Uncovering REITs' Performance Dynamics: A Comprehensive Study of Multi-Asset Portfolio Optimization and Inflation Hedge Capabilities

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ABSTRACT

With recent surges in both real estate appraisals and inflation, attention from investors have been drawn towards the investment vehicles of real estate, while simultaneously looking for investment opportunities with inflation hedge characteristics in order to protect the real returns of their investments. With the current economic conditions providing a high degree of relevance, this thesis embarks on concluding on the following research question: *Can REITs add performance to a traditional mixed-asset portfolio, and do they provide an inflation hedge against recent inflation surges?*

In order to create a solid theoretical and informational foundation, a preliminary analysis was conducted, illuminating REITs and their unique characteristics, historical performance, regulatory requirements, sectoral specifications and correlations, while providing an insight into inflation and it's presumed effect on various asset classes.

Utilizing existing literature within the scholarly discourse of finance, real estate and portfolio optimization, a REIT induced portfolio optimization was computed on a select asset composition, using the Mean-Variance Optimization model originating from the field of Modern Portfolio Theory. The REIT and subsequent REIT sector induced portfolio optimizations was computed on a timeframe of 01.05.2007-31.12.2019 with monthly return data, evidencing no allocation to either REITs or individual REIT sectors. Testing the model's prediction capabilities through an out-of-sample test evidenced significant limitations to the model, inducing doubts of the model's ability to allocate a portfolio for future financial returns. Although acknowledging the model's limitations, the study found reasonable ground for concluding that *REITs cannot add performance to a traditional mixed-asset portfolio* in a historical perspective.

Testing for REITs inflation hedge capabilities on the recent inflation surges, a linear regression analysis was conducted on the timeframe of 01.01.2021-01.05.2023 with monthly return and inflation data. The analysis was conducted on individual REIT sector level, including S&P 500, Gold and TLT (20-year treasury bond ETF), while the inflation was stratified into headline-, core- and energy inflation, adding depth to the findings. While the findings showcased indications of REIT sector inflation hedge capabilities as they in general provided higher positive coefficients than the remaining included assets, the models were concluded statistically insignificant, evidencing low explanatory power and goodness-of-fit. Therefore, the study remains *inconclusive on whether REITs provide an inflation hedge against recent inflation surges*, allowing for further research into the subject matter.

Table of Contents

1. Introduction

In recent years, the global economy has been characterized by turbulence and uncertainty, with the most recent encompassing significant global events such as world pandemics, war on European soil, Brexit, energy crisis, as well as rapid technological development in terms of cryptocurrencies and most recently AI. Simultaneously, something as renowned as real estate has gained traction, attracting interest from the public and in particular investors. Real estate investments are becoming increasingly popular among both retail and institutional investors, while the recent surges and appreciation in housing prices have led to an increase in interest towards real estate investments as an alternative or addition to traditional stocks, commodities and bonds. Furthermore, the world economy is experiencing surges in inflation, incentivizing investors to seek investment opportunities with inflation hedge capabilities, providing a safe haven for keeping their real returns on investments.

This thesis strives to disclose if real estate investments can add additional performance to a mixed-asset portfolio composition by utilizing the quantifiable real estate investment alternative of REITs. Further, with common belief and existing literature suggesting that real estate bear inflation hedge characteristics, combined with the recent surges in inflation and turbulent world economies and conditions, we embark on discussing the inflation hedge characteristics of REITs, by comparably testing their hedging capabilities on recent inflation data.

1.1. Research question

Having briefly described the initial interest and objectives of the study, we arrive to the following overall research question of the thesis:

Can REITs add performance to a traditional mixed-asset portfolio, and do they provide an inflation hedge against recent inflation surges?

To arrive to a conclusion on the overall research question, a series of sub-questions will be answered throughout the study. A thorough preliminary analysis of the investment vehicle of REITs will be presented, creating a solid theoretical and informational foundation of REITs and their special characteristics and performance dynamics, which will be utilized to contextualize the findings throughout. Further, the study subsequently provides an in-depth understanding and analysis of inflation, exploring the effects of inflation on REITs and the real estate sector, laying the informational foundation utilized in the analysis of REIT's inflation hedge characteristics.

1.2. Delimitation and scope of thesis

Although the initial interest and motivation for the thesis centers around testing the performance of real estate investment as a whole in a mixed-asset portfolio setting, the need for quantification of risk and return makes the scope of the thesis depart from utilizing direct real estate investment in the empirical analyses throughout. Instead, the scope of the thesis in terms of the empirical analyses is delimitated to securitized real estate, where quantitative data is obtainable through secondary sources, solely utilizing the characteristics of direct real estate investment in qualitative arguments and discussions to add perspective and reflection. Narrowing the scope within securitized real estate, existing literature is utilized to delimitate the scope and focus of the thesis to REITs, with Glascock et. al. (2018) concluding their research stating that REITs is the superior securitized real estate investment alternative.

Continuing narrowing the scope of the thesis on the grounds of data reasons and quality, this thesis undertakes a U.S. perspective of REITs, delimitating the rigorous analysis of REITs to focus solely on U.S. REITs. The concept of REITs originates from the U.S., and the data collection on U.S. REITs have since their origin been far superior compared to the rest of the world, with the National Association of Real Estate Investment Trusts (Nareit) starting their data collection early on with a very high quality. The delimitation is justified with U.S. REITs constituting more than half of the global equity market capitalization of listed REITs, as described further in section 4.3.1.

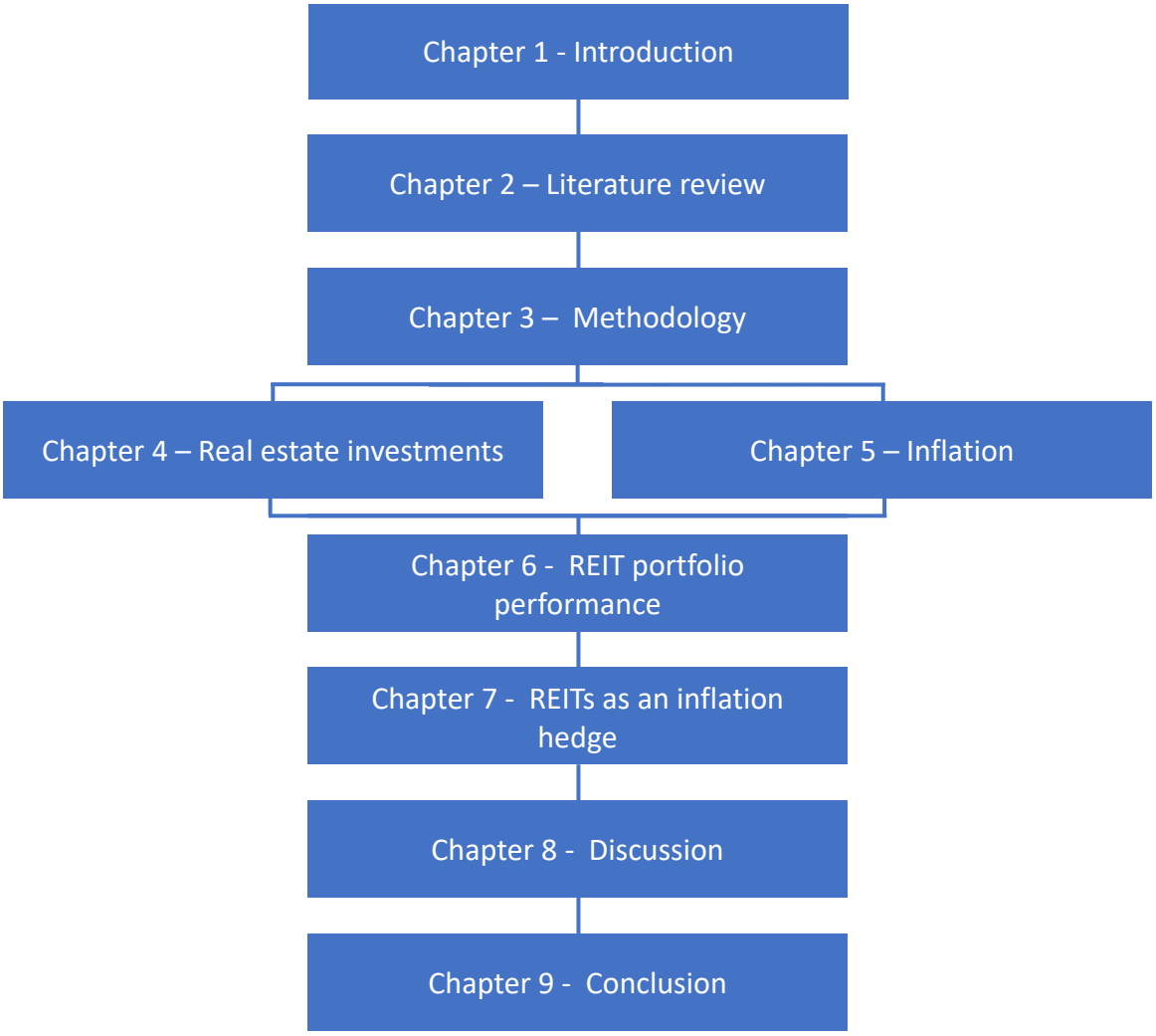
Regarding the timeframe in scope of the thesis, the different timeframes of the various analyses have been described where utilized. In general, the timeframe of analysis varies when dating back

in time, while all newer data and information have been cut off from ultimo April 2023, in line with the completion of the research.

1.3. Structure of thesis

The thesis is structured in nine chapters as seen by *Figure 1* below, all contributing individually towards the research objective. Chapter 1 introduces the reader to the contents of the thesis, while stating the overall research question and the motivation for conducting the study. In Chapter 2, a thorough and concise literature review of the existing scholarly discourse is performed, presenting key findings from existing literature, while establishing the context and rationale for further research, thus imbuing our thesis with purpose and significance. Chapter 3 defines the methodological framework of the thesis, discussing the thesis' philosophical perspective, its theoretical framework, as well as the data collection methods, concluding with a discussion on research quality & bias. Chapter 4 briefly describes various real estate investment alternatives and real estate cycles, before presenting a comprehensive analysis of REITs, their history, regulatory requirements, performance, characteristics and sectors. Grasping the importance of macro-economic factors, in line with our research objectives, Chapter 5 delves into the concept of inflation, analyzing its historical development in order to understand its characteristics and effect on various asset classes. Chapter 6 presents the main empirical analysis of the thesis, testing REITs ability to add performance to a mixed-asset portfolio through a Mean-Variance Optimization model, while discussing and utilizing different investor perspectives and thereby different levels of risk aversion. Chapter 7 encompasses a regression analysis, testing REITs inflation hedge characteristics comparably to various asset classes, while Chapter 8 discusses the findings and alternative approaches to the thesis. Chapter 9 concludes the thesis, presenting key findings and conclusions throughout the study in order to conclude on the research question.

Figure 1 - Thesis structure



2. Literature review

This section provides a concise literature review that focuses on select relevant literature within the research subject of our thesis. The review aims to present the key findings from existing scholarly discourse, establishing the context and rationale for further research, thus imbuing our thesis with purpose and significance. Within the following sections, we delve into the body of literature pertaining to our research topic by dividing the review into two distinctive parts; (2.1.) REITs in mixed-asset portfolios, and (2.2.) REITs as an inflation hedge. By analyzing and synthesizing the relevant literature, we gain insights into the current state of knowledge, identify

gaps and limitations, and lay the foundation for our own research. The literature review acts as a critical evaluation of existing studies, highlighting their contributions and potential areas for exploration, guiding our research objectives and providing a framework for our analysis. It establishes the context, justifies the need for further investigation, and underscores the value and originality of our research contribution. Although this section provides a thorough and concise literature review, additional relevant literature will be presented and discussed throughout the thesis.

2.1. REITs in mixed-asset portfolios

The scholarly discourse of REITs in mixed-asset portfolios and their potential diversification benefits is extensive, yet conflicting. Various methodological approaches and different allocation strategies have been utilized in creating the extensive body of literature. However, the findings have been diverse, emphasizing the need for understanding contextual relationships and specific REIT dynamics, characteristics and macro-economic factors affecting the broader securities markets and REITs in particular.

Drawing on the findings of early research within the scholarly discourse, the diversification benefits of real estate as a whole is evident (Webb, Curcio, & Rubens, 1988). Webb et al. (1988) concluded their study by finding an optimal portfolio allocation of approximately two-thirds to real estate through a mean-variance optimization model, while the last third was allocated to traditional financial investment vehicles. Further studies investigate the diversification benefits in detail, differentiating between private (direct) and public (indirect) real estate, while questioning the room for allocation to both private and public real estate simultaneously, finding that the inclusion of public real estate securities do not add performance to a mixed-asset portfolio, which already contain private real estate (Tuluca, Myer, & Webb, 2000). Chen, Ho, Lu & Wu (2005) find that securitized real estate in the form of REITs (public, indirect) do offer significant performance to a mixed-asset portfolio, concluding through a mean-variance optimization model that there is statistically significant evidence in their research stating that adding securitized real estate enhances the efficient frontier of the portfolio of five chosen asset classes. Likewise, Hudson-Wilson, Fabozzi, & Gordon (2003), finds that securitized real estate can enhance portfolio

performance significantly, portraying the beneficial characteristics of REITs compared to direct real estate investments, which are capital heavy, illiquid and characterized by significant transaction costs.

A significant topic within the scholarly discourse is to what extent securitized real estate, primarily in the form of REITs, have the same diversification and return characteristics as direct real estate, discussing their actual correlation. On one side of the academic dispute, it is argued that the return characteristics of securitized real estate move with the stock market and that REITs in general are more similar to stocks in their characteristics, than they are to direct real estate (Ross & Zisler, 1991). Conversely, Hoesli & Oikarinen (2012) conducts their study on both short-term and long-term dynamics, concluding their research stating that REITs and direct real estate are closely related and good substitutes, arguing that the evidence of their variance decompositions and impulse responses yield significant findings of long-term correlations of REITs and direct real estate.

