) ir Xiong ir kt. (2009), geras informuotumas yra didesnių rizikos fondų privalumas. Investavimo patirtį, kurią išanalizavo Carhartas (1997), Pirotte ir Tuchschmidas (2014), Berglundas ir kt. (2018), Rzakhanovas ir Jetley (2019) bei Berglundas ir kt. (2020), taip pat galima palyginti su rizikos fondų ilgaamžiškumu, vedančiu rizikos fondų valdytojus prie patikimesnių sprendimų. Cui ir kt. (2019) ir Shin ir kt. (2019) taip pat susiejo patirtį su dažnu strategijos keitimu, leidžiančiu išvengti didesnių rezultatų svyravimų.

Nepaisant plataus rizikos fondų veiklos rezultatų matavimo tyrimų, tyrėjai, tokie kaip Savage (2017), Groshens (2018) ir Robertson (2018), pasiūlė suskirstyti rizikos fondų veiklos rezultatus į lemiančių veiksnių kategorijas, pagal jų įgyvendinimo sunkumus ir investicinių priemonių bei strategijų sudėtingumą. Jaeger (2005) pristatė „išmaniosios *beta*" ir „strateginės *beta*" (arba „alternatyvios *beta*") sąvokas, suskirstydamas visus veiksnius į grynąją *beta*, išmaniąją *beta*, alternatyviąją *beta* ir *alfa*. Asness ir kt. (2013), Lustig ir kt. (2011), Moskowitz ir kt. (2012), Baltas ir Kosowski (2013) apibrėžė ir išanalizavo investiciniais veiksniais (t.y. vertė, perkėlimas, kokybė, augimas, pagreitis ir dydis) pagrįstus *beta* rodiklius.

Mokslininkai taip pat plačiai analizuoja rizikos fondų veiklos rezultatus krizės metu arba rizikos fondų veiklos rezultatų ir rizikos apetito pokyčius dėl reguliavimo aplinkos pasikeitimų. Cao ir kt. (2018), Zhao ir kt. (2018), Liang ir Qiu (2019), Gregoriou ir kt. (2020) analizavo, kokių strategijų rizikos fondai būna sėkmingi krizės metu.

Metzger ir Shenai (2019), Sung ir kt. (2020), Denk ir kt. (2020) lygina rizikos fondų veiklos rezultatus krizės metu su lyginamaisiais indeksais ar suderintaisiais fondais. Nors egzistuoja daug skirtingų nuomonių apie rizikos fondų rezultatus krizės metu, krizės veiksnio įtraukimas į rizikos fondų veiklos rezultatų vertinimo modelius nėra plačiai naudojamas. Hespeler ir Loiacono (2015) nustatė rizikos fondų grąžos rodiklių priklausomybę nuo sektoriaus grąžos krizės ir ne krizės metu pasiskirstymo, tačiau jie to neįvardino kaip rizikos fondų veiklos rezultatus lemiančio veiksnio.

Reaguojant į 2007–2008 m. finansų krizę, JAV priimtas Dodďo ir Frank'o Volstryto reformos ir vartotojų apsaugos aktas (Dodd-Frank), o Europos Sąjungoje (toliau - ES) priimta Europos Parlamento ir Tarybos direktyva 2011/61/ES dėl alternatyvių investavimo fondų valdytojų, kuria iš dalies keičiami direktyvos 2003/41/EB ir 2009/65/EB bei reglamentai (EB) Nr. 1060/2009 ir (ES) Nr. 1095/2010 (toliau - AIFV direktyva). Šis reguliavimas turėjo dvejopą poveikį rizikos fondų veiklos rezultatams. Pasak Barr (2008), Brown ir kt. (2012), Chan ir kt. (2007), ir Cerutti ir kt. (2010), rizikos fondai pirmiausia buvo apriboti prisiimti tradicines rizikos fondų rizikas, pvz., reikalavimas registruoti rizikos fondų valdytojus Vertybinių popierių ir rinkų komisijoje (angl. SEC), kai rizikos fondo AUM viršija 100 milijonų JAV dolerių, užkerta kelią galimam labai reikšmingam poveikiui rinkai. Sumažėjusi galimybė naudoti didesnį svertą, padidėjusios skolinimosi išlaidos arba draudimas naudoti skolintų vertybinių popierių pardavimą sumažino galimybes uždirbti didesnę grąžą prisiimant didesnę riziką. Tačiau Sullivan (2019) bei Joenväärä ir Kosowski (2020) taip pat pastebėjo, kad sumažėjo rizikos fondų investuotojų polinkis rizikuoti, todėl atsirado konservatyvesnis rizikos fondų valdytojų požiūris ir sumažėjo *alfa* lygis. Fairchild (2018) padarė išvadą, kad reguliavimas daro didesnį spaudimą rizikos fondų valdytojams uždirbti *alfa*, nes jų uždarbis tiesiogiai priklauso nuo jo.

Nepriklausomai nuo laipsnio, kuriuo analizuojami rizikos fondų veiklos rezultatai, vienas esminis rizikos fondų veiklos rezultatų aspektas yra *alfa* faktorius ir fondo valdytojo gebėjimas jį generuoti. Pasak Siegel (2005), taikydami „pažangaus *beta*" metodą, investuotojai optimizuoja skirtingus rinkos veiksnius ir pasiekia didesnę grąžą, patirdami tą patį rizikos lygį. Jis daro išvadą, kad tai, kas iš pradžių buvo laikoma grynu *alfa*, dabar gali būti laikoma kitų rizikos veiksnių kaip likvidumo ar neskaidrumo priedais.

Rizikos fondų veiklos rezultatų vertinimo modelių kūrimas, veiksnių lemiančių grąžą parinkimas ir analizė, kaip veiklos rezultatai priklauso nuo investicinės aplinkos pokyčių, dažniausiai atliekami pasauliniu mastu, t.y. Naudojant pasaulinius arba JAV registruotus rizikos fondus bei išskirtinai naudojant JAV dolerius. Nepaisant to, 1982 m. Stambaugh pasiūlė analizuoti investicinius portfelius (suderintuosius investicinius fondus), naudojant įvairius ne JAV indeksus. Pirmą kartą Do ir kt. (2005) išanalizavo Australijos rizikos fondus; tačiau jie nustatė labai mažą priklausomybę nuo Australijos ASX indekso, tačiau išsiaiškino, kad Australijos rizikos fondų grąžos pasižymi duomenų šališkumu.

Mokslininkai taip pat analizavo ir kitus regionus: Aziją analizavo Van Dyk ir kt. (2014), Japoniją – Kanuri (2020), Saudo Arabiją ir Malaiziją – Oueslati ir Hammami (2018), o islamo šalis – Karim ir kt. (2020). Auganti Kinijos rizikos fondų rinka taip pat sulaukia nemažai mokslininkų dėmesio: Huang ir Sun (2018), Huang ir kt. (2018), Chen ir kt. (2019), Zhai ir Wang (2020). Gibilaro ir kt. (2018) analizavo Kipro rizikos fondų rinką, nurodydami didelę Kipro rinkos priklausomybę nuo Europos rizikos fondų, kurie pasirinko Kiprą dėl mokestinių lengvatų. Tačiau visi šie moksliniai darbai yra labiau orientuoti į absoliučios grąžos analizę arba skirtumų tarp regioninių ir pasaulinių rizikos fondų kiekybinį įvertinimą.

Nepaisant įspūdingų Šiaurės šalių rizikos fondų veiklos rezultatų, regionas beveik nesulaukia mokslininkų dėmesio. Ekberg ir Iversen (2018) skyrė dėmesį investicinės aplinkos aprašymui ir rizikos fondų analizei. Disertacijos autoriaus atlikta Šiaurės šalių rizikos fondų analizė atskleidė, kad šiam regionui yra būdingas fondų ilgaamžiškumas ir mažesnis rizikos fondų registravimo mokestinių lengvatų teritorijose lygis, todėl šis regionas yra unikalus. Šiaurės šalių investavimo rinka taip pat skiriasi nuo JAV investavimo rinkos tuo, kaip vyksta bendravimas tarp fondų valdytojų ir investuotojų. Preuss (2019 m.) pastebėjo didesnį Šiaurės šalių akcijų fondų valdytojų rizikos suvokimą, dėl kurio fondų kintamumo rodikliai buvo mažesni nei JAV konkurentų. Nors rizikos fondų regionai pasižymi ypatingomis savybėmis (pvz., Šiaurės šalių fondai yra žinomi dėl savo ilgaamžiškumo, o rizikos fondų valdytojai turi turėti didelę patirtį, kaip atlaikyti daugiau nei dvi krizes), šioje disertacijoje sukurta metodika gali būti pritaikyta bet kuriam mažesniam regionui, neatsižvelgiant į regiono ypatumus.

Mokslinė problema – kokie veiksniai lemia regioninių rizikos fondų rezultatus ir kaip vertinimo modeliai bei veiksniai kinta priklausomai nuo investicinės aplinkos pasikeitimo.

Tyrimo objektas – regioninių rizikos fondų veiklos rezultatų vertinimo (kapitalo įkainojimo) modeliai.

Tyrimo tikslas – išnagrinėjus rizikos fondų investavimo reiškinį ir remiantis

Šiaurės šalių imtimi, sukurti regioninių rizikos fondų veiklos rezultatų vertinimo modelius, pritaikomus skirtingoms investavimo aplinkos sąlygoms.

Tyrimo tikslui pasiekti nustatytos šios **užduotys**:

1. Išanalizavus mokslinę literatūrą ir remiantis teorinėmis rizikos fondų investavimo reiškinio charakteristikomis, nustatyti prielaidas parengti ir pritaikyti regioninių rizikos fondų veiklos rezultatų vertinimo metodiką.

2. Atsižvelgiant į veiksnius, apibūdinančius regiono investavimo aplinką ir rizikos fondų investavimo strategijas, apibrėžti regioninių rizikos fondų veiklos rezultatų vertinimo modelio kūrimo metodiką.

3. Vadovaujantis sukurta metodika ir remiantis Šiaurės šalių rizikos fondų grąžos duomenimis, Šiaurės šalių rizikos veiksniais ir investicinės aplinkos sąlygomis, nustatyti Šiaurės šalių rizikos fondų veiklos rezultatus lemiančius veiksnius.

4. Įvertinti Šiaurės šalių rizikos fondų valdytojų indėlį (matuojamą *alfa* rodikliu) įvairiomis investavimo aplinkos sąlygomis (t.y. Krizės ar reguliavimo suvaržymo ar nepaveiktais laikotarpiais).

Tyrimo hipotezės.

H_1: Su konkrečiu regionu susiję rizikos veiksniai gali geriau paaiškinti nei pasauliniai rizikos veiksniai regiono rizikos fondų veiklos rezultatus, naudojant tiek tradicinius (pvz., CAPM, APT), tiek netiesinius (pvz., Fung-Hsieh 8 faktorių) modelius.

H_2: Papildomi rizikos veiksniai (pvz., biržos prekių kainos, išvestinės finansinės priemonės, biržose prekiaujami fondai (toliau – ETF) ir kitas finansinis turtas) ir pseudokintamieji, atspindintys įvairius skirtingos investicinės aplinkos sąlygų laikotarpius, pagerina statistinę modelių reikšmę, leidžiančią patikimiau įvertinti rizikos fondų valdytojo indėlį į rizikos fondo veiklos rezultatus.

H_3: Investicinės aplinkos pokyčiai daro poveikį rizikos fondų veiklos rezultatams daugiau per *alfa,* o ne *beta* rodiklius.

H_4: Rizikos fondų valdytojai krizės metu koreguoja investavimo strategijas, kad užkirstų kelią fondų išpardavimui ir generuoja teigiamą *alfa*.

H_5: Rizikos fondų sektoriui taikomi reguliavimo apribojimai neigiamai veikia rizikos fondo *alfa*.

Tyrimo metodai.

Vertinant Šiaurės šalių rizikos fondų investavimo rezultatus ir taikant kapitalo įkainojimo modelius disertacijoje naudojami šie tyrimo metodai:

- Sisteminė literatūros analizė.
- Teisinių dokumentų analizė.

– Grafinis duomenų aiškinimas ir analizė.
– Statistinės analizės metodai.
– Empiriniai tyrimai.
– Ekspertų vertinimo metodas.

Mokslinių tyrimų apribojimai. Rizikos fondai yra žinomi kaip nenuosekliai teikiantys informaciją apie grąžą, nes tokią galimybę numato jų teisinė registracijos forma. Dėl rizikos fondų valdytojų galimybės atidėti arba ignoruoti grąžos ataskaitų teikimą, rizikos fondų ataskaitų duomenų bazių duomenys susiduria su dideliu šališkumu, kurį dauguma tyrėjų išsprendžia analizuodami labiau apibendrintus skelbiamų rizikos fondų indeksų duomenis ir sukurdami savo indeksus naudodami įvairius rizikos fondų grąžos šaltinius. Tačiau analizuojant rizikos fondus ir jų atitinkamus indeksus mažesniame regione, dėl rinkos dydžio atsiranda papildomų apribojimų. Mažos duomenų bazės ir nedidelė analizės imtis padidina pasikliovimo intervalus ir atitinkamai sumažina modelių tikslumą. O bandymas į modelį įtraukti kuo daugiau rizikos fondų sukelia kitą apribojimą – nesubalansuotus kaupinių duomenis. Ilgas analizės laikotarpis taip pat atlieka labai svarbų vaidmenį nustatant ilgalaikius rizikos fondų veiklos rezultatų veiksnius. Viena vertus, ilgalaikis *alfa* suteikia fundamentalesnį vaizdą apie konkrečiam regionui būdingus rizikos fondų investavimo ypatumus, o ne skirtumus, pastebėtus tik trumpuoju laikotarpiu. Kita vertus, kuriant ilgalaikius modelius sumažėja arba net eliminuojami veiksniai, kurie paprastai keičiasi atsižvelgiant į investicinės aplinkos pokyčius (pvz., keičiant ilgąsias ir trumpąsias strategijas arba kintant *alfa*, remiantis rizikos fondų valdytojo patirties augimu).

Dėl netiesinės rizikos fondų grąžos priklausomybės nuo sisteminės rinkos rizikos reikia pažangių mokslinių tyrimų metodų, pagrįstų netiesinės priklausomybės modeliais. Tyrėjai naudoja netiesines regresijas ir kitus pažangesnius bei sudėtingesnius metodus (pvz., dinaminių panelinių duomenų modelius, panelinius vektorinės autoregresijos (toliu – VAR) modelius, panelinius ARDL modelius ir modelius su netiesine priklausomybe nuo veiksnių). Naudojant tik tiesinėmis priklausomybėmis pagrįstus modelius, kai kurie veiksniai gali būti pašalinti iš tyrimo; tačiau tiesiniai ryšiai yra lengviau interpretuojami.

Mokslininkai, analizuojantys pasaulinių rizikos fondų duomenų bazes, turi galimybių sugrupuoti rizikos fondus į nuoseklias grupes / kaupinius pagal strategiją, amžių, dydį ir kitas savybes. Tačiau mažesniame regione toks grupavimas gali sukelti dar daugiau netikslumų. Panelinių duomenų modeliai naudojami siekiant į modelius įtraukti atskiriems rizikos fondams (jų grupėms) būdingus veiksnius. Tačiau, atsižvelgiant į regiono dydį ir mokslinių tyrimų laikotarpį, panelinių duomenų modeliai taip pat yra riboti, pvz., nėra galimybių naudoti apibendrintą momentų metodą (toliau - GMM), skirtą endogeniškumo problemoms spręsti.

Mokslinis disertacijos naujumas ir jos teorinė svarba:

1. Disertacijos tikslas – išnagrinėti patikimo regioninių rizikos fondų veiklos rezultatų vertinimo modelio sukūrimo ir pritaikymo metodologiją, t. y. nustatyti kokia grąžos dalis priskirtina prisiimamai rinkos rizikai ir kuri yra rizikos fondo valdytojo nuopelnas. Holistinės rizikos fondų grąžos srityje mokslininkai daugiausia analizuoja pasaulinių rizikos fondų duomenų bazes, o šiame tyrime ieškoma įvairių metodų ir veiksnių, kurie galėtų geriausiai atspindėti ir nustatyti atskirų regioninių rizikos fondų veiklos rezultatus.

2. Disertacijoje naudojami įvairūs metodai ir modeliai: t. y. modeliai, naudojantys ilgalaikius laiko horizontus su pseudokintamaisiais, apibūdinančiais investicinės aplinkos veiksnius (krizę ir reguliavimą); suderinti modeliai, atskirai analizuojantys krizės ir reguliavimo paveiktus laikotarpius ir nepaveiktų laikotarpių modelius; ir galiausiai, modeliai, analizuojantys skirtingus krizės laikotarpius, nustatantys, kurie veiksniai yra patvarūs, o kurie kintantys. Tokie metodai parodo *alfa* nuokrypį nuo trumpalaikio iki vidutinio ir ilgalaikio. Ilgalaikis *alfa* leidžia atskirti „sensacijų ieškančius“ fondų valdytojus, kuriuos analizavo Brown ir kt. (2018) nuo tikrųjų ilgalaikėje perspektyvoje sukuriančių vertę fondų valdytojų.

3. Apskaičiuojant ilgalaikius *alfa* ir ilgalaikius *beta* veiksnius, taip pat atskleidžiami, kurie yra stabilūs ilgalaikėje perspektyvoje. Dauguma sisteminės rizikos veiksnių (pvz., akcijų ar obligacijų kainų veiksniai) priklauso nuo investavimo aplinkos. Tačiau rizikos fondų valdytojai yra žinomi dėl savo gebėjimo taikyti „egzotiškas“ strategijas, t. y. atnaujinti arba pakeisti tuos sisteminės rizikos veiksnius, pagrįstus investavimo aplinkos poveikiu (t. y. krize ar reguliavimo tvarka).

4. Disertacijoje taip pat daug dėmesio skiriama rizikos fondų veiklos rezultatų analizei naudojant kapitalo įkainojimo modelius, naudojant metodą su standartizuotais *beta* koeficientais, skirtais veiksnio pasvertam poveikiui fondo grąžai nustatyti. Iki šiol Gelman (2008) analizavo investicinius fondus, naudodamas standartizuotus *beta* koeficientus. Atsižvelgiant į tai, kad šiame tyrime analizuojami ilgo laikotarpio grąžos duomenys, svertiniai veiksniai turi sumažinti veiksnio vertės kintamumą ir pateikti jo ilgalaikį poveikį ilgalaikiams rizikos fondų veiklos rezultatams. Medianų elastingumas taip pat suteikia galimybę pavaizduoti modelį grafiniu būdu.

5. Iki šios disertacijos nė vienas tyrėjas netyrė specifiškai Šiaurės šalių regiono

rizikos fondų grąžą lemiančių veiksnių. Pradinėje Šiaurės šalių rizikos fondų grąžos duomenų analizėje pateikiami keli reikšmingi pastebėjimai. Pirma, Šiaurės šalių rizikos fondai per 2007–2008 m. finansų krizę 8 proc. viršijo pasaulio rizikos fondų indeksus. Antra, iš 72 analizuotų Šiaurės šalių rizikos fondų 57 išgyveno daugiau nei dešimt metų, todėl Šiaurės šalys tapo ilgaamžių rizikos fondų regionu. McCrum (2014) paskelbė pranešimų seriją, teigdamas: „Dauguma rizikos fondų žlunga: jų vidutinė gyvenimo trukmė yra apie penkerius metus“. Toks didelis Šiaurės šalių regiono ilgaamžių fondų skaičius reiškia, kad Šiaurės šalių rizikos fondų valdytojai atlaikė daugiau nei dvi krizes, todėl autorius kelia hipotezę, kad Šiaurės šalių rizikos fondų valdytojai per krizę pasiekė geresnius rezultatus, ko iki šiol netyrė kiti mokslininkai.

Praktinė disertacijos reikšmė:

1. Metodika pateikiama šioje disertacijoje yra pritaikoma bet kokio regiono rizikos fondų veiklos rezultatų vertinimui. Nors regionai iš esmės gali labai skirtis, ir rizikos fondų grąžos taip pat gali labai skirtis, disertacijoje atskleidžiama metodologija, kuri leidžia nuosekliai atlikus tyrimo žingsnius sukurti modelį konkrečiam regionui.

2. Disertacijoje vertinama, ar investavimo aplinka, pavyzdžiui, krizė ar reguliavimas, turi įtakos rizikos fondų grąžai, papildomai nei per tiesioginį rizikos veiksnių poveikį. Ar papildomą grąžą galima priskirti fondo valdytojo įnašui ir individualiems įgūdžiams, už kuriuos paprastai yra atlyginama papildomai? Skaidresnis rizikos fondų grąžos veiksnių atskleidimas turi sumažinti takoskyrą tarp rizikos fondų veiklos rezultatų ir investuotojų lūkesčių (Zheng ir Osmer, 2018) bei suderinti ilgalaikio augimo perspektyvas.

3. Tyrimai siauroje Šiaurės šalių rizikos fondų rinkoje, kurią sudaro tik 140 aktyvių rizikos fondų, paskatins kitus mokslininkus segmentuoti rizikos fondų rinką ir analizuoti mažesnius regionus. Šiaurės šalių regionas turi didelę įtaką Baltijos šalims, todėl tyrimų išvados turi būti pritaikomos Baltijos šalių rinkai.

4. Šiaurės šalių rizikos fondų rinka pristato rizikos fondų kapitalo įkainojimo modelių rezultatus. Šiuos modelius gali naudoti rizikos fondų valdytojai, rodydami savo rezultatus investuotojams. Nordic Business Media skelbiamuose Šiaurės šalių rizikos fondų apdovanojimuose, be absoliučių grąžos skaičių, taip pat galėtų būti naudojamas rizikos fondų valdytojo įnašo į fondo rezultatus (*alfa)* įvertinimas.

Disertacijos ginamieji teiginiai:

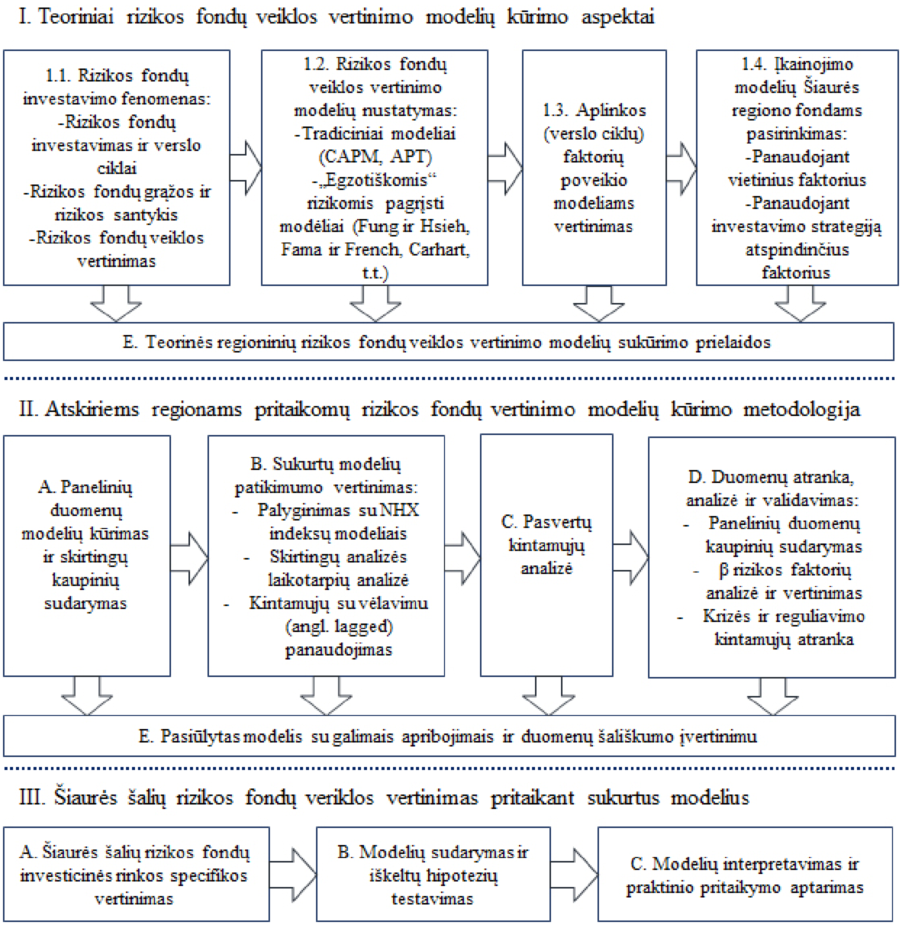
1. Į rizikos fondų kainodaros modelius įtraukus konkrečiam regionui būdingus ir kitus „paslėptus“ rizikos veiksnius, sumažėja *alfa,* o tai įrodo, kad rizikos fondų valdytojai linkę riboti rizikos, kurią prisiima rizikos fondai, atskleidimą.