Given the disputable nature of the findings within the extensive body of literature in the scholarly discourse, the contribution of our thesis embarks on integrating and expanding on the existing findings. Utilizing methodological approaches from existing literature, we seek to provide a comprehensive analysis of the diversification benefits of REITs in a mixed-asset portfolio, concluding on REITs' and REIT sectors' ability to add performance to a constructed mixed-asset portfolio of carefully selected assets. By rigorous pre-liminary analysis of REITs' characteristics and dynamics, our research adds value to the scholarly discourse by embarking on an unexplored timeframe in the existing literature, providing recent insights on the subject.

2.2. REITs as an inflation hedge

Inflation is frequently associated with economic disruptions and adverse effects on financial markets, generating considerable scholarly attention and leading to an extensive body of literature on the subject. The detrimental impact of inflation on economic activity has propelled researchers to delve deeply into this topic, contributing to a substantial volume of academic discourse.

Grasping the extensive body of literature on the subject of REITs and their inflation hedge capabilities, the research goes a long way back.

Commencing this part of the literature review with Fisher's work from 1930; The Theory of Interest, Fisher stated that an investor's expected return on assets ceteris paribus must be equal to the realized return plus the expected inflation rate (Fisher, 1930). With this notion, it is implied that inflation is a key factor in investment decisions, as investors will seek higher returns in inflationary periods to keep their return on investment in real terms. Progressing to the perceived impact of inflation on various asset classes, the scholarly discourse on the topic is extensive, encompassing a substantial body of literature. Researchers have delved into the effects of inflation on different financial assets and explored their potential as inflation hedges, with the broader academic discussion evolving primarily around bonds, stocks, commodities, and of particular interest to our thesis, real estate and securitized real estate (Fama & Schwert, 1977); (Fama, 1981); (Chen, Roll, & Ross, 1986); (Gorton & Rouwenhorst, 2006); (Hardin, Jiang, & Wu, 2012); (Fang, Liu, & Roussanov, 2022) etc. While all literature and economical thinking points to the fact that bonds is negatively correlated with inflation, the early body of literature successfully concludes that stocks is also negatively correlated with inflation, being perverse inflation hedges (Fama & Schwert, Asset Returns and Inflation, 1977); (Fama, 1981).

Focusing on the early research of real estate in regard to inflation, Sirmans & Sirmans (1987) succeeds in establishing evidence of the inflation hedging properties of direct real estate. However, the first body of literature on REITs and securitized real estate indicate REITs as a perverse inflation hedge, contributing to the debate of REITs resemblance of stocks rather than direct real estate (Gyourko & Linneman, 1988). Conversely, later research argues that even though there are no empirical evidence of REITs' inflation hedge properties short-term, REITs are argued to have a long-term inflation hedge capability (Chatrath & Liang, 1998). Chatrath & Liang (1998) fails to, like previous studies, provide any evidence of a positive relationship between REIT returns and inflation through regression analysis. The deviating contribution of the study, however, is the findings of their cointegration tests and alternative analytical approaches, which highlights the potential long-run relationship between REIT returns and inflation.

Jumping forward to more recent literature in the field of inflation hedging, the body of literature is less extensive. Grasping for an explanation of the decreasing amount of research within the field, we argue that the very long period of stable inflation as portrayed in chapter 5 has made it less relevant for researchers to delve deeply into the topic. However, the latest surge in inflation is expected to reignite researchers' interest of assets' inflation hedging capabilities, just as it has for the authors of this thesis. Commenting on the recent body of literature within the scholarly discourse that do exist, we take notice of the study performed by Fang, Liu, & Roussanov (2022). The study is however performed on data ending 2019Q4, missing the recent surge in inflation. What is notable about the study, is the distinction between Headline, Core and Energy inflation, shedding new light on the scholarly discourse of assets' inflation hedging capabilities. The study finds that while stocks, commodities and REITs act as great hedges of energy inflation, the relationships with both core and headline inflation is found to be either negative or insignificant (see chapter 5.3. for further discussion of the study).

Given the less extensive body of recent literature on the subject of REITs as an inflation hedge, combined with the recent surges in inflation, we argue that a study of REITs' relationship with inflation in the current inflationary environment is both original and valuable to the current scholarly discourse. While it is still too soon to evaluate on REITs relationship with the current inflation on the long run, we set out to analyze REITs as an inflation hedge on the short run, challenging and testing the conclusions of previous research that was conducted on the latest inflation surges in the 1980's.

3. Methodology

The following methodology chapter provides a systematic framework of the underlying principles guiding our study towards the research objective of the thesis. Thus, the section seeks to illuminate our systematic research process, how the research was conducted and with what tools and assumptions, as well as the limitations of such.

3.1. Philosophical perspective

This thesis is primarily written with the philosophy of the scientific perspective of positivism, while simultaneously drawing strings from critical realism. While there remain similarities between the two, they complement each other well in our endeavor of achieving our research objective. Commencing with positivism, the philosophical perspective emerged from a prominent group of scientists and philosophers, famously known as the Vienna Circle, which included influential figures like Auguste Comte and Francis Bacon (Saunders, Lewis, & Thornhill, 2016). The ontology of positivism is that there remains one true, unbiased reality. The epistemology of the philosophy therefore evolves around scientific methods, where researchers try to create law-like generalizations and explain causalities, drawing on research from observable and measurable facts (Saunders, Lewis, & Thornhill, 2016). This creates an axiology of the philosophy, where researchers remain unbiased, neutral and detached of their research, which is an assumption that is challenged by most other philosophical perspectives. The assumption, however, is built on the prerequisite of facts being observable and measurable, why the methods of positivism is highly quantitative, distancing the researcher from influencing the research with bias. Thus, it is argued, that positivism greatly compliments the research objective of the thesis, as we seek to provide unbiased research conclusions from quantitative methods such as portfolio optimization and regression analysis, built on objective data.

The authors of the thesis, however, acknowledge that complete unbiased findings and detachment of the research from the researchers themselves, combined with solely quantitative methods, is not sufficient in order to fully achieve the research objectives, why the philosophical perspective of critical realism will be utilized to compliment the stance of positivism. Critical realism derives from the ontological belief that reality is stratified into the *empirical*; observable events, the *actual*; events and non-events generated by the real, and the *real*; causal structures and mechanisms (Saunders, Lewis, & Thornhill, 2016). With the layered ontological belief, the epistemology of critical realism builds on the notion that facts are social constructions, while contributions are in the form of historical causal explanations (Saunders, Lewis, & Thornhill, 2016, p. 136). In contrary to the axiology of positivism where the research is presumed value-free, the axiology of critical realism takes a value-laden research stance, emphasizing the researcher's

acknowledgement of unavoidable bias stemming from culture, heritage and worldviews etc., although every form of bias is sought minimized. With contributions in the sense of historical causal explanations in the center of the epistemological stance of critical realism, the methods align to being retroductive (ibid.). Analysis of historical situations and events allows for research findings and conclusions, while critical realism also paves the way for qualitative methods. Therefore, we argue that utilizing the two philosophies in combination compliments our research greatly, allowing us to fully achieve our research objectives. While we in our ontological approach recognize that there might not be only one true, universal reality, we embark on being as neutral and objective as possible in all respects, which in particular is expressed in our quantitative analyses. Simultaneously, we provide retroductive, historical, qualitative analysis, underlining our utilization of both perspectives.

3.2. Theoretical Framework

As we set out to perform a portfolio optimization in line with the research objectives of the thesis, the purpose of this section will be to lay the theoretical foundation and framework for further analysis. This section draws from the fields of corporate finance and portfolio optimization, briefly discussing various models in the current body of literature within the field, while arguing for the selection of one model which is relied upon in the later analysis.

Grasping the body of literature within the scholarly discourse of portfolio optimization models, the list of models is extensive. Refraining from delving deeply into the details of multiple of the models, the extensive list comprises portfolio optimization models such as the Mean-Variance Optimization (MVO) model developed by Harry Markowitz (1952), the Black-Litterman model developed by Fischer Black and Robert Litterman (1992), and the Fama-French multi-factor model developed by Eugene F. Fama and Kenneth R. French (1992). Selecting one model from the scholarly discourse for use in the further analysis, the benefits and disadvantages of a select handful have been considered and reflected upon. Concluding on the use of one of the models, we argue that the simplicity of the Mean-Variance Optimization (MVO) model, originally presented by Markowitz (1952), aligns the best with our research objective of testing REIT performance in mixed asset portfolios. The model's practicality, simplicity and emphasis on the trade-off between

risk and return make it an attractive approach for portfolio construction. However, we also acknowledge the potential limitations of the MVO, as it is heavily sensitive to input parameters, being built on historical data entirely. Comparing the Black-Litterman and the Fama-French models to the MVO, the Black-Litterman model boast benefits such as including more subjective investor views, while the Fama-French multi-factor models provide insights into asset pricing analysis, allowing for risk premiums in regard to size and value factors. Considering the simplicity, practical approach and alignment to our research objective, we argue that the MVO is the most suitable model for our construction and testing of efficient portfolios with REITs in a mixed asset portfolio constellation.

3.2.1. Modern portfolio theory

With the Mean Variance Optimization model being a technique originating from the field of Modern Portfolio Theory developed my Markowitz (1952), it is deemed necessary to outline the framework of Modern Portfolio Theory in order to present the theoretical and logical thinking behind the model, and thereby the usefulness of the model to our research objective. Modern portfolio theory was developed in order to provide a framework and foundation for constructing a portfolio in an analytical manner. The cornerstone of the theory is the concept of diversification, emphasizing the old saying of "don't put all eggs in one basket". To capture this, Markowitz' work with Modern Portfolio Theory centered around the trade-off between risk and return, culminating in the theory, that combining assets with a correlation of less than 1 in a portfolio would provide an investor with the weighted average of return for the assets, while providing a risk less than the weighted average, thereby optimizing the portfolios risk return trade-off. With volatility, and thereby variance, being a sound expression of an assets and a portfolios' risk, it is inherent in the name of the model of Mean-Variance Optimization. Expressing the equations of the model from Markowitz (1952), simplified by Jones & Trevillion (2022, p. 135), the expected return of the constructed portfolio can be expressed as:

$$E(R_P) = \sum_{i=1\ to\ n} w_i E(R_i)$$

Where:

$$E(R_P) = the\ expected\ return\ of\ the\ portfolio$$

$$w_i = weight\ of\ asset\ i\ in\ the\ portfolio$$
$$E(R_i) = the\ expected\ return\ of\ asset\ i$$
$$n = amount\ of\ assets\ in\ the\ constructed\ portfolio$$

As described previously, risk is measured as the return volatility of the assets and the combined portfolio. Hence, the portfolios risk can be expressed as below (Jones & Trevillion, 2022, p. 135):

$$\sigma_P^2 = \sum_{i=1\ to\ n} \sum_{j=1\ to\ n} w_i w_j \sigma_i \sigma_j \rho_{ij}$$

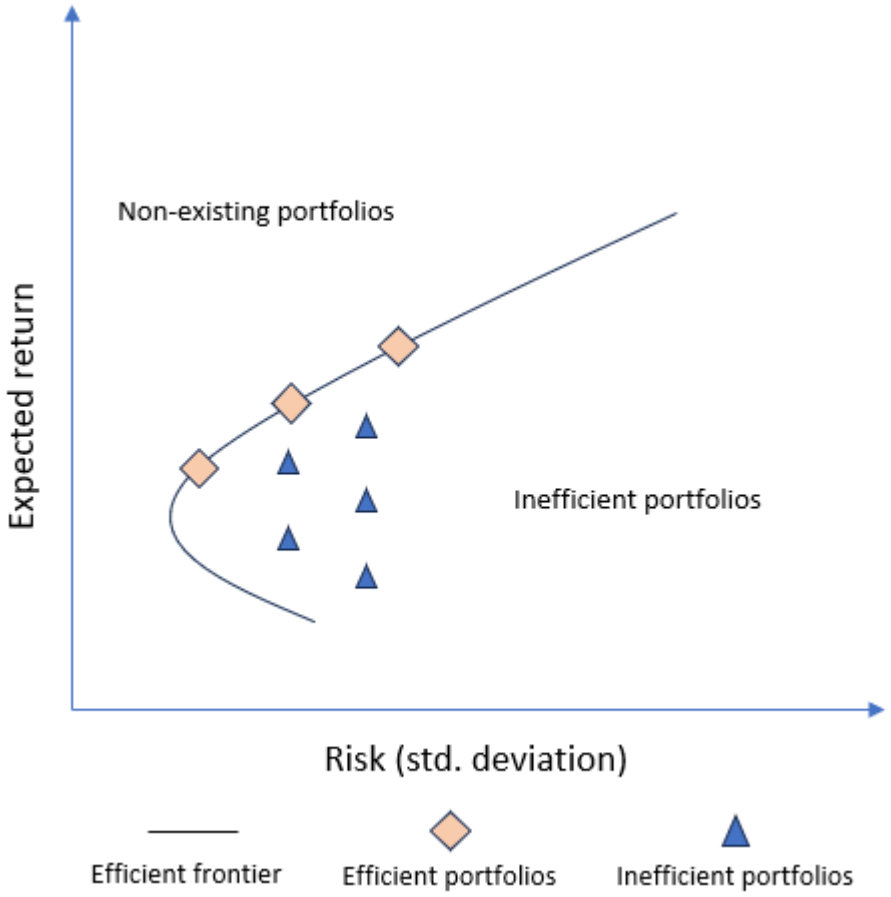
Where:

$$\sigma_P^2 = Portfolio\ risk\ (variance)$$
$$w_i w_j = Individual\ asset\ weights$$
$$\sigma_i \sigma_j = Std.deviation\ of\ individual\ assets$$
$$\rho_{ij} = Correlation\ coefficient\ between\ asset\ i\ and\ j$$

The efficient frontier

Grasping the framework of Modern Portfolio Theory, the efficient frontier is an important concept (Markowitz H. , 1952). The frontier displays every set of efficient portfolios, which create the highest return possible for one unit of risk. As *Figure 2* below also illustrates, there can in theory be several efficient portfolios along the efficient frontier, which comparably provides a smaller or larger return, however the exact same return per unit of risk (or standard deviation). The inefficient portfolios will be placed below the efficient frontier, while there exist no portfolios placed above the efficient frontier. The inefficient portfolios can both be seen as combinations and weightings of assets in a portfolio which is inefficient, as well as individual assets, which will also be placed below the efficient frontier. The Mean-Variance Optimization model can therefore illustratively be interpreted as a mathematical framework that seeks to either push the inefficient portfolios left- or upwards; lowering the risk, or increasing the return, in order to obtain an efficient return per unit of risk.

Figure 2 - Efficient Frontier



Source: Own illustration with inspiration from Jones & Trevillion (2022, p. 136)

3.2.2. Sharpe ratio

In order to optimize the portfolio of our chosen asset composition in practice, and thereby determining the efficient portfolio, we have chosen the Sharpe ratio as our primary performance metric. The ratio was originally presented by William Sharpe in 1966 (Sharpe, 1966), and is commonly used as a performance metric when using the Mean-Variance Optimization model. The ratio provides an expression of the excess return of an investment, for each extra unit of risk undertaken, thereby being a sound performance metric fit for the Mean-Variance Optimization model. The Sharpe ratio (Sharpe, 1966) is calculated as:

$$Sharpe\ ratio = \frac{R_P - R_f}{\sigma_P}$$

Where:

$$R_P = portfolio\ return$$
$$R_f = risk\ free\ rate$$
$$\sigma_P = standard\ deviation\ of\ the\ portfolio$$

By subtracting the risk-free rate from the portfolio return and dividing it by the volatility of the portfolio, you thereby get an expression of excess return of an investment, for each extra unit of risk undertaken.

Discussing common criticism of the Sharpe ratio as a performance metric, the ratio, like the Mean-Variance Optimization model and Modern Portfolio Theory in general, builds on the assumption of normality and a normal distribution behavior of investment returns. However, the nature of investment returns has historically been proven to deviate from perfect normality. Factors such as fat tails and skewness are among causations of this, which is further discussed in section 6.2.3. Another criticism is the fact that Sharpe ratio includes positive volatility as risk. One can argue that an investor would not consider an asset to be risky if all of the volatility of the return is between positive returns above the risk-free rate. Therefore, to broaden the perspective, we have included the Sortino ratio, among other performance metrics, when discussing our findings in regard to portfolio composition later in the thesis. The Sortino ratio is calculated as below (Sortino & van der Meer, 1991):

$$Sortino\ ratio = \frac{R_p - R_f}{\sigma_d}$$

Where:

$$R_P = average\ portfolio\ return$$
$$R_f = risk\ free\ rate\ (the\ minimum\ acceptable\ return)$$
$$\sigma_d = downside\ std.deviation\ (deviation\ of\ all\ returns\ below\ the\ R_f)$$

The Sortino ratio thereby excludes upside variation from risk in the model, adding perspective and depth to the findings and the discussion of such.

3.3. Data collection

As discussed in section 3.1., the combination of the positivist and critical realist philosophical perspectives in alignment with our research objective enables the utilization of both quantitative and qualitative methods and data throughout our research. Hence, the thesis relies upon both quantitative and qualitative data, providing greater flexibility, as well as more nuanced arguments, findings and conclusions. Further, all data utilized throughout the thesis is secondary data, implying that the data have been collected by other researchers, authors and organizations, and subsequently have been collected by the authors of this thesis from open sources such as databases, institutions, previous publishments and websites.

Given the primary positivist approach of the research, aimed at generating unbiased conclusions and 'law-like generalizations', quantitative data stands as the main source of data utilized and relied upon throughout the study. The quantitative data relied upon in the research and empirical analyses have been collected through the likes of Yahoo Finance, CBS' Bloomberg Terminal, US Bureau of Labor Statistics, Nareit (National Association of Real Estate Investment Trusts) etc. Qualitative data, in the form of relevant market reports, papers and other relevant information, have been collected through the likes of CBS' Libsearch and library, as well as reputable institutions through websites etc. The data, their original sources and the collection method utilized will be described where applicable continuously throughout the study.

3.4. Research quality & biases

In line with the axiology of both positivism and critical realism, the authors of this thesis have sought to minimize bias in every regard possible, heightening the quality of the research performed. While acknowledging not all and every bias is avoidable, bias from both the authors and external sources have been sought minimized through an array of active research choices.

Commencing with bias from the authors themselves, it is recognized that not all bias is possible to eliminate, although embarking on upholding a high standard of impartiality and objectivity. The measures and active research choices undertaken in this sense, revolves around relying primarily on quantitative data, computed with academically acknowledged models and methodologies.

However, the quantitative data relied upon is secondary data obtained from external sources, exposing the computations for possible biases within the datasets collected. Undertaking measures against these circumstances, there have been put significant effort into the evaluation of data sources, only collecting data from reputable, reliable and acknowledged sources such as Bloomberg, Yahoo Finance and the Bureau of Labor Statistics. Deviating from the seamlessly impartial and objective external sources, return data on REITs and REIT sectors have been collected from Nareit, the branch organization for the REIT industry. With Nareits apparent incentives to be positively biased towards REITs and the real estate industry, we have refrained from using qualitative and opinion-based analysis from Nareit, only utilizing their presumed unbiased database for quantitative data. Taking further measures to ensure the objectivity of our datasets, the sets have been cross-referenced between data from above mentioned sources, with correlation checks on random sample sizes as expected showing almost perfect correlation.

Beside undertaking extensive measures to ensure the objectivity of the quantitative data utilized, there have been put significant effort into evaluating the quality of the sources from where qualitative data have been collected. As a result, most utilized literature are papers published in highly reputable journals and publishers, such as the Journal of Business, the Journal of Finance, the Journal of Real Estate Finance and Economics, Financial Analysts Journal, the US National Bureau of Economic Research, and several other with similar acknowledgements and accreditations. With the active research choices and strategy utilized, the high quality of research relied upon and the continuous search towards objectivity, we argue that the research conducted, and the quality of the study, is commendable, while the impartiality achieved is deemed adequate.

4. Real estate investments

The following chapter serves as a preliminary analysis commencing with a brief presentation of the various real estate investment alternatives found relevant, as well as a depiction of what is known as the real estate cycles. Delving deeper into the investment vehicle of REITs in line with the research objectives of the study, we seek to provide thorough insights of REITs' historical performance, the regulatory requirements REITs must adhere to, their special characteristics, as well as the individual characteristics and correlations of REIT sectors.

4.1. Real estate investment alternatives

Commencing with the very definition of real estate investment, the authors of this thesis define real estate investments as the concept of investing in real estate in any way possible, in order to obtain future financial return. While there exists a wide range of real estate investment alternatives based on numerous different factors, including investor types, investment strategies and risk adversity, the investment opportunities can broadly be split into two categories: *direct*- and *indirect investments*.

4.1.1. Direct- vs. indirect investments

While direct investments are defined as "*the ownership of the physical asset and its legal interests*", indirect investments are defined as "*a 'paper' asset backed by property returns*" (Jones & Trevillion, 2022, p. 6). Hence direct investments in real estate refer to the ownership of the physical property, either for owner occupation or third-party tenants. Indirect investments in real estate, however, refer to 'paper' assets, and can be separated into *equity* and *debt* investments, with equity investments providing the investor a return through property appreciation and dividends, and debt investments providing a cash-flow similar to debt repayments (Jones & Trevillion, 2022, p. 66).

Direct real estate investments can take various forms, each with different characteristics and potential benefits, including *residential properties*; houses, apartments and other residential homes, *commercial buildings;* offices, hotels, and retail centers etc., and even *infrastructure* and *land*. Investors might acquire the investments alone or through privately held partnerships, amongst other investment structures. In comparison to publicly traded real estate investment funds, direct investments differ substantially in terms of the pricing mechanisms. While the pricing of properties acquired through direct real estate investments are based partly on supply/demand, which relates to the bid/ask price mechanism known from stock exchanges, one of the key differences are related to a liquidity aspect. Since direct investments refer to the purchase of physical properties, they are considered much more illiquid compared to the purchase of shares in publicly traded funds. Another important aspect of variation is related to the factor of

diversification, where the high capital requirements make it substantially more difficult to maintain a certain level of diversification for investors with less funds.

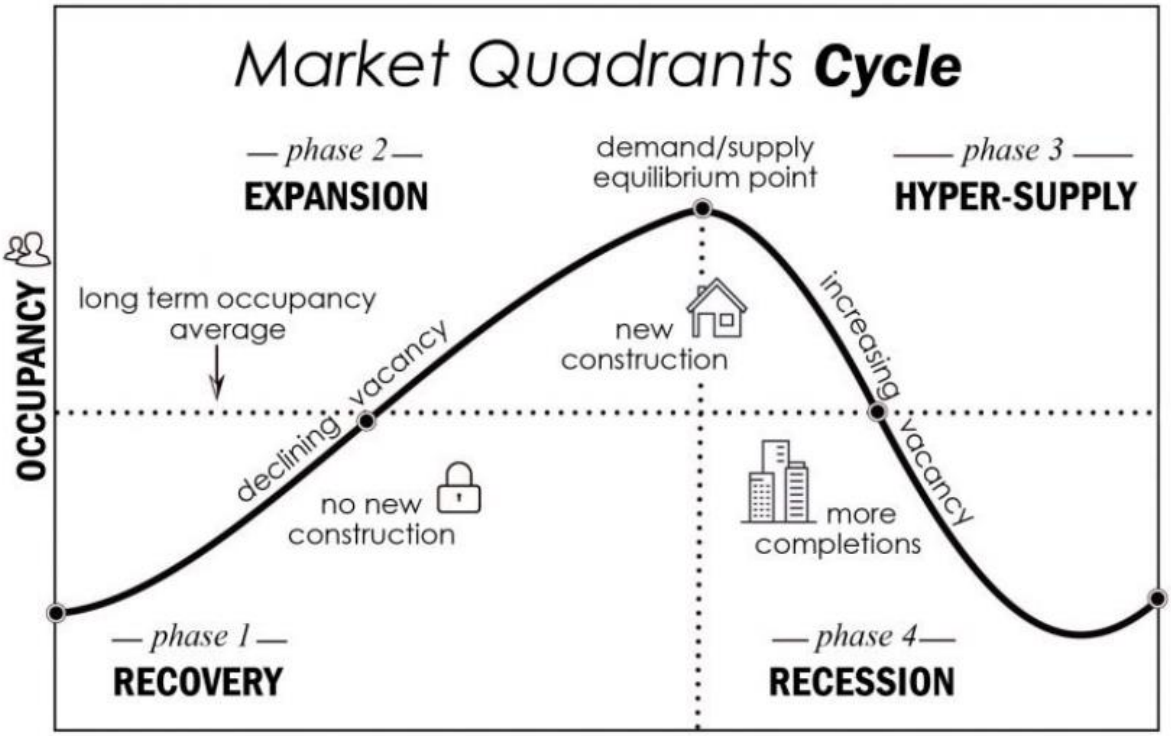
Indirect real estate investments can, like direct real estate investments, take many shapes and various forms, and the best alternative for each investor greatly varies depending on the type of investor, preferences and appetite for risk. As described previously, indirect investments in real estate can be both equity and debt investments, but can also be both public and non-public investments, as some of the alternatives can be traded on a public exchange while other alternatives cannot. The most traditional and popular indirect real estate investment alternatives comprise investment vehicles such as *REITs*, real estate *exchange-traded funds (ETFs)*, *crowdfunding/lending* of real estate, real estate *hedge funds* as well as *private real estate funds* and *limited partnerships* (Jones & Trevillion, 2022, pp. 93-99). All of the beforementioned alternatives gives the investor the right of the financial returns obtained through the real estate investments, but none give the investor a direct ownership of a physical property. Of the beforementioned, it varies across the alternatives whether they are debt, equity, public- or non-public investments. Refraining from going into detail in this section, the opportunities of equity investments comprise all of the alternatives mentioned, while the debt investment opportunities primarily comprise mortgage REITs and crowdlending. Differentiating between public- and non-public investment alternatives, however, is clearer cut, as it is binary whether the investment is made on a public exchange or through private markets.

4.2. Real Estate Cycles

Commercial Real Estate, and the Real Estate industry as a whole, was first acknowledged as a highly cyclical industry by Homer Hoyt in his research in the 1930's (Hoyt, 1934), and is today a concept that is commonly acknowledged in the industry. Building on Hoyt's research and other previous research on the cyclical nature of the real estate industry, Glenn R. Mueller (1995) first presented the "Market Quadrants Cycle" in 1995, as depicted in *Figure 3* below. In order to structure and further define previous research, Mueller (1995) stratified real estate cycles into physical and financial cycles allowing further clarification of causality. While the physical aspect analyses the supply, demand and occupancy of physical space; homes, offices and warehouses

etc., the financial aspect analyses the financial macroeconomic tendencies affecting the industry; the overall state of the economy, interest rates, inflation etc. The "Market Quadrants Cycle" is a construction of four phases showing a simplification of the real estate cycle, with the rise and decline in occupancy (y-axis) taking us through the phases which historically span 18 years on average. The four phases are *Recovery*, *Expansion*, *Hyper-Supply* and *Recession*, respectively.

Figure 3 - Market Quadrants Cycle



Source: (Mueller, 1995)

Phase 1 – Recovery

With the cycle starting from the bottom of occupancy and the highest vacancy, Phase 1 is deemed "recovery", as the low occupancy is a result of decreasing demand and the oversupply by new completions in phase 4 of the previous cycle. Throughout Phase 1, there will (theoretically) not be initiated any new construction, hence the vacancy of the oversupply will slowly be filled by a slightly increasing demand and no new supply. While the demand increases slowly, approaching the demand/supply equilibrium marking the start of Phase 2, rental prices will go from decreasing

in the start of phase 1, to slightly increasing towards the end of the phase, yet still below the rate of inflation.

Phase 2 – Expansion

The equilibrium of demand and supply marks the start of Phase 2. At this stage, the growth level of demand will start to increase surpassing the supply, marking a supply shortage. As tenants will have a lack of alternatives, landlords will have the bargaining power and the rent levels will therefore increase significantly throughout the phase. With increasing demand and significantly increasing rent levels, new construction is suddenly profitable hence the phase is named "Expansion". With new construction feeding the appetite of the continuous growth in demand, the supply and demand growth rates can increase simultaneously, until reaching the peak of the real estate cycle.

Phase 3 – Hyper-Supply

With the peak of the cycle being the inflection point, it marks the entrance to Phase 3. The inflection point marks the point, where the growth rate of supply surpasses the growth rate of demand, and the function of *Figure 3* can therefore be seen change concavity, as the vacancy will increase, and the occupancy will decrease. The inflection point, however, can be incredibly difficult to identify in a present moment of time, hence new constructions will commence throughout the phase, further increasing the oversupply and pushing the vacancy rates back towards the supply and demand equilibrium. With increasing vacancy and construction completion, rents will decrease as tenants will have several alternatives to turn to.