2. Rizikos fondų investicinės aplinkos veiksniai (krizė ir reguliavimas) daro poveikį jų kapitalo įkainojimo modeliams ir kintamiesiems.

3. Regioninių tos pačios strategijos arba rūšies rizikos fondų veiklos rezultatų skirtumus daugiau lemia *alfa* rodiklių skirtumai, o ne sisteminės rinkos rizikos veiksnių *beta* pokyčiai.

Daktaro disertacijos loginė struktūra:

Disertaciją sudaro įvadas, trys pagrindiniai skyriai, išvados ir rekomendacijos, nuorodos ir priedai. Disertaciją sudaro 143 puslapiai (su nuorodomis ir priedais 191 puslapių). Nuorodų skaičius – 290. 1 paveiksle pateikta loginė disertacijos struktūra.



1 pav. Disertacijos loginė struktūra

Rizikos fondų veiklos rezultatų vertinimo modeliavimo teoriniai aspektai:

Dėl rizikos fondų investavimo specifikos jie klasifikuojami kaip didelės rizikos ir didelės grąžos investicinė įmonė. Tačiau nuo kitų investicinių instrumentų juos išskiria ne padidėjusi rizika, bet didelė absoliuti grąža. Tradiciškai rizikos fondų padidėjusi rizika yra priskiriama šioms grupėms: kredito rizikos kanalui, kapitalo rinkos rizikų kanalui ir likvidumo kanalų, kuriuos plačiai pristatė Aiken ir kt. (2012), Brown ir kt. (2012), ir Dixon ir kt. (2012). Rizikos fondams būdingas dažnas strategijos koregavimas ir dažna prekyba papildo šiuos rizikos kanalus.

Priešingai nei suderintieji investiciniai fondai (taip pat žinomi kaip reguliuojami kolektyviniai investavimo subjektai (toliau – KIS)), rizikos fondai yra gerai žinomi dėl savo neribojamų strategijų, kurios lydimos antagonistiniu interpretavimu ir gandais. Nors remiantis įvairiais skaičiavimais, rizikos fondų valdomas turtas sudaro tik beveik 4% visos KIS rinkos; jie pritraukia nemažą tyrėjų dėmesį dėl aukštų *alfa* rodiklių. Pasiekus aukštą *alfa* lygį, sumažinama rinkos įtaka grąžai ir pasiekiama neutrali rinkai portfelio struktūra bei pasiekiamas gana aukštas portfelio diversifikavimas. Rizikos fondai sugeba atrasti idealią struktūrą, dar žinomą kaip optimalus portfelis (arba diversifikuotas portfelis), kurią aprašė Markowitz (1952) šiuolaikinėje portfelio teorijoje. Lyginant rizikos fondus su suderintaisiais fondais, turinčiais tą patį investavimo profilį (t.y. Priemones, investicijų trukmę, kryptis, regionus), rizikos fondai paprastai turi mažesnį kainų kintamumą ir aukštesnius Sharpe koeficientus. Įvairiais skaičiavimais nustatyta, kad rizikos fondai pasiekia reikšmingus teigiamus rezultatus daugiau kaip 11% visų fondų atvejų, kai suderintieji fondai savo rezultatais stulbina mažiau nei 4% investuotojų (Cederburg ir kt., 2018, Grinblatt ir kt., 2020, Karehnke ir de Roon, 2020). Hartley (2019) palygino likvidžių alternatyvių suderintųjų fondų (toliau - LAMF) veiklos rezultatus su panašių strategijų rizikos fondais ir atrado bent 1% vidutinį rizikos fondų pranašumą prieš LAMF.

Nors skirtinguose regionuose rizikos fondų apibrėžimai šiek tiek skiriasi, Europos Komisija juos apibrėžė kaip didelės rizikos fondus, kuriais siekiama absoliučios grąžos. Tačiau rizikos fondus nuo kitų KIS skiria net tik veiklos rezultatų lygis, bet ir strategijos kompleksiškumas. Grinblatt ir kt. (2020) teigia, kad rizikos fondų strategijos yra labiau kontraversiškos ir neatitinka rinkos tendencijų, o suderintieji fondai labiau atitinka rinką. Rizikos fondų strategijas sudaro keturios pagrindinės grupės: krypties, orientuotos į įvykius, neutralios rinkos atžvilgiu ir fondų fondai. Skirtingi regionai gali turėti skirtingas rizikos fondų klasifikacijas. Dėl šių skirtumų veiklos rezultatų vertinimo modelių rezultatai gali būti sunkiai palyginami, pvz., Šiaurės šalyse Nordic Business Media praneša apie šias penkias rizikos fondų strategijas: akcijų, fiksuotų pajamų, Biržos prekių prekybos patarėjus (toliau - CTA), daugialypės strategijos ir fondų fondų.

Nepaisant to, kad rizikos fondų pagrindinis tikslas yra maksimali grąža, rizikos fondai sulaukia nemažai neigiamo dėmesio žiniasklaidoje dėl įvairių gandų ir dėl ryšio su finansų krizėmis. Nors krizių metu rizikos fondai daugiau nei kiti KIS susiduria su likvidumo problemomis ir gali nukentėti dėl pozicijų išpardavimo lenktynių, Jame (2018), Li ir kt. (2020) išskyrė, kad rizikos fondai taip pat vaidiną reikšmingą vaidmenį palaikant visos rinkos likvidumą. Taip pat rizikos fondai vis dar veikia kaip apsidraudimo priemonės nuo tam tikrų rinkos rizikų. Ir galiausiai, jie suteikia talentingiems investicijų valdytojams darbo vietų. Nepaisant rizikos fondų rinkos pakilimų ir nuosmukių, kai kurie rizikos fondai klesti ir gyvena ilgai, o kiti patiria nuostolių arba žlunga per rinkos neramumus. Rizikos fondų veiklos rezultatų veiksnių išskyrimas gali padėti atskleisti, kuri veiklos rezultatų dalis priklauso nuo fondo valdytojo sėkmingų sprendimų ir kuri dalis yra susijusi su prisiimta rinkos rizika.

Pažymėtina, kad pateikiama informacija apie rizikos fondų veiklos rezultatus paprastai yra šališka ir pateikiama remiantis principu, kad fondų valdytojai nori atskleisti tik sėkmingus fondų rezultatus. Tačiau investuotojai nori matyti „teisingus“ arba nešališkus rizikos fondų veiklos rezultatus, juos lemiančius veiksnius ir tų veiksnių įverčius.

Norint teisingai įvertinti rizikos fondo pagal riziką pasvertus veiklos rezultatus ir nustatyti veiklos rezultatais grindžiamą atlygį, taikomi įvairūs metodai. Šie metodai išskiria skirtingus veiksnius, lemiančius galutinį rezultatą. Value Research Desk (2020) pateikia pagrindinius investicinio portfelio rezultatų vertinimo rodiklius: *alfa*, *beta*, determinacijos koeficientas R^2, standartinis nuokrypis ir Sharpe rodiklis. Tačiau Grau-Carles ir kt. (2017) nustatė, kad Sharpe rodiklis yra šališkas dėl rizikos fondų grąžoms būdingo nepaprasto susiskirstymo (skirstinio).

Per daugiau nei 20 metų rizikos fondų veiklos vertinimo (kapitalo įkainojimo) teoriją iš esmės išplėtojo Fung ir Hsieh (1997, 2001, 2004, 2008), Liang (2000), Agarwal ir Naik (2004), Kosowski ir kt. (2007), Bali ir kt. (2011), Brown ir kt. (2012), Edelman ir kt. (2012), Cao ir kt. (2018), Joenväärä ir Kosowski (2020). Naujausi šios srities tyrimai vis dar analizuoja kokią dalį rizikos fondų grąžos gali paaiškinti tradicinės rizikos (t. y. dydžio ar vertės poveikio) ir kokią dalį „egzotiškos“ rizikos, išskirtinai būdingos rizikos fondų investavimui (t. y. pagreičiui arba įvairioms netiesinėms ir pasirinkimo sandorius atkartojančioms investicijoms). Nepaisant to, vis dar yra daug sėkmingų bandymų rizikos fondams naudoti tradicinius kapitalo įkainojimo modelius. Todėl, mokslininkai, vertindami rizikos fondų veiklos rezultatus, vis dar renkasi tarp dviejų pagrindinių kapitalo įkainojimo modelių krypčių:

- Tradicinių kapitalo įkainojimo modelių, kylančių iš tokių teorijų kaip: kapitalo turto įkainojimo modelis (CAPM) (Treynor, 1961) ir Arbitražo įkainojimo teorija (APT) (Ross, 1976) ir
- Fung ir Hsieh (2004b) nustatytų „egzotiškų" rizikų, būdingų rizikos fondams, siekiantiems absoliučios grąžos ir naudojantiems dinamišką stilių bei didelį svertą.

Tradiciniai kapitalo įkainojimo modeliai pagrįsti tiesine priklausomybe tarp rizikos ir grąžos. Šių kapitalo įkainojimo modelių, ypač tų, kurie grindžiami APT logika, sąvoka grindžiama tinkamo turto arba investavimo priemonėmis grindžiamų veiksnių, geriausiai paaiškinančių investicinio portfelio veiklos rezultatus, nustatymu. Viena vertus, tyrėjai tobulina modelius, pridėdami įvairių akcijų ir skolos rinkos priemonių. Kita vertus, rizikos fondai taip pat gali sukurti palyginti didelę koreliaciją su konkrečiomis žaliavų rinkos kainomis. Stafylas ir kt. (2018), Swartz ir Emami-Langroodi (2018), Racicot ir Theoret (2019), Shrydeh ir kt. (2019), Mensi ir kt. (2020), Chirwa ir Odhiambo (2020), Lambert ir Platania (2020) analizavo rizikos fondų veiklos priklausomybę nuo aukso, vario, naftos ir kitų žaliavų kainų pokyčių. Rizikos fondams priskiriamą sverto strategiją taip pat galima paaiškinti CAPM modeliu, kurį mokslininkai naudoja daug metų (Stattman, 1980, Rosenberg ir kt., 1985, Bhandari, 1988, Chan ir kt., 1991, Asness ir kt., 2013 m., Frazzini ir Pedersen, 2014 m., Hübner ir Lambert, 2019 m., Bian ir kt. 2020 m., Li J. ir kt. , 2020 m.).

Tačiau įprastiniai kapitalo įkainojimo modeliai turi bendrų trūkumų, kai juos naudoja rizikos fondo veiklos veiksniams (įskaitant akcijų, fiksuotų pajamų ir CTA strategijas) nustatyti. Šie modeliai grindžiami tiesiniais grąžos ir rizikos veiksnių ryšiais, kuriuos rizikos fondų valdytojai gali greitai pašalinti naudodami išvestines finansines priemones arba į pasirinkimo sandorius panašias strategijas. Tačiau, remiantis Agarwal ir kt. (2018), Stutzer (2018) ir Knif ir kt. (2020), CAPM ir ICAPM modeliai vis dar patikimai paskaičiuoja rizikos fondų *alfa*, nepriklausomai nuo rizikos fondų ir juose naudojami finansinių priemonių. Pagrindinis šių modelių pranašumas kaip parodo ankstesnės kitų tyrėjų išvados – jie yra ekonomiškai palankūs modeliai ir manoma galėtų būti naudojami ir nustatant alfa rodiklius neįprastuose regioniniuose rizikos fonduose.