Phase 4 – Recession

With landlords realizing the demand-shortage and thereby decreasing rents, many construction projects, both on-the-way and already completed projects, suddenly becomes unprofitable pushing the real estate cycle into Phase 4: Recession. Although there (theoretically) will be no new construction initiated in Phase 4 because of the unfeasible rent, already commenced construction projects will most likely be completed, further increasing the vacancy with both increasing supply

and a negative growth in demand. The cycle continues until the bottom of occupancy is reached, thereby entering the recovery phase where demand once again starts to increase.

4.3. Real Estate Investment Trusts (REITs)

The following chapter provides a thorough analysis of the investment vehicle that REITs is, laying the informational foundation for later empirical analysis. By commencing the section with a discussion of REITs background and their historical evolution, we delve deeply into their historical performance and the regulatory requirements REITs must adhere to. Further discussing REITs characteristics in detail, the section is concluded with an analysis of REIT sectors and their correlations mutually and to broader stock indices.

4.3.1. Background

Real Estate Investment Trusts (”REITs”) are companies and entities owning, managing or financing real estate that produces income. Although being invented prior to, REITs were officially established in the U.S. in 1960 by regulatory actions and has since been subject to several reforms to refine REITs as we know them today (NAREIT, n.d.). The original purpose, and the purpose REITs still serve to this day, is to allow regular citizens to invest in income producing real estate, which so far had only been possible in a direct manner for the wealthy and for institutional investors such as hedge funds and banks (ibid.).

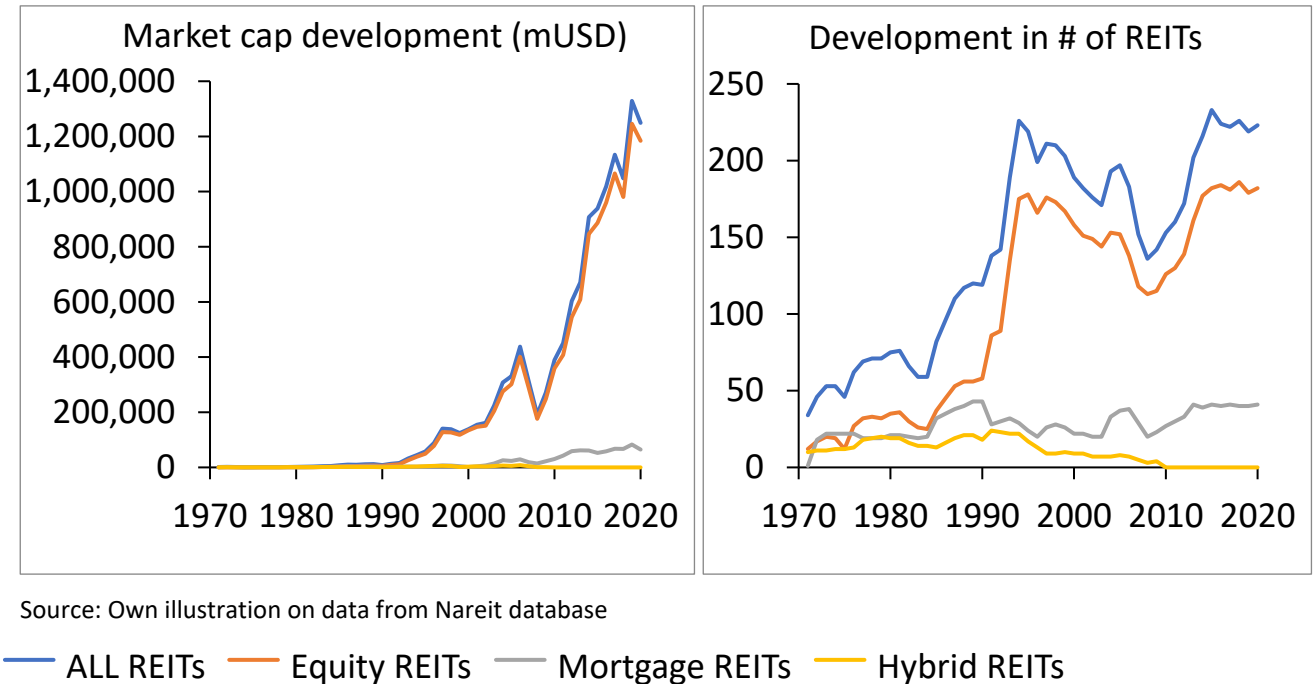
4.3.1.1. Historical development of REITs

Since REITs were officially established as an investment vehicle in 1960, the concept of REITs has grown substantially over the years, both in the U.S. and globally, with REITs becoming an acknowledged and utilized investment vehicle among both institutional- and private investors. Looking at the numbers, over 40 countries has adopted REIT legislation as of 31st December 2021, with 865 listed REITs globally comprising an equity market cap of $2,5t of which the 223 listed U.S. REITs contributes $1,3t, comprising more than half of the global equity market cap of REITs (NAREIT, 2021). Stressing the acceptance and acknowledgement of REITs in the investment industry, research shows that 64% of the 25 largest institutional investors globally use REITs in

their portfolio composition (NAREIT, 2021), which can be credited to REITs unique features and diversification opportunities.

Analyzing the historical development of REITs in *Figure 4*, the stark rise of REITs popularity seems evident. With NAREIT collecting data from 1972, a remarkable evolution of the market cap has been observed in the period, with the market cap reaching its highest of $1,7t in 2021, having only amounted to $138b in the year of 2000. The great increase of the market cap of REITs has been on a positive trend for most of the observed period, which can be credited to both underlying drivers as well as investor sentiment, while a few periods deviate the positive trend. Refraining from going into detail with all underlying drivers throughout the observed period, some factors, both industry specific and macro economical, have had a great influence on the development of REITs.

Figure 4 - Historical development of REITs



Source: Own illustration on data from Nareit database

1960-2000 – Reforms, organizational structures and economies of scale

Shallowly analyzing the drivers behind the REIT industry evolution, some events remain unavoidable. Commencing with the industry specific drivers and events, there had been several regulatory changes to REITs in the first three decades of the industry's official lifetime, including multiple tax reforms. None of these reforms, however, managed to gravely change investor

sentiment, as REITs did not pick up any momentum. In the latter of the 1980's, REITs began to revisit their organizational structures, as there at the time existed two: internally advised and externally advised (Ambrose & Linneman, 2001). Recognizing that there were inefficiencies in the organizational structures of externally advised REITs should prove to be a turning point in the investor sentiment towards REITs, as REITs experienced a boom in the early 1990's (Isik & Topuz, 2017), depicted in *Figure 4*. The development in organizational structures of REITs changed investor sentiment for the better, with sudden interest from institutional investors launching an IPO-boom inaugurating the "*Modern REIT era*" (Isik & Topuz, 2017). From 1990-1995, the number of listed REITs went from 119 to 219, with the market cap increasing by 659% from $8,7b to $57,5b (*Figure 4*), stressing the fact that REITs were now an asset class to be reckoned with.

In the late 1990's and start 2000's, the REIT industry came to a stalemate with a limited growth in market capitalization and even a decrease in number of listed U.S. REITs. Ultimately affected by macroeconomic factors in form of the Dot-com bubble pulling investor sentiment away from public markets, the period acted as a consolidation period within the industry, with an economies of scale effect becoming evident providing larger REITs expense- and funding advantages (Linneman, 1997). To further strengthen and cement the industry's progress, the REIT Modernization Act (RMA) was implemented in 1999 (NAREIT, 1999), which still to this day serves as the latest regulatory change made. The modernization act allowed REITs to own taxable subsidiaries, further strengthening REITs competitiveness by profiting from economies of scale.

2000-2008 – Bull market and the Great Recession

Following the REIT Modernization Act, REITs entered a period of rapid growth up until the great recession. The period starting from the mid 1990's up until 2007 was characterized by an incredibly bullish real estate market with low interest rates, laissez-faire lending policies from banks and a rapidly expanding mortgage securitization industry (Grusky, Western, & Wimer, 2011), all benefitting the REIT industry with a market cap growth of 316% from 2000 to 2006. With the unravelling of the mortgage securitization industry in 2007, marking the start of the great recession and the deepest financial crisis since 1929, REITs took a big hit together with the rest of the global public markets, with REITs' market cap plunging from $438b in 2006 to $192 by the end

of 2008, constituting a drop of 56%. For comparison, the S&P 500 plunged 36% in the same period, with the difference in the drop of the two emphasizing investors skepticism towards the real estate industry, as it was the very mortgage business tipping the scale of the crisis, almost completely eradicating the main funding source of real estate and REITs.

2009-2017 – Recapitalization, yield-seeking and inflation-hedging

The aftermath of the financial crisis demanded a recapitalization of the REIT industry, with the plunged market cap having affected the REITs with "… higher debt to asset ratios and shorter maturity debt" (Sun, Titman, & Twite, 2013, p. 1) most severely. Luckily for REITs, investors sought yield to provide them a steady cash flow as well as a hedge against inflation to follow the presumed economic bounce back, hence REITs provided a very strong investment case post the financial crisis, raising a much-needed capital injection through equity. The essentials of REITs proved beneficial to investors, rallying the REIT industry from a market cap of $272b in 2009 to $1.134b in 2017 providing a CAGR of 22% in the period.

2017-2021 – COVID-19

While trade wars and GICS inclusion in the years of 2016 and 2018 respectively somewhat affected the REIT industry, the ultimately biggest event that affected the REIT industry in recent years, and the public markets as a whole, is the global COVID-19 health crisis. The initial reaction to the pandemic was a global lockdown, bringing the fear of an instant recession to investors worldwide as leisure activities and retail stores, among other entire industries, came to a halt. The reaction on the public markets to the sudden pandemic was an immediate drop in stock prices, with commercial real estate prices dropping simultaneously (Deghi, Natalucci, & Qureshi, 2022), intensifying the effect on the REIT industry. COVID-19 was declared a pandemic by WHO on the 11th of March, 2020 (World Health Organization, 2020), which saw some REIT sectors' total return drop as much as 55% in March alone (Schnure, 2020). The bounce back, however, was almost as swift as the drop, with REITs already on the mend in April 2020 averaging a growth of 8,8% across all equity REITs, salvaging the year of 2020 resulting in only a minor drop in market cap compared to 2019. As a result of social distancing for health safety measures, consumer behavior across sectors changed gravely with a sudden working-from-home culture affecting office REITs and a

lack of physical retail store options pushing expenditures towards e-commerce affecting retail- and data center REITs adversely. An in-depth REIT sector analysis with inter-sector correlation will be presented in section 4.3.6.

2021-2023 – Russia invades Ukraine

In 2021, post-pandemic, REITs' market cap concluded on an all-time high of $1,7t achieving an astronomical growth of 72%. The growth was fueled by an increasing inflation and low interest rates throughout the year, providing easy and cheap access to capital, as well as stark increases in real estate prices and rental income proving the perfect conditions for REITs to thrive. While the economic environment of 2021 proved beneficial for REITs, 2022 spiraled in the other direction. In February 2022, Russia invaded Ukraine, starting the biggest conflict on European soil since World War 2. The sanctions on Russia following the conflict disrupted global supply chains for essential energy markets such as gas and oil, further increasing the already high inflation. To counter the inflation, the Federal Reserve was forced to increase interest rates continuously, sending the global economy into a downward spiral affecting the public markets negatively. Being a capital-intensive industry, REITs market cap was affected severely, dropping 25% and closing on a market cap of $1,3t.

4.3.2. Regulatory requirements for REITs

As described previously, REITs have undergone several regulatory reforms since being officially established in the U.S. in 1960. The several reforms, with the latest being the REIT Modernization Act in 1999, defines a framework for the regulatory requirements REITs must adhere to in order to obtain or maintain the beneficial REIT status. The requirements originate from four tests the corporations must satisfy, and primarily acts as a safeguard of the status, which make REITs the unique investment vehicle it is. The four tests concern REITs *organizational*, *operational*, *distribution* and *compliance* requirements (NAREIT, n.d.), which together forms a list of regulatory requirements.

Commencing with the *organizational* test, REITs must meet several requirements with the most notables being the requirement of director or trustee governance, at least 100 shareholders and

that “five or fewer individuals cannot own more than 50% of the entity” (NAREIT, n.d.). To ensure that corporations benefitting from the REIT status is truly deriving their income from real estate operations, REITs must semi-annually prove that 75% of their income originates from rent or interest from real estate, while also having to document quarterly that at least 75% of their assets is real estate assets. The test of *distribution* relates to the dividend structure of REITs and is a part of what make REITs a unique investment vehicle. As described previously, part of the purpose of REITs is to make real estate investment available to regular Americans by designing REITs as tax pass-through vehicles, with investors having to pay income taxes, as they would have to, had they owned and obtained rent through direct real estate investment. REITs must therefore distribute at least 90% of their taxable income to their shareholders in order to be exempt from paying taxes, as all retained income will be taxed. Lastly, there is the compliance requirements, which in turn is more administrative requirements, as corporations need to file several forms in order to obtain REIT status (NAREIT, n.d.).

4.3.3. REIT performance

In this section, a focus will be targeting the historical performance of REITs, while including observations on how the performance is affected by economic fluctuations, as well as commenting on the key drivers that have influenced the historical development. For this section, other major indices, including the S&P 500, Russell 2000, Nasdaq Composite & Dow Jones Industrial, will be included and used as a comparative benchmark for the performance. *Table 1* below presents the historical performance of REITs, relative to all the beforementioned indices, for the periods specified in the left-handed side of the table.

Table 1 - Historical performance

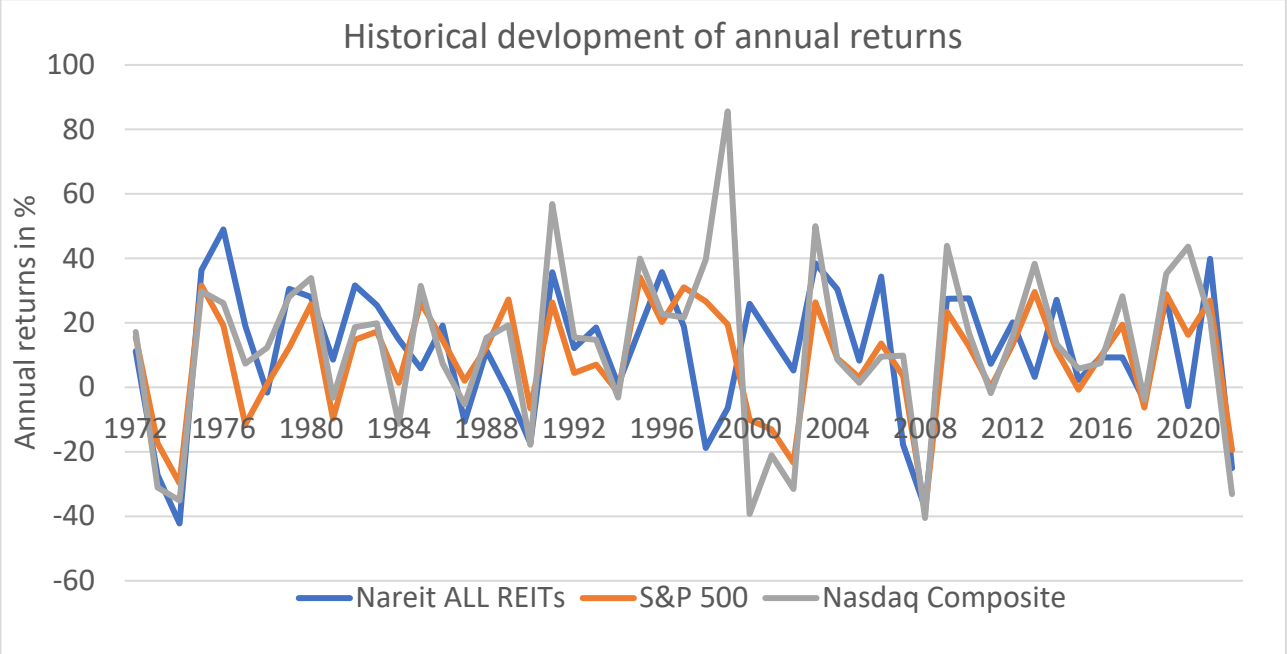
	FTSE Nareit					Dow Jones
	All REITs	All Equity REITs	S&P 500	Russell 2000	Nasdaq Composite	Industrial Average
2023: YTD	10.30	10.07	6.28	9.75	**10.72**	2.93
1-Year	-10.49	-10.27	-8.22	-3.38	-17.95	**-0.92**
3-Year	2.37	3.03	**9.88**	7.51	9.04	8.68
5-Year	6.66	7.09	9.54	5.54	**10.34**	7.77
10-Year	7.46	7.74	12.68	9.36	**15.14**	11.98
15-Year	7.16	7.40	9.70	8.34	**11.10**	9.52
20-Year	9.59	10.10	10.28	10.03	**11.47**	10.13
25-Year	8.15	**8.60**	7.85	7.60	*8.19*	*6.02*
30-Year	9.48	**9.91**	9.84	8.84	*9.83*	*8.08*
35-Year	9.00	9.98	**10.58**	9.69	*10.56*	*8.50*
40-Year	9.31	10.83	**11.31**	9.47	*10.08*	*9.02*
1972 - 2023	9.33	**11.29**	10.60	-	*7.80*	*7.40*

Data in percent; highest return for the period in bold.
Returns in italics are price-only.

Source: Nareit database (2023)

Table 1 illustrates that REITs have generally performed well over the years, especially when considering the longer periods, shown in the strong results for the Nareit ALL Equity REIT index, which have performed best of all in most of the 25-year+ periods. However, the performance of REITs has been more mixed in recent years, and mostly underperforming, when compared to the other indices. Yearly return data has been collected for Nareit ALL REITs, S&P 500 and Nasdaq Composite for the whole period of 1972-2023, shown in *Figure 5* below that illustrates a comparison of the development in yearly returns.

Figure 5 - Historical development of annual returns

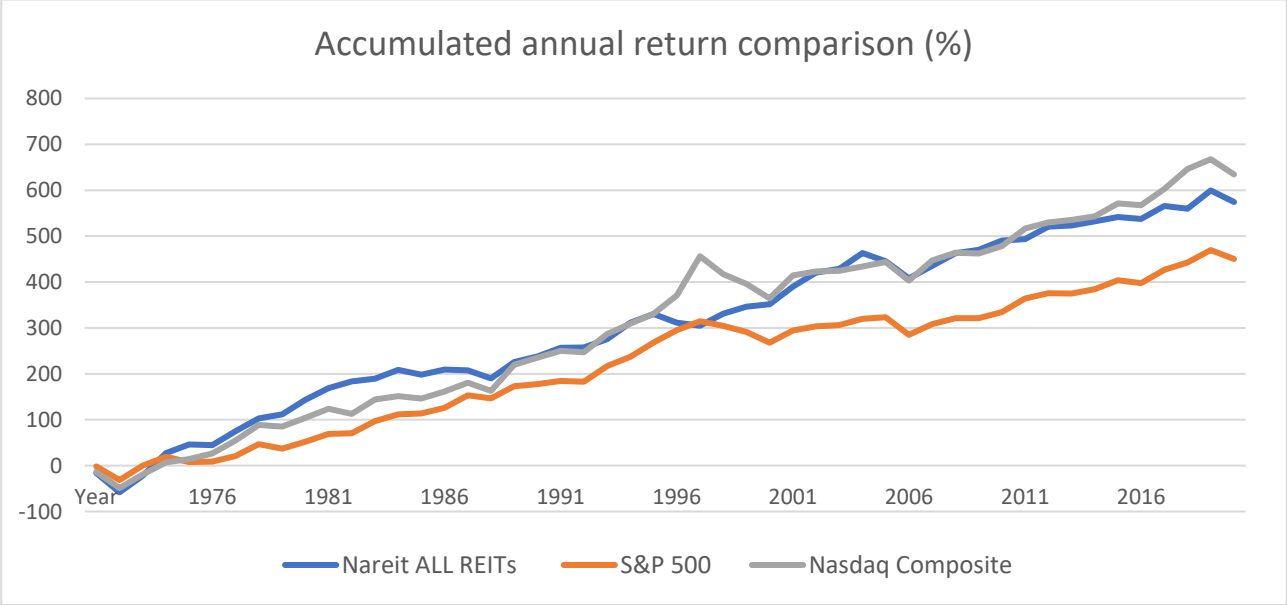


Source: Own illustration on data from Nareit database and Yahoo Finance

The figure clearly indicates that the yearly return of REITs predominately follows the development of both S&P 500 and Nasdaq Composite. However, variations are present, especially in the years around 1996-2002, where the returns of REITs substantially differ from both S&P 500 and Nasdaq Composite. Assessing the huge spike for the Nasdaq Composite index, the impact affected by the emergence of new industries, such as e-commerce, and the generally increased demand for tech companies is inevitable. The period is connected to the later burst of what is known as the dotcom bubble, which is generally perceived to be caused by speculation, unrealistic valuations and rapidly increasing demand for internet-based businesses from 1995-2000 (CFI, 2023). The returns of REITs seem to be negatively correlated with the general stock market in this period, at least when S&P 500 and Nasdaq composite is used as proxy. Since the Nasdaq index is tech-heavy, the returns are enormously impacted by both the rapid increase and the following crash around the dot.com bubble. The impact was not as direct for REITs, which suffered from a correction around the years of Nasdaq's rise, which was allegedly caused by years of trading with a substantial premium that was to be corrected (Howard, 1998). The fact that almost all eyes were directed towards the new phenomenon of internet-based businesses is likely to have impacted the interest of the real estate market, and thereby it's returns. The illustration does, however, show a quicker bounce-back for

REITs when comparing the results of the returns to both S&P 500 and the Nasdaq Composite. The immediate increase of REITs in the early 2000's is likely to be affected by numerous factors, including circumstances such as low interest rates and easily obtainable credit from the banks, contributing to more accessibility for houseowners and investors and thereby an increased demand (Justiniano, 2015). All factors that were later believed to have massively influenced the housing-bubble burst, followed by the great recession. To better assess and evaluate on the performance of REITs, relative to the indices of S&P 500 and Nasdaq Composite, *figure 6* below is conducted, presenting the accumulative return for all three assets. The data has been preferred to be illustrated for two separate periods, showcasing the development in both a more recent period, displaying the annual results for the period 2000-2022, and a historic perspective, illustrating the development inherent to the period 1972-1999.

Figure 6 - Accumulated returns in %



Source: Own illustration on data from Nareit database and Yahoo Finance

Commencing with the initial period, stating back to the very start of publicly traded REITs as we know them today, REITs have performed strong and even outperformed both the S&P 500 and the Nasdaq Composite for several years. However, towards the years of around 1998 – REITs experienced the beforementioned correction, while both S&P500 and Nasdaq Composite continued to rise, especially Nasdaq Composite, due to the previously mentioned factors.

Illustrating the accumulated returns of the included indices for the more recent period between 2000-2022, the figure is showing an overall similar and less exponentially increasing development for both REITs and the two indices. The figure indicates that REITs performed rather well in the early 2000's, closing the gap to Nasdaq Composite, and overperforming the S&P 500 index. All assets were, not surprisingly, negatively affected by the great recession, shown in the dip around 2008.

The impact of rising interest rates

It is generally asserted that REITs should be negatively impacted by rising interest rates, since – all else equal – rising interest rates should increase the borrowing cost for REITs. A thought that has been more frequently questioned and analyzed in recent years, where studies, as one conducted by S&P Global, has found little to no evidence on such relation between interest rates and REITs performance (Orzano & Welling, 2017). However, in general terms, it is likely to believe that rising interest rates would make factors such as REITs' high dividend yield less attractive, as it would increase investors required rate of return, due to a higher risk-free rate. The beforementioned study on the performance of REITs doing periods of rising interest rates relies partly on *table 2* below, showing the performance of REITs during sustained periods of rising interest rates, i.e., periods where the 10-year treasury yield has grown significantly. The performance of "Stocks" is based on results from S&P 500, whereas the REITs returns are based on numbers for the FTSE Nareit Equity Index.

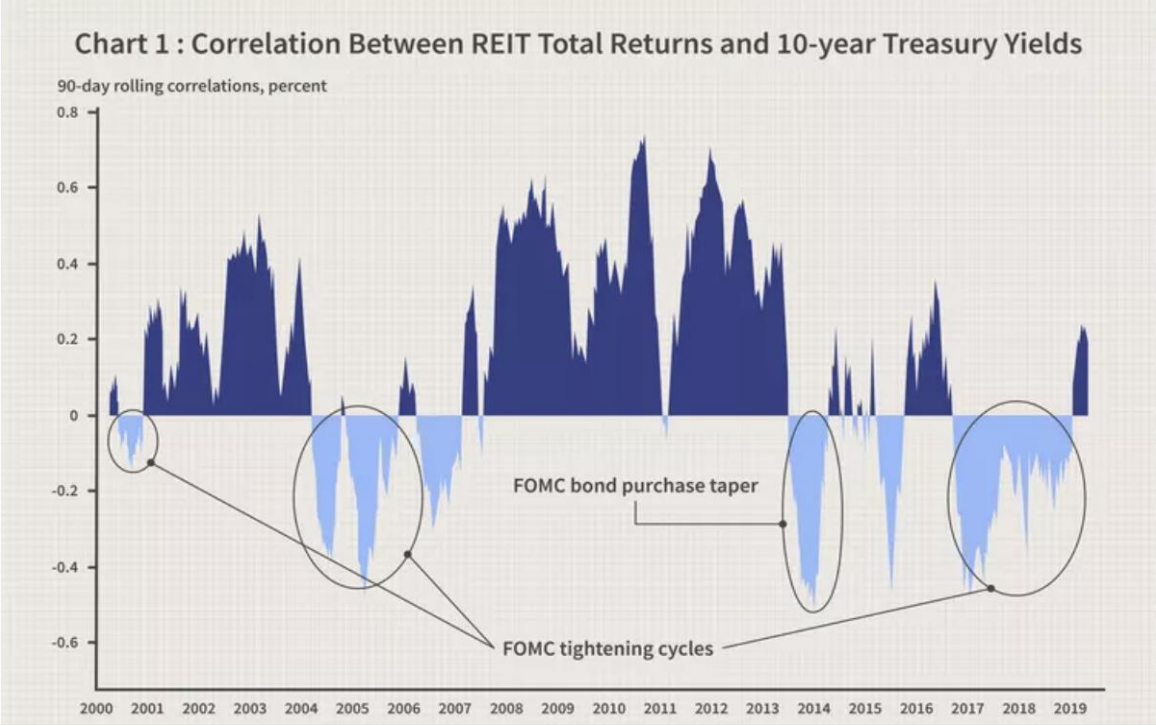
Table 2 - Treasury Yield vs. Cumulative Return

TIME PERIOD	U.S. 10-YEAR TREASURY YIELD			CUMULATIVE TOTAL RETURN OVER PERIOD		
	BEGINNING YIELD (%)	ENDING YIELD (%)	CHANGE (%)	REITS (%)	STOCKS (%)	DIFFERENCE (%)
December 1976-September 1981	6.9	15.3	8.5	137.4	46.0	91.4
January 1983-June 1984	10.5	13.6	3.1	35.6	16.5	19.1
August 1986-October 1987	7.2	9.5	2.4	-10.1	10.9	-21.0
October 1993-November 1994	5.3	8.0	2.6	-10.3	0.1	-10.3
October 1998-January 2001	4.5	6.7	2.1	27.4	27.8	-0.4
June 2003-June 2006	3.3	5.1	1.8	108.2	37.6	70.6

Source: Orzano & Welling (2017)

The table shows that REITs, for the periods specified in the left-hand side of the table, have had positive returns in 4 out of 6 periods and even outperformed stocks in 3 out of those 4 periods. The results indicate that while rising interest rates undoubtably have some negative consequences, the performance of REITs is impacted on various factors, including factors related to rising interest rates that can affect REITs both positively and negatively. For instance, rising interest rates is usually associated with economic growth, which is likely to positively influence the real-estate sector. On the other hand, rising interest rates also tend to negatively impact the purchasing power of investors, thereby decreasing the demand for investments. The conclusion of the S&P Global study (Orzano & Welling, 2017) is in fact rather inconclusive since, ultimately, interest rates was not found to be the key driver of the performance of REITs. Rather, the underlying reasons and dynamics of what drives the increase was found to be of most importance, indicating that when the rise of interest rates are caused by strong economic growth and welfare, the negative factors is likely to be more than compromised by positively related factors. *Figure 7* below shows the correlation between REIT performance and the US 10-year treasury yield, which supports the conclusion that the performance of REITs is both positively and negatively correlated to the interest rates, depending on the specific periods and the underlying factors.