Kadangi rizikos fonduose yra įvairių finansinių priemonių su tiesine ir netiesine grąža, jie gali naudoti apsidraudimo ir (arba) išvestinių finansinių priemonių priemones ir labai dinamišką prekybą. Todėl, remiantis Fung ir Hsieh (1997a), nei Fama-French trijų veiksnių modelio (arba 1997 patobulinto Carhart 4-faktorių modeliu) nei įprastų CAPM ar APT modelių gali nepakakti Šiaurės šalių rizikos fondų veiklos rezultatams įvertinti. Fung ir Hsieh sukūrė modelį, pagal kurį įvertinami rizikos fondų investavimo stilius nusakantys grąžos rodikliai: vertės, sistemos/trendo sekimo, sistemos/galimybių, nuvertėjusio turto veiksnių ir globalių/makro veiksnių. Nors šie veiksniai atspindi beveik visus rizikos fondų grąžos variantus, būtina pažymėti, kad jie turi nelinijinį ryšį su tradicine kapitalo, prekių ir finansų rinka. Fung ir Hsieh sukūrė pažangių indeksų portfelį, leidžiantį jiems imituoti šiuos komponentus. Svarbu pažymėti, kad Fung ir Hsieh galėjo paaiškinti beveik 80 procentų visų akcijų rizikos fondų, analizuodami jų mėnesinę grąžą, taip tapdami efektyviausia priemone rizikos fondų grąžai stebėti. Edelman ir kt. (2012) dar labiau patobulino modelį ir pridėjo aštuntąjį modelio veiksnį – besiformuojančios rinkos indeksą. Dabar šis modelis vadinamas Fung-Hsieh 8 faktorių modeliu.

Agarwal ir Naik (2004) paminėjo, kad rizikos fondai, taikydami išvestinių finansinių priemonių strategijas su pasirinkimo sandorių struktūra, demonstruoja grąžas neatitinkančias normalųjį pasiskirstymą. Į tiesinių veiksnių modelį įtraukus pasirinkimo sandoriais pagrįstą rizikos veiksnį, Agarwal ir Naik (2004) padidino savo tikslumą vertinant rizikos fondų veiklos rezultatus 5–20 procentų (matuojant pakoreguotu R^2), palyginti su modeliais be pasirinkimo sandorių.

Savage (2017), Groshens (2018) ir Robertson (2018) plačiai naudojo „išmaniosios *beta*“ ir „strateginės *beta*“ (arba „alternatyviosios *beta*“) koncepcijas, kurias pristatė Jaegeris (2005). Ši koncepcija išplečia tradicinį požiūrį į kapitalo įkainojimo modelius naudojant keturias kintamųjų kategorijas: gryną *beta*, išmaniąją *beta* versiją, alternatyvią *beta* ir *alfa*. Jie susiejo rizikos veiksnius su savo santykine kaina, atsižvelgiant į tai, kad „egzotiškus“ rizikos veiksnius yra sunkiau ir brangiau pasiekti. Todėl investuotojai ir fondų valdytojai turi pasirinkti tarp pastangų pasiekti grąžą ir pačios grąžos. Investicijų strategijomis pagrįstos *betos* (t. y. vertė, nešiojimas, kokybė, augimas, pagreitis ir dydis) papildo arba prieštarauja Fung-Hsieh 8 veiksnių modeliui.

Kita svarbi tyrimo dalis yra susijusi su papildomais su rizika susijusiais veiksniais, kurie yra susiję su likvidumo ar kintamumo rizika. Pástor ir Stambaugh (2003) sudarė likvidumo indeksą, plačiai naudojamą kitų tyrėjų. Chen ir kt. (2018), Jame

(2018) ir Li ir kt. (2020) taip pat išanalizavo rizikos fondų, kurie koncentruojasi į mažo likvidumo turtą (pvz., blogos skolos), rezultatus. Jie nustatė, kad šie fondai nepakankamai įvertina ir nepakankamai praneša apie didelę likvidumo riziką, kurią turi fondas. Likvidumo rizika, kurią atspindi nelikvidžios pozicijos rizikos fonduose, suteikia rinkai likvidumo, todėl rizikos fondai yra taip pat labai naudingi rinkai neramumų metu.

Kintamumo rizika yra susijusi su dažnesne prekyba, ypač tų fondų valdytojų, kurie remiasi algoritmine prekyba, ir tų, kurie taikos griežtus kontrolinių nuostolių ir nuostolių sustabdymo reikalavimus. Asensio (2019) nustatė sąsajų tarp VIX ateities sandorių struktūros nuolydžio ir rizikos fondams būdingų kainų skirtumo sandorių.

Sujungęs skirtingus mokslinius darbus, autorius atrinko šiuos veiksnius, remdamasis Fung-Hsieh 8 faktorių modeliu, patobulintu su kitais veiksniais.

1 lentelė. Rizikos fondų kainodaros modelio veiksnių santrauka

Rizikos veiksnys	**Faktoriaus aprašymas**
Akcijų indeksas*	S&P 500 akcijų rinkos indekso (arba kito pagrindinio akcijų indekso) mėnesinė grąža, atėmus nerizikingą palūkanų normą
D_10YRF*	Mėnesinė 10 metų trukmės vyriausybės obligacijų pajamingumo reikšmė minus nulinės rizikos grąža
Dydžio skirtumas*	Mėnesinė Russell 2000 akcijų indekso (arba kitų mažos kapitalizacijos įmonių akcijų indekso) grąža minus S&P 500 akcijų indekso (arba kito pagrindinio akcijų indekso) grąža
D_Baa10Y*	Mėnesinis Moody's Baa reitingo obligacijų pajamingumas minus 10 metų trukmės vyriausybės obligacijų pajamingumo reikšmė
MSEMKFRF*	MSCI Besivystančios rinkos indekso mėnesio grąža atėmus nerizikingą palūkanų normą
PTFSBDRF*	Mėnesinė PTFS atgalinio obligacijos žvilgsnio grąža minus nulinės rizikos grąža
PTFSFXRF*	Mėnesinė PTFS atgalinio valiutos kurso žvilgsnio grąža minus nulinės rizikos grąža
PTFSCOMRF*	Mėnesinė PTFS atgalinio prekių žvilgsnio grąža minus nulinės rizikos grąža
SMB**	Mažas minus didelis
HML**	Aukštas minus žemas
MOM**	Pasaulinis impulso faktorius
FX	Valiutos rizikos veiksnys (Adrien Verdelhan rizikos veiksniai, 2012)

GOLD***	Mėnesinis aukso neatidėliotinų sandorių kainos pokytis atėmus nerizikingą palūkanų normą
COPPER***	Mėnesio vario ateities kainų pokytis atėmus nerizikingą palūkanų normą
SILVER***	Mėnesinis sidabrinių ateities sandorių kainos pokytis atėmus ner-izikingą palūkanų normą
BROIL***	Mėnesinis „Brent“ naftos neatidėliotinų sandorių kainų pokytis atėmus nerizikingą palūkanų normą
NGAS***	Mėnesinis Natural Gal ateities kainų pokytis atėmus nerizikingą palūkanų normą
COCOA***	Mėnesio kakavos ateities kainų pokytis atėmus nerizikingą palūkanų normą
LIQ	Likvidumo rizikos veiksnys[44]
OCMDRWT***	Mėnesinė biržos prekių TR indekso grąža minus nulinės rizikos grąža [45]
VIX	30 dienų tikėtinas JAV akcijų rinkos kintamumas, gautas iš realaus laiko vidutinių S&P 500® indekso (SPX^{SM}) pasirinkimo sandorių kainų realiuoju laiku, vidutinėmis kotiruotėmis.[46]

* Fung-Hsieh veiksniai iš Edelman ir kt. . (2012), David A. Hsieh duomenų biblioteka, kurią galima rasti adresu: https://faculty.fuqua.duke.edu/~dah7/HFRFData.htm

** Fama-French veiksniai Carhartas (1997)

*** Kiti veiksniai renkami iš https://www.investing.com/

Krizė ir reguliavimas turi įtakos rizikos fondų veiklos rezultatams. Tačiau nedaugelis mokslinių straipsnių įtraukia krizės ar reguliavimo veiksnius į rizikos fondų kapitalo įkainojimo modelius. Disertacija nesiremia veiksniais, paprastai naudojamais krizės ir reguliavimo poveikiui pateikti (pvz., palūkanų norma, finansinio turto kainos), dėl kurių atsirastų autokoreliacija su akcijomis ar kitais veiksniais. Todėl šioje disertacijoje investicinę aplinką atspindės ne krizės ir reguliavimo poveikį atspindintys veiksniai, bet jų laikotarpiai.

Įvairūs pasauliniai ir nacionaliniai krizių ir reguliavimo laikotarpiai gali turėti

44 Likvidumo rizikos veiksnys pasiekiamas: https://faculty.chicagobooth.edu/-/media/faculty/lubos-pastor/data/liq_data_1962_2019.txt

45 Pagal riziką įvertintas patobulintas žaliavų be grūdų indeksas, kurį stebėjo Ossiam ETF, apima 20 iš 24 komponentų iš S&P GSCI TR. Šia strategija siekiama užtikrinti kintamumo mažinimą ir geresnį visų prekių sektorių dalyvavimą, visų pirma vengiant koncentracijos energijos rinkose (pasveriant maždaug 70 % GSCI S&PSCI asignavimo). Šaltinis https://www.next-finance.net/Ossiam-ETF-on-the-Risk-Weighted

46 Jis visame pasaulyje pripažįstamas kaip pagrindinis nepastovumo matas, kurį naudoja tyrėjai ir žiniasklaida (http://www.cboe.com/vix)

įtakos rizikos fondų veiklos rezultatų vertinimo (kapitalo įkainojimo) modeliams ir prie jų patikimai prisidėti. Krizė – išsamiai išanalizuota Cao ir kt. (2018), Zhao ir kt. (2018), Liang ir Qiu (2019), Metzger ir Shenai (2019), Denk ir kt. (2020), Gregoriou ir kt. (2020), Sung ir kt. (2020). Kalbant apie krizės laikotarpius, disertacijoje nagrinėjami šios krizių apraiškos: bankų krizė, skolinimo krizė, valiutos krizė, pasaulinė krizė ir pasaulinis rizikos fondų išsipardavimas. Reguliavimas – nuodugniai analizuotas Chan ir kt. (2007), Barr (2008), Brown ir kt. (2012), Cerutti ir kt. (2010), Sullivan (2019) ir Berglund ir kt. (2018 ir 2020). Buvo atsižvelgta į AIFV direktyvos įgyvendinimą, Tarptautinio valiutos fondo finansinio stabilumo (toliau - FSI) indikatorius, ir Pasaulio banko valdysenos (toliau – WGI) indeksą.

Tačiau, aukščiau aprašyti modeliai nebuvo naudojami vertinant regioninių rizikos fondų veiklos rezultatus. Stambaugh (1982) pasiūlė pradinę idėją analizuoti investicinius portfelius naudojant arba derinant įvairius ne JAV indeksus. Regioniniams rizikos fondams būdingas grąžos duomenų šališkumas, dėl kurio regioninių rizikos fondų veiklos rezultatų vertinimo modeliavimas tampa dar sudėtingesnis. Platus modelių spektras ir įvairūs veiksniai suteikia daugiau galimybių kurti patikimus modelius ir išbandyti metodiką Šiaurės šalių rizikos fondų pavyzdžiu. Kita vertus, Šiaurės šalių rizikos fondų gyvavimo trukmė yra palyginti ilgesnė nei pasaulinis 5 metų vidurkis (McCrum, 2014). Iš 72 disertacijoje analizuotų Šiaurės šalių rizikos fondų 57 išgyveno daugiau nei dešimt metų, todėl Šiaurės šalys tapo ilgaamžių rizikos fondų regionu. Tai parodo, kad Šiaurės šalių rizikos fondų valdytojai turi daugiau kaip dviejų krizių išgyvenimo patirties.