Figure 7 - REIT and Treasury Yield correlation



Source: (Seth, 2022)

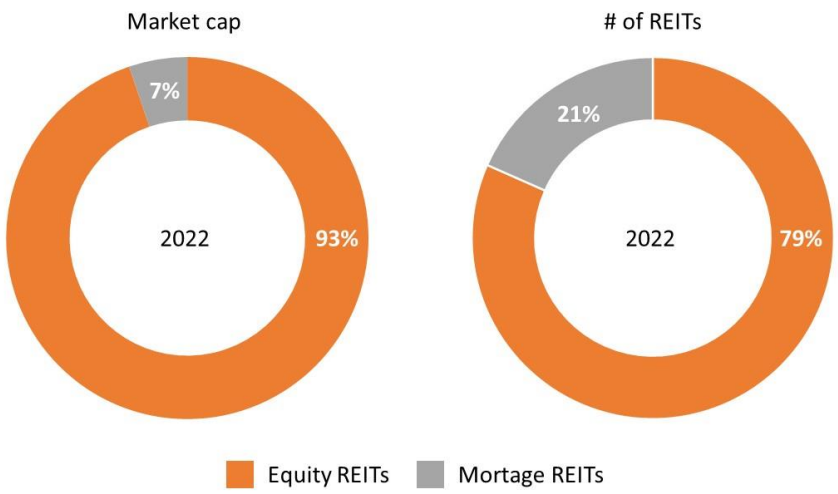
Lastly, it is worth mentioning, that the impact of rising interest rates is found to differ substantially between the different sub-sectors of REITs, primarily due to differentiation in lease term length, which is considered to be one of the key factors to how the rising interest rates affects the performance. For instance, REITs that have shorter lease term lengths are arguably more agile in terms of reacting to economic fluctuations, when compared to REITs with substantially longer lease term lengths.

4.3.4. Main characteristics

To properly understand the concept of REITs, how they respond to market conditions and why they could act as a good investment alternative and addition in traditional mixed-asset portfolios, their unique characteristics will be described in the following section. Given the unique characteristics of the REIT types of Equity and Mortgage, arguments regarding their characteristics will be sought stratified throughout. In *Figure 8* below, the distribution of REIT types on both

market cap and number of REITs is visualized, with equity REITs being the vast majority of listed U.S. REITs measured on both market cap and nominally.

Figure 8 - Distribution of REIT types on market cap and numbers

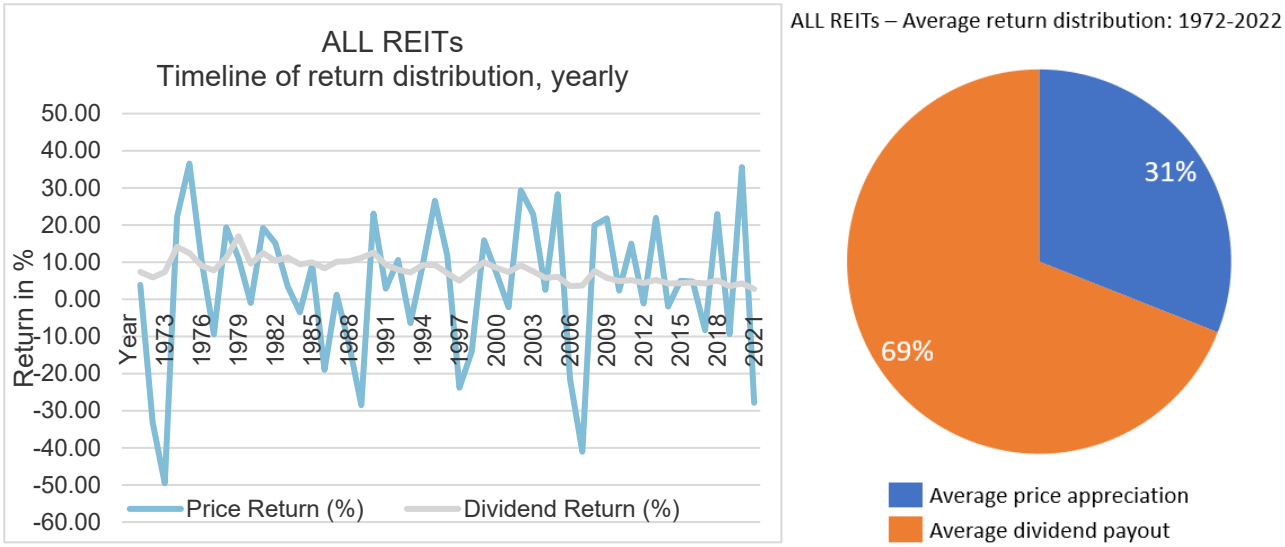


Source: Own illustration on data from Nareit database

4.3.4.1. Return Distribution (Dividends vs appreciation)

As mentioned previously, regulations strictly require REITs to distribute a minimum of 90% of their taxable income towards shareholders in the form of dividends. Consequently, a unique distribution of the total return of REITs characterizes all types of REITs, resulting in a higher general level of dividend yields when compared to other securities. Although the requirements to qualify as a REIT are applicable across all types of REITs, differences in the fundamental structure between equity and mortgage REITs creates mentionable variations in the distribution of total return to shareholders. Mortgage REITs specializes in investments in mortgages, thereby generating income solely from interest, whereas equity REITs acquire, manage, and sells income producing real estate, thereby generating income mostly on rental income and secondly on potential price appreciation on the properties (Nickolas, 2022). *Figure 9* below illustrates the average distribution of the total return between dividend payments and price appreciation for Nareit ALL REITs, as well as a comprehensive figure illustrating a timeline of the yearly return distribution between price and dividends.

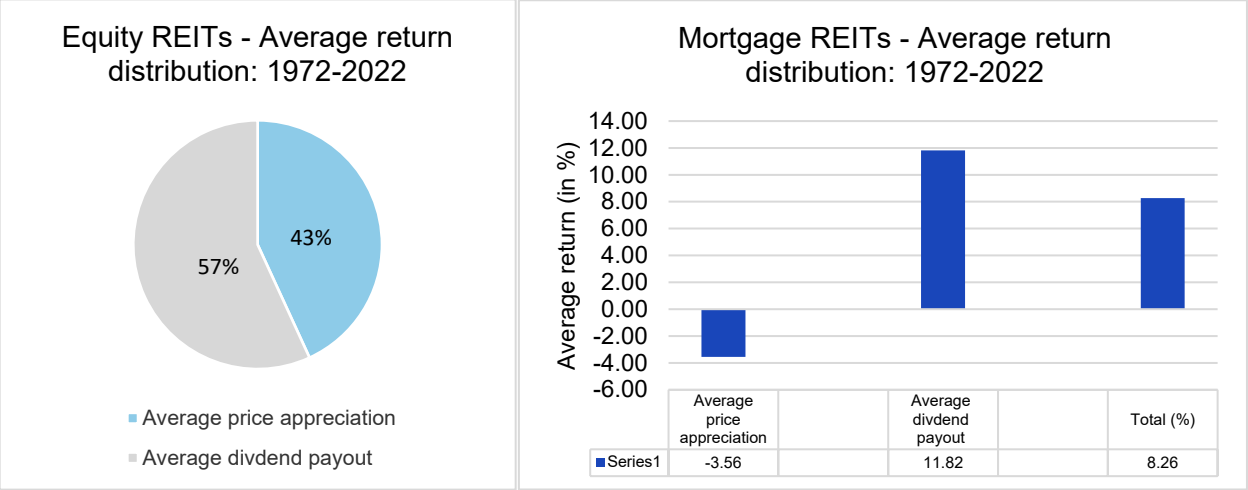
Figure 9 - REIT return distribution



Source: Own illustration on data from Nareit database

As shown in the left-handed part of the figure, price appreciation/depreciation shows a great amount of volatility, ranging between both substantial price depreciation of up to -50% to appreciations near 40%. The yearly dividend return is showing much more consistency throughout the entire period, however, reflecting a downward trend which is reflected in a relatively lower level in recent years. The right-handed side of the figure shows the overall average distribution of return from 1972-2022, where the huge spikes in price appreciation has been offset in years with similar depreciations, resulting in average dividends to account for the majority of total average returns with 69% against 31% in price appreciation. Breaking down the data further, *figure 10* below shows the previously mentioned differences between equity and mortgage REITs, where mortgage REITs are superior in terms of average dividend payout, while equity REITs obviously contains a balanced average return distribution with price appreciation has accounted for 43% historically, thereby 57% in dividend return.

Figure 10 - Equity vs. Mortgage REITs return distribution



Source: Own illustration on data from Nareit database

Besides the obvious differences between mortgage and equity REITs presented in this chapter, a further distinguishment of dividend yield variations between different sub-sectors of equity REITs will be covered in chapter 4.3.6., containing an in-depth review of the underlying sub-sectors and their mutual correlation.

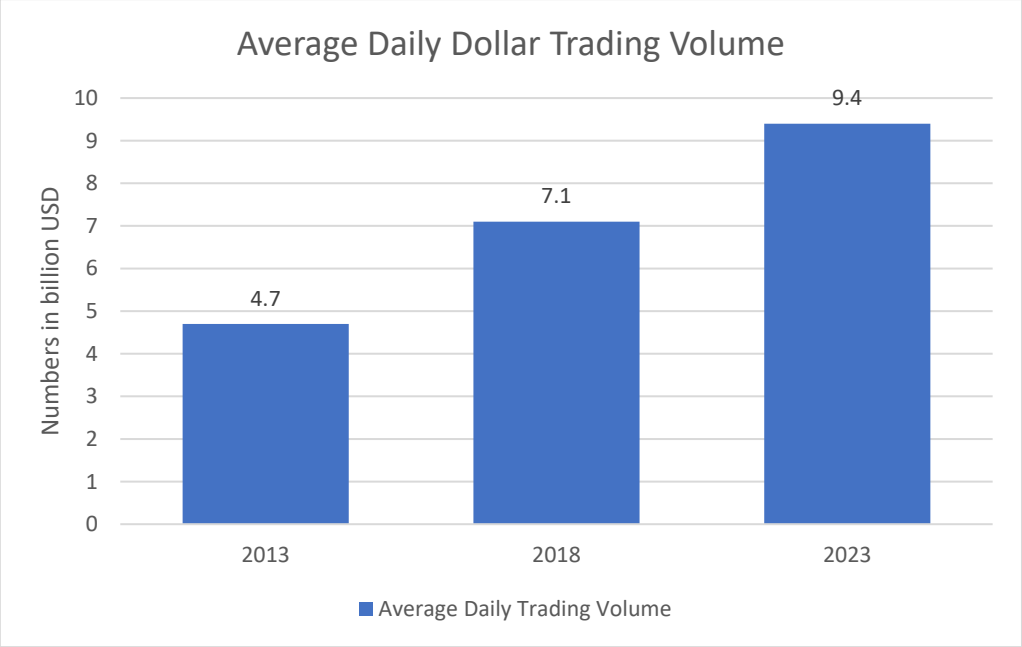
4.3.4.2. Diversification (correlation with asset classes etc.)

Diversification is perceived to be an important aspect in MPT - Modern Portfolio Theory - (Markowitz H. , 1952), where the importance of diversification is emphasized in the context of portfolio management, closely related to the perspective of risk management. MPT builds upon the idea that an efficient and optimal portfolio is constructed by the inclusion of assets with low or even negative correlations, with the purpose of reducing the overall portfolio risk without compromising returns (Corporate Finance Institute, 2023). Considering the risk, we distinguish between idiosyncratic risk, which refers to risk of individual assets or asset groups, and systematic risk, known as the broad market-wide risk, inherent in and relevant to the broader market or specific asset class of interest (Chen J. , 2022). The theory has proven its ability to lower the idiosyncratic risks in a portfolio, since potential losses in one asset should be simultaneously offset in relative gains from the other diversified assets in the portfolio where the correlation principle is observed. The diversification benefits of REITs and REIT sectors will be discussed further in Chapter 4.3.6.

4.3.4.3. Liquidity

Real estate is commonly seen and referred to as a prime example of an illiquid asset, which is defined as assets that cannot be easy and quickly converted to cash (Hoisager, 2022). Usually, the process of selling/buying real estate is both time consuming and difficult, especially for direct real estate investments, where capital requirements are extremely high, publicly available information is limited and the completion of each transaction often requires a lot of paperwork and the inclusion of several parties (Hoisager, 2022). This is, however, seen as one of the biggest attributes of the establishment of REITs, where publicly traded REITs fundamentally changes the liquidity aspect of real estate investments as they are listed on national security exchanges, like regular bonds and stocks (Chen J. , 2022), which mitigates some liquidity risk issues and enriches the accessibility for all sorts of investors. Although publicly traded REITs has improved liquidity for real estate investments, investments in REITs are still broadly considered to be less liquid than regular stocks and bonds, primarily due to the lack of a second market for buyers/sellers of properties, which results in liquidity being solely provided by the repurchase offers from the specific real estate trust fund (Corporate Finance Institute, 2023). Nevertheless, from *Figure 11* below – showing the development of average trading volume of REITs – the pattern shows a strong growth in volume, which is considered interrelated and a solid indicator of the liquidity level (Corporate Finance Institute, 2023), indicating a positive development in the liquidity level of REITs in recent years.