Kuriant regioninių rizikos fondų veiklos rezultatų vertinimo metodiką, disertacijoje remiamasi aukščiau išvardintais modeliais ir veiksniais bei ieškoma atsakymų į iškeltas hipotezes ir ginamuosius teiginius. Atsižvelgiant į tai, kad mažesni rizikos fondų regionai pateikia šališkus grąžos duomenis, kuriant regioninių rizikos fondų veiklos rezultatų vertinimo modelius ypatingas dėmesys skiriamas modelio patikimumui ir alternatyvių modelių naudojimui. Žemiau pateiktoje 2 lentelėje pateiktas agreguotas kapitalo įkainojimo modelis, apimantis įvairius veiklos rezultatą lemiančius veiksnius. Kiekvienas veiklos rezultatą lemiantis veiksnys gali priklausyti nuo vietos rinkos ypatumų. Disertacija tikrina šią priklausomybę per metodiką ir modelio kūrimą.

2 lentelė. Rizikos fondų kapitalo įkainojimo modelio agreguotas modelis

Veiklos veiksnys / rizikos veiksnys	**Kategorija**	**Priklauso nuo regiono**
Sisteminė ir (arba) bazinė rizika (akcijų, obligacijų, IR, FX rinka)	*Beta*	Taip
Kitas turtas (biržos prekės, kitas finansinis turtas)	*Beta*	Ne
„Egzotiška“ / Išmani / Alternatyvi rizika (išvestinės finansinės priemonės, svertas, dažna prekyba ir kt.)	*Beta*	Ne
Fondo valdytojo indėlis	*Alfa*	-
Investicinė aplinka (krizė *vs*. ne krizė; reguliuojama *vs*. liberalizuota)	-	Taip

Šaltinis: sukūrė autorius pagal Agarwal ir kt. (2018) ir Groshens (2018).

Kito turto ir „egzotiški“ / išmanieji / alternatyvūs veiksniai neturi būti būdingi konkrečiam regionui, kaip siūloma 2 lentelėje. Tačiau, remiantis APT teorija, rizikos fondai gali priklausyti nuo veiksnio, jei toks veiksnys atspindi portfelio ir (arba) rizikos fondo finansinę priemonę. Todėl disertacijoje analizuojami ir testuojami visi veiksniai, atrinkti pagal kiekvieną rizikos fondo strategiją, nepriklausomai nuo išankstinio nusistatymo.

Regioninių rizikos fondų veiklos rezultatų vertinimo modelio kūrimo metodologija.

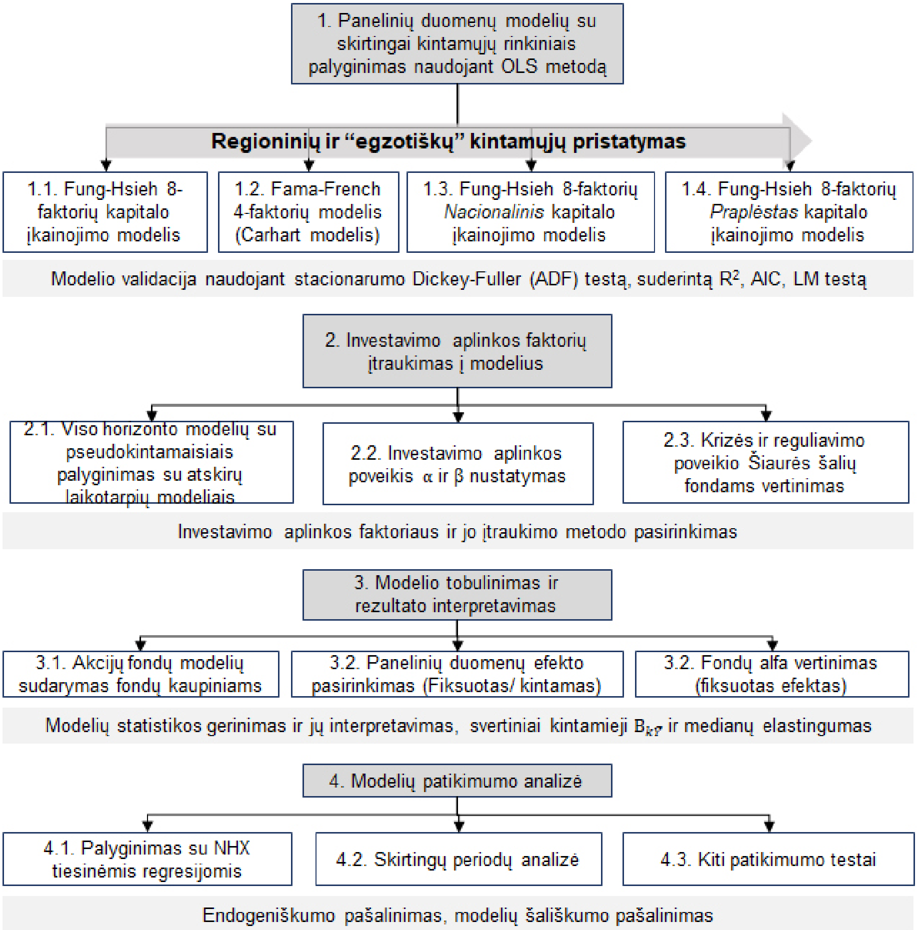
Metodologinė dalis apima tris pagrindinius aspektus: modeliavimo metodo, skirto rizikos fondų veiklos veiksniams nustatyti, parinkimą; veiksnių parinkimą; ir įvairių modeliavimo patikimumo tikrinimo metodų pateikimą. 2 paveiksle pateikta modelio kūrimo metodologija ir numatomi rezultatai (metodai), t. y.:

Panelinių duomenų modelių sudarytų naudojant skirtingų veiksnių grupes (pasauliniais, regioniniais ir „egzotiškais“) palyginimas. Naudojamas OLS metodas be efektų statistiniam reikšmingumui nustatyti.

Modelio išplėtimas naudojant investicinės aplinkos veiksnius.

Modelio tobulinimas susiaurinant rizikos fondų fondus į nuoseklius fondų kaupinius, parenkant panelinių duomenų fiksuotą arba kintamą efektą ir analizuojant bei interpretuojant modelio rezultatus.

Įvairių modelio patikimumo testų taikymas.



2 pav. Rizikos fondų turto kapitalo įkainojimo modelio kūrimo ir testavimo etapai
Šaltinis: Sukūrė autorius.

Panelinių duomenų modelių naudojimas padeda išspręsti heteroskedastiškumo problemą, jei modeliuose naudojami duomenys yra stacionarūs. Siekiant užtikrinti, kad modelių kintamųjų reikšmės būtų stacionarios, kiekvienam kintamajam, kaip rekomenduoja Moffatt (2019), buvo atliktas Dickey-Fuller (ADF) testas, tikrinantis, ar kintamųjų duomenys sudaro standartinį susiskirstymą.

Fama-French 4 faktorių modelis sudarytas naudojant OLS metodą be efektų vadovaujantis lygtimi [1].

$$R_{i,t} - RF_t = \alpha + \beta_1(RM_t - RF_t) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_{i,t} \quad 1.$$

Kur:

R – rizikos fondo arba NHX indekso grąža.

RF – nerizikinga grąžos norma.

α – modelio konstanta / Jensen Alpha.

RM – bendra rinkos grąža (S&P500 indeksą keičia kiekvienos Šiaurės šalies pagrindinis akcijų indeksas).

SMB – dydžio priemoka (mažos kapitalizacijos indeksas – didelės kapitalizacijos indeksas).

HML – vertės priemoka (didelė rinkos vertė – maža rinkos vertė).

MOM – premija už pranokstančias pozicijas, atėmus prasčiausias pozicijas.

$\beta_{1\text{-}4}$ – faktorių koeficientai.

ε – liekana arba paklaida.

i – skerspjūvių / rizikos fondų skaičius (i = 1,2, ..., N).

t – laikotarpiai (t = 1,2, ..., T).

Ir Fung-Hsieh 8-faktorių modelis, pagrįstas JAV (pasauliniais) veiksniais išreikštas lygtimi [2].

$$\begin{aligned} R_{i,t} - RF_t = \alpha &+ \beta_1 SPRF_t + \beta_2 TYRF_t + \beta_3 RLSP_t + \beta_4 BAATY_t + \beta_5 MSEMKFRF_t \\ &+ \beta_6 PTFSBDRF_t + \beta_7 PTFSFXRF_t + \beta_8 PTFSCOMRF_t + \varepsilon_{i,t} \end{aligned} \quad 2.$$

Kur:

Remiantis [1] išaiškinimais su papildomais terminais:

SPRF, TYRF, RLSP, BAATY, MSEMKFRF, PTFSBDRF, PTFSFXRF ir PRFSCOMRF – 8 Fung-Hsieh modelio veiksniai, pateikti aukščiau 1 lentelėje.

$\beta_{1\text{-}8}$ – faktorių koeficientai.

Mokslininkai, tokie kaip Agarwal ir kt. (2018), Berglund ir kt. (2018) ir Duanmu ir kt. (2018) laikėsi to paties požiūrio, kad tiesinė veiksnių priklausomybė yra patogesnė pristatant rezultatus iš ekonominės perspektyvos.

Modelių patobulinimas pasiektas pakeičiant pasaulinius akcijų rinkos ir obligacijų rinkos veiksnius nacionaliniais pakaitalais, pridedant papildomus prekių ar kito finansinio turto veiksnius, ir integruojant investavimo aplinkos, kurią apibūdina krizė ir reguliavimas. Papildomi veiksniai buvo įtraukti taikant žingsninės regresijos į priekį metodą.

Metodikoje taip pat pabrėžiama, kaip svarbu visiems skaičiavimams naudoti vieną (JAV dolerį) valiutą. Modelių veiksniai, kurie išreiškia tam tikrų kainų arba pajamingumo pokyčius koreguojami pagal JAV doleriais išreikštų reikšmių pokytį. Panelinių duomenų modeliuose taip pat reikia pasirinkti tinkamą įvertinimo modelį, kuris nustatomas naudojant tris efektus (bendras efektas, fiksuotas efektas ir kintamas efektas). Pasirinkus tinkamiausią efektą, gali padidėti modelių statistinis reikšmingumas ir būtų galima padidinti modelių rezultatų praktinę interpretaciją.

Investavimo aplinkos įterpimas į modelius buvo atliktas dviem būdais. Pirmuoju metodu paneliniai duomenys suskirstomi į laikotarpius, atsižvelgiant į tai, kuris investicinės aplinkos etapas vyksta (pvz., krizės veiksnio atveju – krizės laikotarpis ir ne krizės laikotarpis). Antruoju būdu įvedamas pseudokintamasis, atspindintis paveiktą laikotarpį, ir nulinė vertė atitinka nepaveiktą laikotarpį.

Panelinių duomenų modeliai taip pat leidžia taikyti fiksuotą arba kintamą efektą endogeniškumo problemai išspręsti, įvertinti individualų poveikį rizikos fondui ir padidinti praktinį modelių pritaikomumą. Tačiau mažas rizikos fondų skaičius regione, ilgo laikotarpio rizikos fondų grąžos duomenys ir rizikos fondų grąžos duomenų skelbimo šališkumas, sukelia tam tikrus apribojimus. Šie apribojimai yra atskleisti ir pagal galimybę sumažinami.

Daugelis mokslininkų taip pat ieško ryšio tarp rizikos fondų grąžos ir anomalijų trumpuoju laikotarpiu (pvz., kainų sukrėtimų, fondų išsipardavimų). Šiems reiškiniams analizuoti paprastai naudojami netiesinės regresijos ir kiti pažangesni ir sudėtingesni metodai (pvz., autoregresinį vektorių). Kiti modeliai ir metodai taip pat yra gana paplitę rizikos fondų veiklos analizėje, įskaitant, bet neapsiribojant, dinaminių panelinių duomenų modelius, panelinius VAR modelius, panelinius ARDL modelius ir modelius su netiesine priklausomybe nuo veiksnių. Mokslininkai pabrėžia, kad tie pažangesni modeliai ir metodai leidžia pasiekti didesnę statistinę pasirinktų veiksnių reikšmę. Tačiau šie metodai yra šiek tiek mažiau informatyvūs analizuojant rezultatus ekonominiu požiūriu ir gali trūkti pritaikymo kitiems regionams sąlygų.