Figure 11 - Trading volume



Source: own illustration on data from Nareit database

The structure of REITs and its effect on liquidity

While Miller & Modigliani (1961) suggest that a firms payout policy shouldn't affect the value nor the price of an asset, the theory relies on one major prerequisite; perfect capital markets, which implies that the economy has no imperfections nor frictions. This assumption would likewise enable investors to, costless, sell securities to create self-made dividends from capital gains where liquidity issues arise. In practice, however, capital markets are not perfectly liquid, and trading could very well involve non-trivial frictions (DiBartolomeo, Gatchev, & Harrison, 2021). In accordance with the abovementioned, the market imperfections that unfolds could cause implications, particularly in a risk-management perspective, where the regulatory requirements of REITs and its dividend payout structure is likely to entail liquidity benefits to the investors.

From a conducted study of liquidity risk (DiBartolomeo, Gatchev, & Harrison, 2021), it is contended that the uniqueness of the payout structure of REITs reduces investor reliance on stock market in terms of meeting their short-term liquidity obligation/needs. To examine the liquidity risk of REITs, relying on the theoretical framework of Pástor and Stambaugh (2003) for measuring the return sensitivity to market-wide liquidity shocks, the study showed significant negative

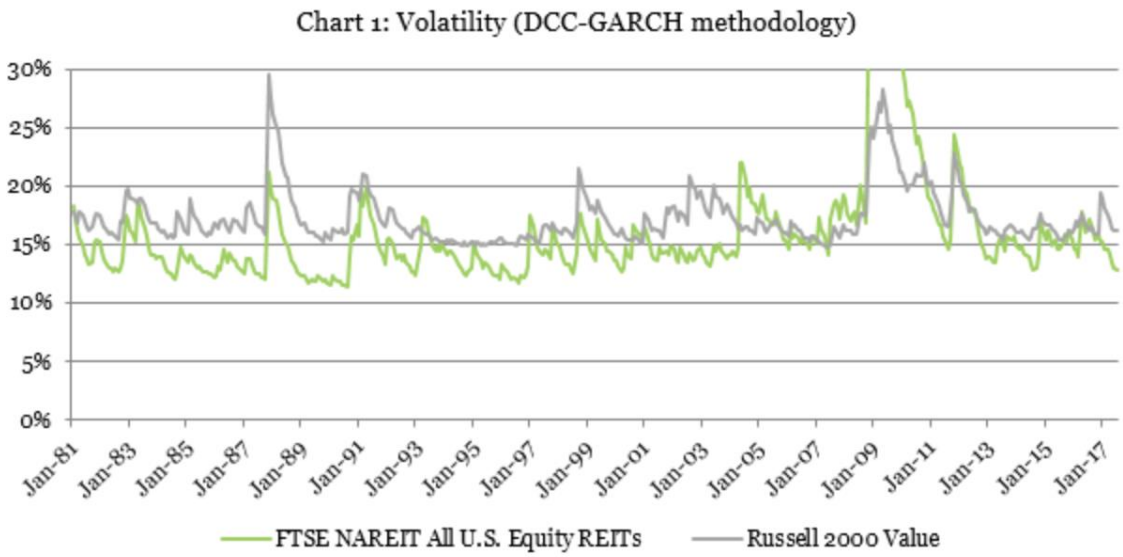
sensitivity of REITs, which implies that when market liquidity declines, the relative return of REITs would increase (DiBartolomeo, Gatchev, & Harrison, 2021). The findings of negative liquidity betas were found to be evident across different types of REITs, however, still showing more conspicuous results for specialized REITs, compared to more diversified REITs. The study moreover concludes that the findings showed great evidence and support towards the initial stated notion, which predicts that the dividend policy can mitigate liquidity risk, where REITs were found to have relative low liquidity risks, compared to the general market of non-REITs. Thus, implying that REITs investments serves as a hedge against liquidity risk, making REITs an attractive investment alternative, especially in periods of high market-wide liquidity risk (DiBartolomeo, Gatchev, & Harrison, 2021).

4.3.4.4. Volatility

Volatility is another important aspect when considering risks of an asset since it measures the fluctuations in prices of a given security over a specified period of time. There are countless of factors which affects the volatility of securities, including company size, liquidity, investors sentiment, general market conditions and even monetary policy changes etc. (Vaidya, n.d.). Volatility has generally shown to be more predominant for growth stocks when compared to value stocks, which is partly caused by company size and the return distribution, where growth stocks are expected to deliver substantial growth in sales and thereby future price appreciation, whereas value stocks typically have proven to generate profits and usually distributing returns partly through dividend payouts (Forbes, 2022). Dividend paying stocks tend to be less volatile than non-dividend paying stocks due to the steady cashflow to shareholders, which can be attractive to investors in times of uncertainty (Gallant, 2022). Volatility of REITs are no different in terms of the beforementioned factors, and the fact that REITs, through regulatory requirements, are forced to maintain a high dividend payout ratio should therefore decrease the general level of volatility for equity REITs. Moreover, given the fundamentals of REITs and the real estate market cycle, studies have shown that the performance of REITs are mostly comparable to the performance of low-cap value stocks (Nareit, 2016). *Figure 12* below illustrates the development of volatility for both equity REITs and the Russell 2000 index, containing small-cap value stocks, where REITs have been almost constantly below Russell 2000 in terms of volatility. The volatility has, however, been more

or less equal to U.S. Total Stock Market, with a 10-year average volatility of 16.63% for equity REITs, and 15.20% for the total stock market (Nareit Database, 2023).

Figure 12 - Volatility



Source: (Case, 2017)

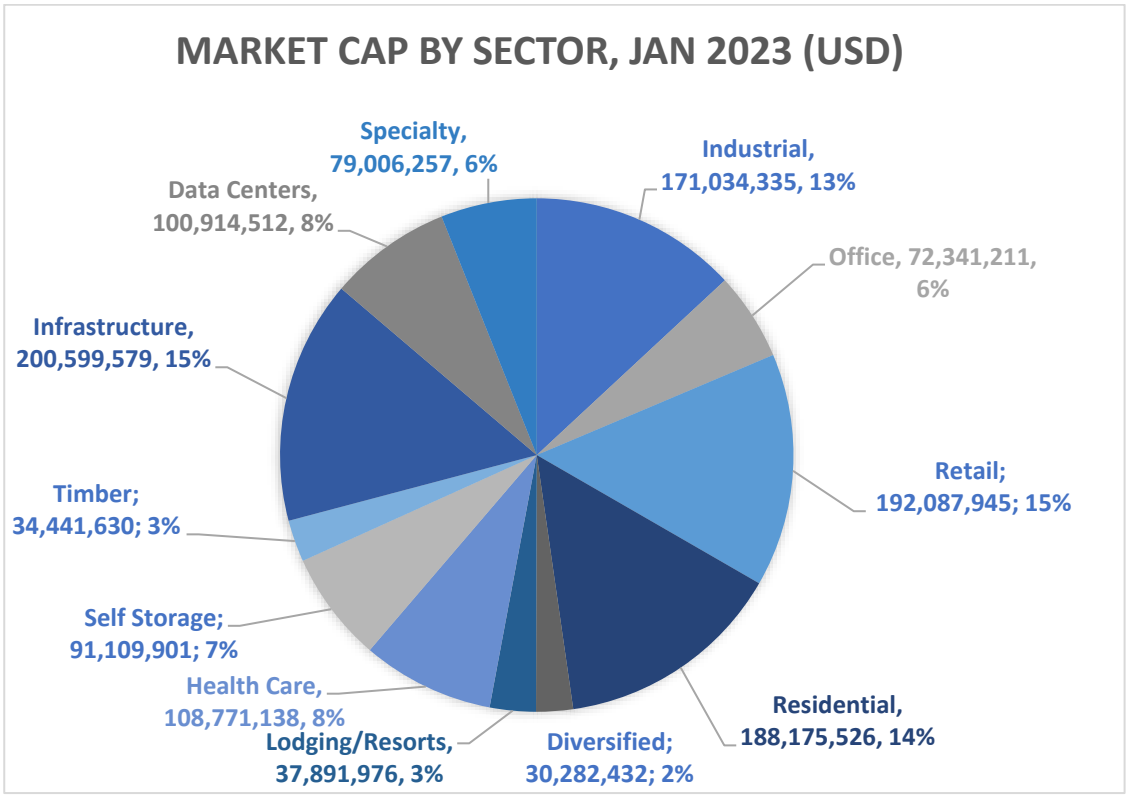
While *Figure 12* is showing the overall volatility for all equity REITs, data shows quite substantial variations in volatility across different sub-sectors, where some sub-sectors have been significantly more volatile in challenging and uncertain economic periods, for instance around the great recession (Qing & Orzano, 2020). The variations are mainly a result of the lease period for the underlying assets in each subsector, where sectors with properties containing shorter lease-periods – such as lodging/hotels, self-storage and residential buildings – are substantially less volatile than REITs specializing in longer-lease assets like malls, health care and industrial buildings (Qing & Orzano, 2020).

4.3.5. REIT types and sectors

The following section will constitute a thorough review of the different types and sub-sectors that exists within both mortgage and especially equity REITs. The section is structured to first present main characteristics and hard facts of each individual sub-sector that is found relevant to be included. Secondly, a more thorough comparative analysis of the performance and correlation

between the sub-sectors will follow, creating more clarity towards the macro-economic influence on the individual sectors, and how both volatility and performance differ in specific periods. The data that is presented and reflected upon in this section has been retrieved from Nareit Database, specifically from the latest published performance report of February (Nareit Database, 2023). According to Nareit, FTSE ALL REITs has a total market cap of $1,4 trillion as of ultimo January 2023, where FTSE All Equity REITs accounts for $1,3 trillion of the total market cap, or approximately 95%, showing substantially more value in equity REITs compared to Mortgage REITs, why the focus would be primarily on equity REITs and the underlying sectors. The total market cap of equity REITs are spread across a total number of 147 constituents between 13 different sub-sectors that consists of; Industrial, Office, Retail, Residential, Diversified, Lodging/Resorts, Health Care, Self-Storage, Timber, Infrastructure, Data Centers & Specialty. *Figure 13* below presents the distribution of both market cap and number of constituents for each of the beforementioned sub-sectors of equity REITs.

Figure 13 - Market cap by REIT sector



Source: Own illustration on data from Nareit database

To maintain the relevance of the later comparative analysis, the REIT sectors Diversified, Specialty and Timber will be excluded going forward. The REIT sector of Timber has been excluded due to its minimal influence and contribution to the overall market capitalization, whereas Diversified and Specialty has been excluded since they both consists of a mix of REITs from different sectors, thereby compromising the pure-play purpose of evaluating sub-sector specific performance and correlation.

4.3.5.1. Sectoral descriptions

In order to better comprehend the unique and individual features and characteristics of every REIT sector found relevant for the thesis, this section acts as a visually informational paragraph, lightening the absorption of the information presented. Below schemes encompasses a series of characteristics found particularly relevant for each sector. The information was gathered through Nareit research database (Nareit, n.d.).

Office

- *Market cap and number of constituents:* $72b, #19
- *Property types:* Office real estate ranging from local single facility offices to office parks and skyscrapers
- *Average lease term length:* Long-term, averaging 5-10 years
- *Tenants:* All types of companies seeking office space. Some office REITs specialize in types of tenants such as biotech firms
- *Tenant credentials:* amazon salesforce

Industrial

- *Market cap and number of constituents:* $171b, #12
- *Property types:* Industrial facilities such as warehouses, distribution centers and production facilities
- *Average lease term length:* Medium-term, averaging 3-5 years
- *Tenants: Companies operating within retailing, distribution and manufacturing*
- *Tenant credentials:* amazon Walmart The Home Depot

Retail

- *Market cap and number of constituents:* $192b, #33
- *Property types:* Retail real estate ranging from malls and shopping centers to stores in general
- *Sub-sectors:* Retail REITs is stratified in three sub-sectors: Shopping centers, Regional Malls and Free Standing
- *Average lease term length:* Long-term, averaging 7-10 years
- *Tenants:* Operators of retail stores, shopping centers etc.
- *Tenant credentials:* Whole Foods Market NORDSTROM

Lodging/Resort

- *Market cap and number of constituents:* $38b, #14
- *Property types:* Resorts and hotels
- *Business model:* Lodging/Resort REITs own and/or operate resorts and hotels, with some REITs having external operations
- *Average lease term length:* Short-term, day-to-day
- *Tenants:* Travelers in general looking for overnight/weekly stays
- *Operator credentials:* The Ritz-Carlton Hilton Marriott

Residential

- *Market cap and number of constituents:* $188b, #20
- *Property types:* Apartments, family homes, student housing, manufactured homes
- *Sub-sectors:* Residential REITs is stratified in three sub-sectors: Apartments, Manufactured, and Single-Family Homes
- *Average lease term length:* Short-term, averaging 6-12 months
- *Tenants:* Individuals and families

Healthcare

- *Market cap and number of constituents:* $109b, #15
- *Property types:* Hospitals, senior living facilities, medical offices and nursing facilities
- *Average lease term length:* Long-term, averaging 10-15 years +
- *Tenants:* Operators of abovementioned property types and facilities

Self Storage

- *Market cap and number of constituents:* $91b, #5
- *Property types:* Storage facilities, form single-room storage parks to larger storage spaces
- *Average lease term length:* Short-term, monthly
- *Tenants:* Both individuals and businesses in need of storage space

Infrastructure

- *Market cap and number of constituents:* $201b, #4
- *Property types:* Energy pipelines, wireless infrastructure, fiber cables, telecom towers
- *Average lease term length:* Medium-term, averaging 3-5 years
- *Tenants:* Wireless service providers, broadcasters and television companies
- *Tenant credentials:* T-Mobile, AT&T

Data Centers

- *Market cap and number of constituents:* $101b, #2
- *Property types:* Data centers
- *Average lease term length:* Medium-term, averaging 5 years
- *Tenants:* Companies looking to stare data such as tech-companies
- *Tenant credentials:* IBM, UBISOFT, AT&T

Mortgage

- *Market cap and number of constituents:* $58b, #34
- Unlike all the previous REIT sectors, mortgage REITs do not own, manage nor operate real estate directly, but instead invests in mortgages and mortgage-backed securities.
- Mortgage REITs provide financing for both residential and commercial mortgages, but typically specializes in one.