Atsižvelgiant į Bernard ir kt. (2019) ir Almeida ir kt. (2020), autorius suskirstė Šiaurės šalių rizikos fondus į siauresnius nuoseklesnius kaupinius pagal rezultatų sąveiką su skelbiamu rizikos fondų NHX indeksu. Siekiant geresnio rezultatų interpretavimo ir grafinio pristatymo, apskaičiuoti standartizuoti koeficientai ir pateikiamas kiekvieno veiksnio svertinis indėlis naudojant medianų elastingumo metodą.

Šiaurės šalių rizikos fondų grąžos duomenys.

Šiaurės šalių rizikos fondų ir atitinkamų indeksų grąžos duomenys paimti iš Nordic Business Media Aktiebolag. 3 lentelėje pateiktas priklausomų kintamųjų, apimančių rizikos fondų ir Šiaurės šalių rizikos fondų indeksų mėnesinę grąžą, aprašymas.

3 lentelė. Priklausoma kintama sudėtis

Kintamasis	Apibūdinimas	Kintamųjų skaičius	Laikotarpis	Dažnumas	Parametrai
HFR_j	Rizikos fondų grąža	72 fondai	2005M1-2020M6	Mėnesio	Šalis; Strategija
$HFIR_k$	Strategijos indekso grąža	5 strategijos indeksai	2005M1-2020M6	Mėnesio	-

Šiaurės šalių rizikos fondai suskirstyti į šias kategorijas pagal jų strategijas: akcijų, fiksuotų pajamų, daugialypė strategija, CTA / valdomų ateities sandorių ir fondų fondų. Nors Šiaurės šalių rinkoje yra gali pasitaikyti ir kitų rizikos fondų strategijų arba strategijos porūšių, joms nėra skaičiuojamas ir skelbiamas atskiras indeksas. Fondai, priskirtini kitoms žinomoms strategijoms (pvz., neutralioms rinkai), priklauso bet kuriai iš aukščiau minėtų strategijų.

Hespeler ir Loiacono (2015 m.), Ardia ir Boudt (2018 m.) bei Canepa ir kt. (2020 m.) taip pat pasiūlė rizikos fondus suskirstyti į kategorijas pagal veiklos rezultatus (pvz. į kvartilius nuo geriausių rezultatų fondų ir mažesnių veiklos rezultatų fondų). Dėl palyginti nedidelio rizikos fondų skaičiaus akcijų strategijoje tikslinga suskirstyti fondus į tokias grupių poras: viršijantys indeksą ir nesiekiantys indekso rezultatus; koreliuojantys su indeksu ir pasižymintys neutralumu. Dėl mažo rizikos fondų skaičiaus kitose strategijose tik akcijų strategijos rizikos fondai buvo suskirstyti į nuoseklias grupes.

Šiaurės šalių rizikos fondų veiklos rezultatų vertinimo modelių kūrimas.

Disertacijoje nagrinėjami šių 3 Šiaurės šalių rizikos fondų strategijų baziniai modeliai: akcijų, fiksuotų pajamų ir CTA, o ketvirtoji rizikos fondų grupė „akcijos+“ apjungia akcijų, daugialypių strategijų ir fondų fondų strategijas, atsižvelgiant į jų koreliacijos koeficientus, kurie svyruoja nuo 0,79 iki 0,84. Modeliavimo rezultatai pateikė tokius atsakymus į iškeltas hipotezes:

***H_1*:** *Su konkrečiu regionu susiję rizikos veiksniai gali geriau paaiškinti nei pasau-*

liniai rizikos veiksniai regiono rizikos fondų veiklos rezultatus, naudojant tiek tradicinius (pvz., CAPM, APT), tiek netiesinius (pvz., Fung-Hsieh 8 faktorių) modelius.

a) CAPM nacionalinis modelis tiek akcijų, tiek „akcijos+" strategijose padidino koreguotą R^2 nuo 43,70% iki 52,00% ir nuo 44,32% iki 49,24%; ir sumažino AIC nuo -3,7743 iki -3,9355 ir nuo -3,8879 iki -3,9815, o tai įrodo, kad vien tik nacionalinis akcijų indeksas yra dominuojantis rizikos veiksnys akcijų rizikos fondams. Tačiau fiksuotų pajamų ir CTA rizikos fondų strategijoms nacionalinių veiksnių įtaka buvo mažesnė.

b) Fama-French 4 faktorių Carhart (1997) modelis, pagrįstas nacionaliniu akcijų indeksu, taip pat turi panašius rezultatus kaip ir CAPM modelio stebėjimas. Taigi nacionaliniai veiksniai nepadidino fiksuotų pajamų ir CTA strategijos rizikos fondų statistinio reikšmingumo, **atmesdami** H_1 hipotezę. Tačiau Fung-Hsieh 8 faktorių nacionalinis modelis **patvirtino** hipotezę H_1 visose strategijose, įskaitant fiksuotų pajamų ir CTA rizikos fondus.

***H_2*:** *Papildomi rizikos veiksniai (pvz., biržos prekių kainos, išvestinės finansinės priemonės, ETF ir kitas finansinis turtas) ir pseudokintamieji, atspindintys įvairius skirtingos investicinės aplinkos sąlygų laikotarpius, pagerina statistinę modelių reikšmę, leidžiančią patikimiau įvertinti rizikos fondų valdytojo indėlį į rizikos fondo veiklos rezultatus*. Fung-Hsieh 8 faktorių išplėstas modelis **įrodo** ir **atmeta** hipotezę H_2 šiose rizikos fondų strategijose:

a) Akcijų ir "akcijų+" koreguotas R^2 ir AIC pagerėjimas yra labai nežymus, o tai galima paaiškinti APT teorijos logika, darant prielaidą, kad papildomi veiksniai vertinami rizikos fondų grąžos atžvilgiu nėra įtraukti į minėtus rizikos fondus. Tačiau, Pástor ir Stambaugh likvidumo rizikos premija LIQ ir OCMDRWT biržos prekių indeksas šiek tiek paveikė akcijų modelį. "Akcijos+" veiklos rezultatų vertinimo modelis turi statistiškai reikšmingą ryšį su dauguma naujai siūlomų veiksnių; tačiau šie veiksniai atrodo gana nereikšmingi, kai vertinamas jų svertinis poveikis (medianų elastingumas).

b) Fiksuotų pajamų koreguoto R^2 ir AIC pagerėjimas yra šiek tiek didesnis, palyginti su Akcijų ir „Akcijos+" modeliais. Tačiau, kaip ir Akcijų modelio atveju, yra mažai ryšio tarp naujai pasiūlytų veiksnių ir fiksuotų pajamų strategijos, nes šios strategijos fondai tikriausiai investuoja į obligacijas ir kitas palūkanas mokančias priemones. Pagal fiksuotų pajamų fondų modelį buvo atrinkti tie patys veiksniai kaip ir Akcijų modelio: likvidumo LIQ ir OCMDRWT žaliavų indeksas.

c) Koreguoto R^2 ir AIC CTA pagerėjimas yra gana reikšmingas. Koreguotas R^2 padidėjo nuo 26,26% iki 32,93%, o AIC sumažėjo nuo -3,3592 iki -3,4504. Kadangi CTA yra su biržos prekėmis susijusi strategija, pagal APT teoriją fondo veiklos rezultatus galima geriau paaiškinti, kai modelis apima į modelį įtrauktas priemones. Fama-French (SMB, HML ir MOM), aukso ir sidabro kainos bei likvidumo LIQ ir OCMDRWT žaliavų indekso veiksniai daro didelę įtaką CTA modeliui. Kaip aptarta „Akcijos+" modelio atveju, medianų elastingumas taip pat turi parodyti, kaip šie veiksniai daro didelę įtaką CTA rizikos fondų veiklos rezultatams.

***H_3*: *Investicinės aplinkos pokyčiai daro poveikį rizikos fondų veiklos rezultatams daugiau per alfa, o ne beta rodiklius*. *Beta* rodiklių analizė lyginant bazinį modelį ir pseudokintamųjų krizės bei reguliavimo modelius daro nedidelį poveikį *beta* rodikliams. Tačiau *alfa* rodikliai patyrė reikšmingesnius pokyčius, kurie yra labai artimi naudojant pseudokintamųjų modelius ir modelius, analizuojančius tik konkrečius laikotarpius. 4 lentelėje pateikiami modelių rezultatai iš *alfa* rodiklio perspektyvos akcijų strategijoje: absoliučiais skaičiais ir medianų elastingumu (3-asis skaičius kiekviename langelyje).

4 lentelė. Alfa analizė "Krizė" ir "Reguliavimas"

Strategija	**Indikatorius**	**Bazinis modelis**	**Susiję laikotarpiai**	**Nepaveikti laikotarpiai**	**Pseudo modelis**
Krizės modelis	*Alfa*	0,0026*** (0,0005) 65,49%	0,0039*** (0,0007) 294,64%	0,0012* (0,0007) 16,39%	0,0012* (0,0007) 30,90%
	Krizės veiksnys				0,0025*** (0,0010) 34,65%
Reguliavimo modelis	*Alfa*	0,0026*** (0,0005) 65,49%	-0,0008 (0,0008) -52,27%	0,0045*** (0,0006) 82,91%	0,0044*** (0,0006) 111,93%
	Reguliavimo veiksnys				-0,0047*** (0,0010) -45,59%

***H_4*: *Rizikos fondų valdytojai krizės metu koreguoja investavimo strategijas, kad užkirstų kelią fondų išpardavimui ir generuoja teigiamą alfa*. Kaip nurodyta aukščiau, akcijų rizikos fondų bazinio modelio alfa padidėjo nuo 0,0026 iki 0,0039, krizės laikotarpio modelio atveju, ir sumažėjo iki 0,0012 modelyje be krizės. Be to, visi rizikos fondų strategijų modeliai su krize turėjo didesnes *alfa* nei modeliai be krizės. Aukščiau nurodytas krizės laikotarpių akcijų modelio *alfa* yra 0,0039 ir statistiškai reikšmingas. Palyginimui, *alfa* modelyje su krizės pseudokintamuoju yra 0,0012+0,0025=0,0037 ir tai taip pat yra statistiškai reikšminga, įrodanti aukščiau pateiktą prielaidą, kad krizę galima tinkamai išanalizuoti lyginant bazinius modelius analizuojančius tik krizės laikotarpius ir modelius su krizės pseudokintamaisiais. Panašūs rezultatai buvo pasiekti ir fiksuotų pajamų bei CTA strategijose.

H_5**:** *Rizikos fondų sektoriui taikomi reguliavimo apribojimai neigiamai veikia rizikos fondo alfa*. Modelių su reguliavimo veiksniais rezultatai yra priešingi nei modelių su krizės veiksniais, pvz., akcijų rizikos fondų bazinio modelio atveju alfa sumažėjo nuo 0,0026 iki -0,0008 analizuojant tik laikotarpius atitinkančius sugriežtinto reguliavimo sąlygas, ir padidėjo iki 0,0045 analizuojant laikotarpius iki reguliavimo sugriežtinimo. Be to, visų strategijų rizikos fondų alfa rodikliai, sumažėjo, palyginus su laikotarpiais iki reguliavimo taikymo. Alfa reguliuojamų laikotarpių modelyje yra -0,0008, o *alfa* modeliuose su reguliavimo pseudokintamaisiais yra 0,0044-0,0047=-0,0003. Panašiai kaip ir krizės modeliuose, reguliavimo veiksnio poveikį galima tinkamai išanalizuoti lyginant bazinį modelį ir modelį su reguliavimo pseudokintamaisiais.

Ginamasis teiginys Nr. 1 *Į rizikos fondų kainodaros modelius įtraukus konkrečiam regionui būdingus ir kitus „paslėptus" rizikos veiksnius, sumažėja alfa, o tai įrodo, kad rizikos fondų valdytojai linkę riboti rizikos, kurią prisiima rizikos fondai, atskleidimą.* Tačiau tai buvo įrodyta kuriant bazinį modelį, nors ir su tam tikrais nenuoseklumais. Pridėjus akcijų ir obligacijų kintamuosius, atspindinčius vietinę rinką, žymiai padidėjo statistinis modelių patikimumas, išskyrus CTA, kurio determinacijos koeficientas padidėjo labai nereikšmingai. Dėl modelio patobulinimų pasikeitė *alfa* koeficientai ir medianų elastingumo procentai.

Kuriant modelius su pseudokintamaisiais, geriausiai šio teiginio rezultatus turėtų atskleisti sumažėjęs *beta* veiksnių kumuliatyvinis dydis išreiškiamas medianų elastingumo metodu. Todėl ginamasis teiginys galėtų skambėti taip – *kaupiamasis elastingumas beta priemonėse didėja*. Tačiau akcijų, „akcijos+" ir CTA modelių atveju analizės rezultatai yra priešingi prielaidai. Visgi, šis testas neįrodo šio teiginio, to pasekmėje, paremtas Agarwal ir kt. (2018), Stutzer (2018) ir Knif ir kt. (2020) apie CAPM ir ICAPM modelių galimybę gerai paaiškinti rizikos fondų *alfa*, yra įmanomas.

Ginamasis teiginys 2 *Rizikos fondų investicinės aplinkos veiksniai (krizė ir reguliavimas) daro poveikį jų kapitalo įkainojimo modeliams ir kintamiesiems*. Krizės ir reguliavimo pseudokintamųjų pridėjimas turėjo nedidelį, bet nuoseklų poveikį modeliams:

- *Alfa* veiksniams daromas nuoseklus poveikis: krizės atveju – *alfa* didėja; reguliavimo atveju – jis mažėja.
- Poveikis *beta* veiksniams yra šiek tiek nereikšmingas, t.y. *beta* veiksnių rinkiniai yra beveik identiški.

Ginamasis teiginys 3 *Regioninių tos pačios strategijos arba rūšies rizikos fondų veiklos rezultatų skirtumus daugiau lemia alfa rodiklių skirtumai, o ne sisteminės rinkos rizikos veiksnių beta pokyčiai*. Išanalizavus skirtingų akcijų strategijos rizikos fondų homogeniškus kaupinius (surinktus pagal veiklos rezultatus ir koreliaciją su indeksu), paaiškėjo, kad *beta* kintamųjų veiksnių rinkinių kitimas tarp skirtingų fondų yra beveik nereikšmingas, o pagrindinis pokytis atsiranda dėl *alfa* rodiklio pokyčių. Analizuojant bendrą visų veiksnių poveikį didesnę grąžą gaunantiems akcijų strategijos rizikos fondams nustatyta, kad didžiausią poveikį išskirtiniams veiklos rezultatams daro *alfa* rodikliai, kuriuos atspindi ir svertiniai dydžiai naudojant medianų elastingumą.

Žvelgiant iš **praktinės perspektyvos,** panelinių duomenų modeliai gali sumažinti triukšmą naudodami atsitiktinius arba fiksuotus efektus. Harvey ir Liu (2018) padarė išvadą, kad efektų metodai pranoksta kitus alternatyvius metodus populiacijoje (apibendrinti duomenys) ir atskirų fondų lygmenyse. Galų gale jie teigia, kad atsitiktinio ir fiksuoto efekto metodų taikymas pagerino *alfa* prognozę. Taikant fiksuotą efektą, galima įvertinti individualų poveikį modelio konstantai, t.y. įvertinti individualų rizikos fondą *alfa*. Efekto pasirinkimas disertacijoje buvo vykdomas atliekant keletą testų (t. y. atsitiktinių efektų LM testas pagal Breusch-Pagan (1980); Hausmano (1978) pasirinkimas tarp fiksuotų ar atsitiktinių efektų; ir Breuscho-Pagan (1980) kryžminio efektų diagnostinis testas). Nors taikant efektus modelių statistinis reikšmingumas nepadidėjo, akcijų ir fiksuotų pajamų rizikos fondų modeliams efektų pritaikymas yra galimas. Fiksuotas efektas leidžia įvertinti poveikį kiekvieno rizikos fondo *alfa* atskirai ir palyginti, kaip fiksuotas efektas (individualus *alfa*) kinta tarp modelių, t. y. bazinio modelio, krizės ir reguliavimo pseudokintamųjų modelių, pvz., rizikos fondai, kurių fiksuotas efektas krizės pseudokintamojo modelyje didėja, palyginti su baziniu modeliu, ir mažėja pagal reguliavimo pseudokitamojo modelį, reikštų:

– šis konkretus rizikos fondas per krizę gerokai padidino savo alfa nei rinka ir
– daugiau sumažino alfa reguliavimo metu nei rinka.

Nordic Business Media įsteigė apdovanojimus, skirtus apdovanoti Šiaurės regiono rizikos fondų geriausius rizikos fondų valdytojus. Šioje disertacijoje sukurti modeliai atspindi ilgalaikius veiklos rezultatų vertinimo rezultatus, o Šiaurės šalių rizikos apdovanojime daugiau dėmesio skiriama rizikos fondų rezultatams per pastaruosius trejus metus. Skiriant apdovanojimą rekomenduojama apsvarstyti galimybę kaip kitus kriterijus įtraukti ilgalaikius *alfa* veiklos rezultatų kriterijus, ypač ankstesnius krizės metu pasiektus rezultatus. Modeliai taip pat gali būti taikomi analizuoti trumpesnius (naujesnius) laikotarpius ir pateikti trumpalaikius *alfa* rodiklius, nors ir praranda ilgalaikius ir ankstesnius rezultatų ypatumus.

Modelių patikimumo analizė patvirtino vieną iš **apribojimų** – ilgesnio laikotarpio modeliai gali būti taikomi tik ilgaamžiams fondams, kurie dėl savo ilgalaikio ataskaitų teikimo negali būti priskiriami tai pačiai kategorijai kaip jauni ir augantys rizikos fondai. Kitas gana reikšmingas modelių apribojimas yra su investavimo strategija susijusių *beta* veiksnių, kurie apima ilgos / trumpos strategijos pakeitimus, dažną prekybą, pasirinkimo sandorių ir kitų išvestinių finansinių priemonių naudojimą, taip pat žinomas kaip „egzotiški“ rizikos veiksniai, sumažėjimas. Kitas būdingas apribojimas kyla iš regioninių rizikos fondų duomenų bazių dydžio. Skirtingų rizikos fondų investavimo strategijų imties dydis svyravo nuo 10 iki 27, todėl patikimumo intervalai svyravo nuo 9,75 % iki 26,27 %.

Išvados ir rekomendacijos būsimiems moksliniams tyrimams:

Išsami kapitalo įkainojimo modelių analizė leido nustatyti tinkamiausius modelius Šiaurės šalių rizikos fondų veiklos rezultatams įvertinti. Rizikos fondų investavimo reiškinio analizės, modelio parinkimo ir rizikos veiksnių atrankos rezultatai su išsamia sanglauda su kitais tyrėjais leidžia autoriui padaryti šias išvadas:

1. Dėl unikalių rizikos fondų investavimo strategijų modeliuose naudojami „egzotiški“ veiksniai, atspindintys fondų valdytojų dėmesį absoliučios grąžos ir didelės *alfa* pasiekimui. Daugelis mokslininkų vis dar siekia nustatyti ir atskleisti teisingą *alfa*.

2. Mokslininkai teigia, ar rizikos fondams pritaikyti kapitalo įkainojimo modeliai (tokie kaip Fung-Hsieh 8 veiksnių modelis) gali geriau paaiškinti *alfa* nei įprastas, pavyzdžiui, CAPM. Todėl autorius nusprendė apjungti įvairesnius veiksnius, daugiau

dėmesio skirdamas regioninei specifikai ir alternatyvioms rizikos fondų investavimo strategijoms (pvz., dažna prekyba ar tam tikros biržos prekės).

3. Panaikinus daugiavaliutiškumo efektą, atsirandantį dėl rizikos fondų ir vietos rinkos indeksų ataskaitų teikimo vietos valiuta ir viską perskaičiavus į JAV dolerius, modeliai buvo iš esmės patobulinti. Modelių rezultatai tapo patikimi ir palyginami su kitais pasaulinių fondų modeliais skirtais jų veiklos rezultatų vertinimui.

4. Pakeitus JAV dominuojančius veiksnius Fung-Hsieh 8 faktorių modelyje (S&P500 ir 10 metų JAV obligacijų pajamingumą) atitinkamais vietiniais veiksniais, pakoreguotas R^2 akcijų ir fiksuotų pajamų strategijose padidėjo 17–19 procentų. 7 procentų CTA koreguoto R^2 pagerėjimas buvo pasiektas į modelį įtraukus žaliavas ir kitas išvestines finansines priemones, įrodančias 1 ir 2 hipotezes.

5. Nepaisant 1 ir 2 hipotezių rezultatų, 1-asis ginamasis teiginys, „*alfa* pervertintas neatskleidžiant kai kurių rizikos veiksnių" (pvz., likvidumo faktoriaus), vis dėlto buvo įrodytas su tam tikru nenuoseklumu. Viena vertus, lyginant Fama-French 4 faktorių nacionalinio modelio *alfa* su analogišku Fung-Hsieh 8 faktorių nacionalinio modelio *alfa*, *alfa* sumažėja (pvz., nuosavybės strategijos atveju nuo 0,0028 iki 0,0025). Kita vertus, alfa pokytis, įrodinėjant 1 ir 2 hipotezes, turėjo priešingą kryptį (t. y. Akcijų strategijos atveju padidėjo nuo 0,0025 iki 0,0026).

Įvairių rizikos fondų veiklos rezultatų vertinimo modelių ir metodų testavimas leido patikrinti iškeltas hipotezes ir pasiekti aukštą modelių patikimumo lygį. Šiaurės šalių rinkos pavyzdžiai su jos investavimo ypatumais leido pasiekti pakankamai patikimus rezultatus:

6. Panelinių duomenų modelis leidžia įtraukti į modelį konkrečios šalies, konkrečių fondų, konkrečios strategijos ir laiko veiksnius. Atsižvelgiant į tai, kad šie veiksniai turi tiesinę priklausomybę su rizikos fondų grąža, modelius gana lengva interpretuoti. Įvairių investicinės aplinkos pokyčių, atspindinčių laikui būdingus veiksnius – pseudokintamuosius, įtraukimas į modelius buvo taikomas pirmą kartą rizikos fondų kapitalo įkainojimo modelių kontekste. Į modelius buvo įtraukti pasaulinės krizės ir Alternatyvių investicijų direktyvos (AIFV) įgyvendinimo terminus, įrodančius 2-ąjį ginamąjį teiginį.

7. Medianų elastingumas, pritaikytas modelių rezultatams pristatyti ir interpretuoti, leido nustatyti, kaip *alfa* ir *beta* veiksniai kinta tarp pranokstančių ir prastų rezultatų arba koreliuojančių su neutraliais fondų kaupiniais. Daugeliu atvejų *beta* veiksniai

yra atsakingi už gana panašią grąžos dalį, o *alfa* skiriasi priklausomai nuo bendrų rizikos fondų veiklos rezultatų. Naudojamas medianų elastingumo metodas, leido sustiprinti 3 hipotezės patvirtinimą.

8. Vidutinė rizikos fondų gyvavimo trukmė yra penkeri metai, o daugiau nei 50 procentų Šiaurės šalių rizikos fondų skelbė grąžą ilgiau nei dešimt metų, todėl Šiaurės šalių regionas pelnytai laikomas ilgaamžių rizikos fondų regionu. Ši rizikos fondų kokybė reiškia, kad rizikos fondų valdytojai turi ilgą sėkmingą patirtį ir atlaikė bent du krizės laikotarpius. Taip pat – Šiaurės šalių rizikos fondai 8 procentais pralenkė pasaulinius rizikos fondus per didelį rizikos fondų verčių kritimą, įvykusį 2007–2008 m. finansų krizės metu.

9. Krizės ir reguliavimo laikotarpių atranka pagal autoriaus ir kitų mokslininkų apibrėžtas rinkos sąlygas leido išvengti autokoreliacijos problemų. Atrinkti pasauliniai krizės laikotarpiai ir AIFV direktyvos įgyvendinimo laikotarpis buvo statistiškai reikšmingi, ir todėl buvo pasirinkti kaip tinkamiausi pseudokintamieji ir įtraukti į modelius.

10. Išanalizavus krizės ar reguliavimo poveikį ilguoju laikotarpiu, buvo gauti nuoseklūs rezultatai analizuojant laikotarpius atskirai ir kartu, naudojant konkrečiam laikui būdingus pseudokintamuosius. Šis rezultatas leido supaprastinti modelius naudojant vieną modelį tiek krizės, tiek ne krizės ar reguliavimo ir iki reguliavimo laikotarpiams. Tačiau ši išvada negalioja analizuojant rizikos fondų veiklos rezultatus naudojant trumpalaikius laikotarpius.

11. Taikant ir analizuojant panelinių duomenų fiksuotą modelio efektą, pavyko nustatyti rizikos fondų individualius *alfa* rodiklius, kuriuos galima naudoti lyginant rizikos fondų veiklos rezultatus tarpusavyje.

Disertacijos metodika suteikė tvirtą pagrindą kurti konkretaus regiono rizikos fondų veiklos rezultatų vertinimo modelius. Metodika taip pat leido patvirtinti Šiaurės regiono specifikai pritaikytas 4 ir 5 hipotezes:

12. Daugelis tyrėjų sutinka, kad krizės įvykis daro didelę įtaką rizikos fondų veiklos rezultatams ir valdymui, dramatiškai pakeisdamas portfelio rinkos rizikos veiksnius (jų derinį). Atsižvelgiant į tai, kad Šiaurės šalių rizikos fondų imtį sudaro ilgai gyvuojantys rizikos fondai, teigiama *alfa* premija krizės metu nėra stebinanti išvada.

13. Reguliavimo poveikis rizikos fondų *alfa* rodikliui yra neigiamas. Darant išvadą, kad reguliavimo institucijų nustatyti apribojimai daro tiesioginį poveikį bendrai investavimo aplinkai, taip pat rizikos fondams arba rizikos fondų valdytojams, visa tai

lemia didesnes sandorių sąnaudas ir ribotas galimybes prisiimti didesnę riziką į rizikos fondą. Rizikos fondų veiklos rezultatų *beta* analizė taip pat parodė, kad reguliavimas neturi didelio poveikio ilgalaikiams *beta* veiksniams. Todėl sumažėjęs *alfa* paaiškina neigiamą reguliavimo poveikį grąžai.

14. Šiaurės šalių akcijų rizikos fondų suskaidymas į nuoseklius kaupinius pagal veiklos rezultatus ir rezultatų koreliaciją su indekso grąža taip pat parodė, kad pagrindinis fondų skirtumų šaltinis yra *alfa*, o ne *beta* veiksnių kitimas, nors *beta* veiksnių skirtumai buvo akivaizdūs lyginant skirtingas strategijas (pvz., Akcijos ir fiksuotos pajamos). Toks tyrimo rezultatas patvirtina 3 ginamąjį teiginį ir įrodo, koks yra svarbus *alfa* veiksnys renkantis tinkamą rizikos fondą investicijai.

Atliekant kitų regioninių rizikos fondų veiklos rezultatų vertinimo modeliavimą, autorius siūlo atsižvelgti į tokias rekomendacijas:

1. Kitų regionų (pvz., Persijos įlankos šalių, Australijos ir Europos regionų) atveju rizikos fondų strategijos gali būti labiau orientuotos į dominuojančias vietines prekes. Be to, žaliavų kainos laikomos pasaulinėmis, ir yra galimybė nustatyti didelį šių žaliavų poveikį veiklos rezultatams ir modeliams.

2.Taip pat patartina persvarstyti bazinį modelį skirtinguose regionuose, nes kitų regionų rizikos fondai gali būti ne taip stipriai priklausomi nuo vietos finansų rinkų (t. y. akcijų, obligacijų, palūkanų normų, pinigų rinkos priemonių). Vietoj to, jos galėtų būti labiau orientuotos į anksčiau minėtas biržos prekių priemones arba netgi labiau priklausomos nuo kredito rizikos arba likvidumo rizikos priemokų (besiformuojančios rinkos atveju).

Siekiant skatinti rizikos fondų kapitalo įkainojimo modelių kūrimą ir išsamesnę analizę, kaip krizė ir reguliavimas veikia kapitalo įkainojimo modelius, rekomenduojami šie mokslinių tyrimų veiksmai ar sritys:

3. Teigiama, kad rizikos fondai generuoja absoliučią grąžą; todėl rizikos fondų veiklos rezultatų vertinimo modeliais, ypač regioniniais, siekiant nustatyti grynąjį *alfa* rodiklį, reikia siekti nustatyti neatskleistus *beta* veiksnius. Siekiant užtikrinti modelių patikimumą, reikėtų atlikti jų rezultatų palyginimą su analogiškų strategijų suderintųjų fondų modelių rezultatais.

4. Sudaryti trumpesnių ir tiksliau apibūdinančių investicinę aplinką laikotarpių modelius, kurie, viena vertus, turėtų dar labiau pašalinti heteroskedastiškumo problemas ir, kita vertus, taip pat nukreiptų modelį analizuoti tą patį fondo valdytoją ir jo

unikalų stilių. Palyginimas su kitais tyrimais rodo, kad ilgalaikius modelius labiau lemia turtu pagrįsti rizikos veiksniai, o ne tie, kurie yra „egzotiški“, kurie laikui bėgant paprastai keičiasi, ypač pokyčių laikotarpiais, naudojant trumpalaikius analizės horizontus.

5. Ilgalaikiame modelyje daroma prielaida, kad skirtingi krizės laikotarpiai atitinka tą patį scenarijų ir priklauso nuo to paties kapitalo įkainojimo modelio analizuojant krizes. Atskirų krizės laikotarpių analizė parodė, kad modeliai skiriasi lyginant skirtingus krizės laikotarpius tarpusavyje. Išsamesnė įvairių krizės laikotarpių analizė suteikia kitokį požiūrį į tai, kaip pagrindinės krizės priežastys gali iš esmės skirtis.

6. Kadangi homogeniški panelinių duomenų modeliai nesiūlo jokių galimų ryšių su paslinktaisiais laike kintamaisiais, panelinių duomenų modeliuose gali būti naudojamas VAR metodas. Pritaikius Grangerio priežastingumo testą siekiant nustatyti priežastingumą su reikšmingais prislinktaisiais laike kintamaisiais, juos būtų galima perkelti į homogeniškų panelinių duomenų modelį. Šie praslinktieji laike kintamieji taip pat turėtų nustatyti sėkmės dalį pasiekus aukštą *alfa*; ar ši sėkmė turi trumpalaikį poveikį?

7. Įvairūs tyrėjai apibrėžė ryšį tarp rizikos fondų veiklos rezultatų ir jų pasiekto *alfa* lygio su fondo dydžiu. Nors Šiaurės šalių rizikos fondų duomenų bazėje nėra reguliariai pateikiama rizikos fondų dydžio (AUM) suma ir AUM augimo tempas, kituose regionuose rekomenduojama ieškoti šių duomenų.

8. Rizikos fondų veiklos rezultatų analizė turi apimti „mirusius“ rizikos fondus. Nors ilgai gyvuojantys rizikos fondai iš esmės turi stabilesnę grąžą ir mažesnį nepastovumą, „mirę“ fondai gali atstovauti tiems sensacingiems fondams, kuriems pavyko pasiekti absoliučią grąžą tik per vieną verslo ciklą.

9. Analizuojant praktinį modelių pritaikomumą ir suskirstant rizikos fondus pagal jų ilgalaikį *alfa* rodiklį, rezultatai buvo gana panašūs į Nordic Business Media skelbiamų apdovanojimu sąrašus. Tačiau šie apdovanojimai daugiausia grindžiami nuo vienerių iki trejų metų rizikos fondų veiklos rezultatais. Rekomendacijos dėl praktinio modelių taikymo Šiaurės regionuose yra šios:

10. Ilgalaikių rizikos fondų veiklos rezultatų vertinimo modeliai parodo ilgalaikius krizės ir reguliavimo *alfa* rodiklius, kuriais turėtų būti papildomi dabartiniai vienerių trejų metų veiklos rodikliai, naudojami Nordic Business Media apdovanojimuose.

Trumpalaikių rizikos fondų veiklos rezultatų vertinimo modeliai neatspindėtų rizikos fondų valdytojų indėlio į veiklos rezultatus krizės metu ar kitų investicinės aplinkos pokyčių. Tačiau naudojant fiksuotą efektą turinčių panelinių duomenų modelius trumpalaikiuose modeliuose galima gauti įrankį rizikos fondams reitinguoti pagal *alfa* arba konkrečius *beta* rodiklius.

Mokslinio darbo rezultatų disertacijos tema skelbimas

Tyrimo rezultatai skelbti straipsniuose, publikuotuose Lietuvos mokslo tarybos pripažintuose nacionaliniuose ir tarptautiniuose mokslo periodiniuose leidiniuose, pristatyti nacionalinėse ir tarptautinėse mokslinėse konferencijose.

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DETERMINANTS OF THE REGIONAL HEDGE FUND PERFORMANCE: EVIDENCE FROM NORDIC COUNTRIES: daktaro disertacija. – Vilnius: Mykolo Romerio universitetas, 2022. P. 266

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The doctoral dissertation develops the methodology of building the regional hedge funds' performance measurement models, which underline the importance of the region-specific risk factors, embedding the investment environment crisis and regulation factors, and reflecting the hedge fund managers' contribution – alpha. Due to their unique strategies focused on absolute return and high diversification, hedge funds' performance is often analyzed by non-linear connections with market risk factors. However, the author seeks robust performance measurement models based on the Fung-Hsieh 8-factor model with linear dependencies. The research uses panel data models, allowing fund-specific national risk factors and investment environment periods. The models revealed equity and fixed-income strategy hedge funds' significant dependence on the national stock and bond risk factors, while CTA funds' performance - was on commodity and other financial asset prices. The longevity of the Nordic hedge funds analyzed in the research resulted in a positive crisis alpha premium indicating Nordic region hedge fund managers' abilities to overcome the crisis. The applied fixed effect allows rating hedge funds by alpha in a predefined coherent pool of hedge funds. The developed methodology reflects the region specifics and can be transformed to other regions with their hedge fund investment peculiarities.

Keywords: *Hedge funds, Nordic countries, asset pricing models, panel data models, alpha, risk factors.*

Daktaro disertacijoje plėtojama regioninių rizikos fondų veiklos vertinimo modelių kūrimo metodologija, pabrėžianti regionui būdingų rizikos veiksnių svarbą, įtraukiant investicinės aplinkos krizės ir reguliavimo veiksnius bei atspindinti rizikos fondų valdytojų indėlį – alfa. Dėl unikalių strategijų, orientuotų į absoliučią grąžą ir didelę diversifikaciją, rizikos fondų veiklos rezultatai dažnai analizuojami per netiesinius ryšius su rinkos rizikos veiksniais. Fung-Hsieh 8-faktorių modelio pagrindu autorius kuria veiklos vertinimo modelius, pagrįstus tiesinėmis priklausomybėmis. Tyrimas atliktas naudojant panelinius duomenų modelius, kurie leido panaudoti su fondais susietus nacionalinius rizikos veiksnius ir investicinės aplinkos pokyčius. Modeliai atskleidė didelę akcijų ir fiksuotų pajamų strategijos rizikos fondų priklausomybę nuo nacionalinių akcijų ir obligacijų rizikos veiksnių, o CTA fondų – nuo biržos prekių ir kito finansinio turto kainų. Tyrime analizuojamų Šiaurės šalių rizikos fondų ilgaamžiškumas lėmė teigiamą krizės alfa premiją, rodančią Šiaurės šalių rizikos fondų valdytojų gebėjimą įveikti krizę. Fiksuoto efekto taikymas leidžia reitinguoti rizikos fondus pagal generuojamą alfa numatytose kategorijose. Sukurta regioninių rizikos fondų veiklos vertinimo metodologija atsižvelgia į regiono specifiką ir gali būti adaptuojama pagal kitų regionų rizikos fondų investavimo ypatumus.

Raktiniai žodžiai: *Rizikos fondai, Šiaurės šalys, kapitalo įkainojimo modeliai, panelinių duomenų modeliai, alfa, rizikos veiksniai.*

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DETERMINANTS OF THE REGIONAL HEDGE FUND PERFORMANCE:
EVIDENCE FROM NORDIC COUNTRIES

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