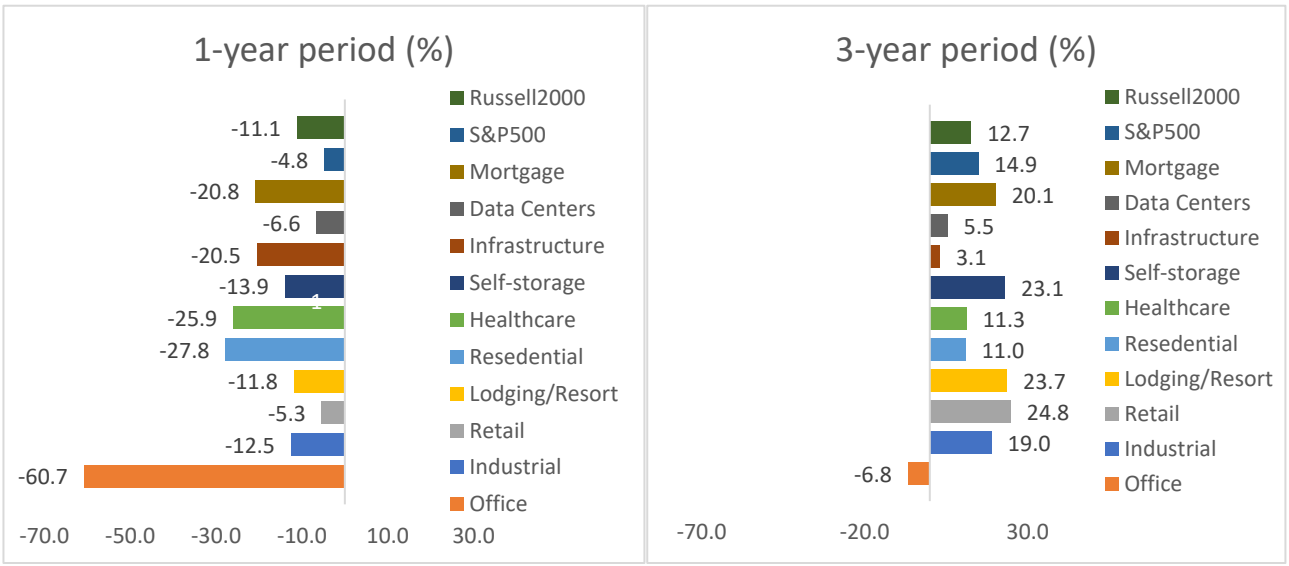
4.3.6. Sectoral comparative analysis

This section provides a comparative analysis of the selected REIT-sectors of interest, with a focus on how their performance differs throughout different economic periods. First, an overview of sectorial performance will be presented, highlighting the historical performance of different sectors as well as the factors that have influenced the performance. Secondly, the interrelations of the different sub-sectors will be analyzed, examining the correlation coefficients, and using multivariate regression to investigate the extent to which the different sub-sectors move together or have more divergent performances. Finally, we will delve into an analysis of the volatility of each sector, taking specific economic periods into consideration. This will involve a cause-of-effect analysis of the relationship between volatility and economic cycles, thereby identifying the key drivers of sectorial volatility. Overall, this section seeks to provide a comprehensive overview of the performance of different REIT sub-sectors, specifically by emphasizing the underlying drivers of performance throughout different periods.

4.3.6.1 Sectoral Performance

The performance of the selected REIT sub-sectors will be analyzed on behalf of monthly total return data, retrieved from Nareit (Nareit Database, 2023), focusing initially on a 1 and 3 -year trailing period illustrated in *Figure 14* below that reflects the average yearly return for each individual REIT sector. The indices of both S&P 500 and Russell 2000 has also been included in the illustration, creating the opportunity to compare the sectoral performance to the performance of the broader market. S&P 500 is included since it contains the largest listed companies in the US and is thereby often used as a proxy for the performance of the general market. Russell 2000, which contains small-cap value stocks, is included since it – as previously mentioned – has shown to be most comparable to REITs. The data clearly indicates a rough period across all REIT sectors on a 1-year period, which is not at all surprising considering the overall market condition the past year, also reflected in the returns of both S&P 500 and Russell 2000, with -4,8% and -11,1%, respectively. Fairly more positive is it when considering the yearly returns over a 3-year period, where all sectors besides for office REITs are showing positive returns. Quite substantial variations between the results of the individual sectors and the volatility for the observed period, which will be further analyzed in the subsequent section of *sectoral correlations*.

Figure 14 - Average yearly return



Source: Own illustration on data collected from Nareit database, Yahoo Finance and Bloomberg

Office as the biggest short-term loser

Despite the overall negative returns across the broader stock market, some REITs sectors have shown substantial losses that far exceeds the general pull-back. Most conspicuous is the office sector, with a negative return of -60,74%, more than double the loss of any other sector and far worse than both S&P 500 and Russell 2000. The office sector is moreover the only REIT sector that has provided a negative return over a 3-year period, with a result of -6,76% in average yearly return. The downward trend of the office sector performance has arguably begun as a result of the COVID-19 outbreak that kept workers at home, forcing companies to implement remote working strategies to keep the wheels turning. While the pandemic is behind us, a study, carried out by real estate security provider Kastle Systems, show that the office occupancy rates remain extremely low, averaging only 50,1% as of numbers from ultimo February 2022 (Weil, 2023). These numbers clearly indicates that the pandemic, at least when it comes to remote work, has led to persistent changes in the work processes that characterized the business-life prior to the crisis. Another aspect that is likely to have influenced the weak performance of office REITs, is that this sector is expected to have suffered significantly from the recent spikes in interest rates, since most of the debt has floating interest rates making office REITs relatively sensitive to cyclical changes (Weil, 2023).

Residential rollercoaster

The residential sector likewise shows a substantial loss on the 1-year period with a total return of -27,79%, which ranks residential second in terms of the poorest performing sector on the short-term basis. However, when considering the 3-year period, the total return of the residential sector is substantially more appealing, showing a yearly average return of 11%, despite a rough past year. The massive fluctuations that are observed for the residential sector is mainly caused by the initial economic boom after the COVID-19 crisis, resulting in a massive increase in demand for the private real estate sector, leading to rapidly increasing housing prices, followed by the challenging past year in the world economy with substantial rises in interest rates (Fidelity , 2022). Residential REITs are, however, normally not very impacted by rising interest rates as it is typically a sign of a strong economy that benefits the sector more. Research from S&P global concludes that interest rates as a single parameter is not the key driver for the performance, at least not over a medium – to long-term period, since it depends more on the underlying factors that drives the spike in interest rates (Orzano & Welling, 2017).

Retail stability despite ecommerce disruption

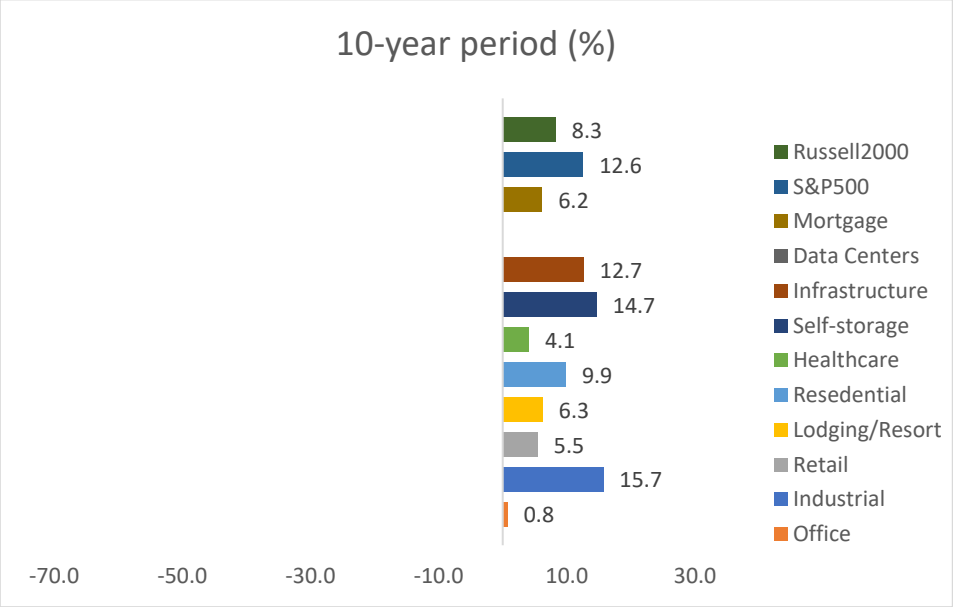
Figure 14 reflects a somewhat unexpected stability of the retail sector that has performed best – or less bad – than the remaining REIT sectors on the 1-year period with a negative return of -5,3%. However, still slightly worse than the S&P 500, but significantly better than the Russell 2000. Furthermore, the data shows that the retail sector have performed best of all on the 3-year period, indicating a relative strength and stability. While the general sector was believed to have suffered greatly from the continuous growth in ecommerce, specifically after the COVID-19 pandemic, the numbers clearly indicate otherwise. The reasoning is argued to be found within the fundamentals of most retail-contracts with relatively long lease-periods, in particular for the larger retail chains (DiLallo, Investing in Retail REITs , 2023). Another aspect that arguably affects the observed results for retail REITs, is the fact that some retail sectors are relatively immune to disruption from ecommerce, due to either the products they sell or the services that they provide. An analysis, carried out by S&P Global, suggests that retailers within areas of apparel, consumer electronics & furniture are likely to be most vulnerable to the growth of ecommerce, while

restaurants, some sort of grocery stores, and service oriented retailers are most likely to defy the disruption of the digital world and remain relevant (Lai & Skoufis, 2014).

The longer-term perspective

While the data presented in *Figure 14* have provided the opportunity to reflect and analyze upon the sectoral performance on a short-term basis, the following part will focus on the performance of the individual sectors over a 10-year period, illustrated in the data shown in F*igure 15* below.

Figure 15 - Average yearly return



Source: Own illustration on data collected from Nareit database, Yahoo Finance and Bloomberg

On the longer-term perspective, all REITs have generated a positive yearly return, however, continuously showing relatively large fluctuations among the different sectors, ranging all the way from 0,8% for the office sector and up to 15,7% provided from the industrial sector. The relatively low return from office is obviously massively influenced by the previously covered short-term losses, which has only just been offset on the 10-year period. In the other end of the scale, the sectors of infrastructure, self-storage and industrial are all showing strong returns, superior to both the Russell 2000 and S&P 500 index, with average annual returns of 12,7%, 14,7% and 15,7%, respectively. The industrial sector is argued to have benefitted – and likely to keep benefitting –

from the rise of ecommerce, accelerated by the COVID-19 pandemic, which have caused increased demand for warehouses and distribution centers (DiLallo, Investing in Industrial REITs , 2023). Another aspect that is argued to have created increased demand for industrial REITs is connected to the recent supply-chain issues, which have led the US to focus more on national manufacturing. Lastly, the fact that industrial REITs are known for its long-term lease contracts makes the argument, that the sector is supposed to provide more stability and being less cyclical affected than other sectors, which is supported in the relatively strong returns throughout all observed periods. These highlighted factors have also positively influenced the occupancy ratio, where the recent report from Nareit is showing an occupancy rate of 97,76% for the industrial REITs as of numbers for Q4 ended 2022 (Nareit Database, 2023).

Self-storage REITs are another one of them, which have shown significant strength on a medium- to long period. Nareit Data even shows that the self-storage sector has provided the largest return, especially risk adjusted return, when taking the whole period of REITs existence in account (Nareit Database, 2023). The sector is likely to have benefitted from the ever-increasing growth in both population and urbanization, where several factors including need for downsizing and temporary housing are argued to have influenced the relatively high demand. The COVID-19 pandemic is also argued to have influenced the self-storage sector positively, mainly due to people spending more time at home decluttering their living space. In addition, the REIT self-storage sector have shown to be relatively recession-resistant when compared to other sectors since these periods also tend to influence the need for downsizing, creating an increased demand for storage facilities in tough and burdened economic periods. An argument which is supported by the relatively strong returns that the sector has provided on a both short – and especially long-term period.

4.3.6.2 Sectoral correlations

To thoroughly analyze and present the intersectoral correlations within the REIT sectors described previously, *Figure 16* illustrates a correlation matrix of the REIT sectors of interest, as well as their correlation with the S&P500 and Russell 2000 indices. The matrix is built on monthly trailing data for total return as of March 31st, 2023, whereas the top right of the matrix represents a 3-year

trailing period and the bottom left represents a 10-year trailing period (Data Center REITs are excluded from the 10-year trailing period as they were established in the late 2015, with data starting from the 21st of December 2015). The matrix gives an overview of the intersectoral correlation coefficients, hence an expression of how the sectors respond to movements in the market. However, it should be noted, that even though all correlation coefficients presented are positive, and therefore is expected to be impacted negatively by an economic downturn and vice versa, correlation coefficients are not a direct expression of causality, hence idiosyncratic risk, extraordinary events and underlying market drivers can affect the market, industry and sector movements diversely.

Figure 16 - Correlation matrix

	Top right: trailing 3-year period											
	Equity REITs									Mortage REITs	Indecies	
	Office	Industrial	Retail	Lodging/Resort	Resedential	Healthcare	Self Storage	Infrastructure	Data Centers	Mortgage	S&P 500	Russell 2000
Office	**1,00**	0,58	0,84	0,76	0,84	0,82	0,33	0,49	0,43	0,78	0,72	0,75
Industrial	0,68	**1,00**	0,57	0,32	0,78	0,65	0,74	0,72	0,81	0,60	0,72	0,52
Retail	0,80	0,58	**1,00**	0,79	0,74	0,75	0,29	0,49	0,40	0,85	0,79	0,81
Lodging/Resort	0,75	0,44	0,74	**1,00**	0,57	0,65	0,26	0,29	0,13	0,71	0,65	0,77
Resedential	0,82	0,77	0,76	0,57	**1,00**	0,81	0,58	0,71	0,62	0,68	0,77	0,65
Healthcare	0,78	0,65	0,80	0,59	0,85	**1,00**	0,43	0,71	0,60	0,85	0,81	0,71
Self Storage	0,44	0,65	0,43	0,27	0,64	0,55	**1,00**	0,58	0,50	0,32	0,53	0,39
Infrastructure	0,45	0,60	0,38	0,23	0,54	0,56	0,48	**1,00**	0,76	0,55	0,67	0,45
Data Centers	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	**1,00**	0,52	0,65	0,44
Mortgage	0,74	0,52	0,83	0,72	0,69	0,77	0,31	0,37	n/a	**1,00**	0,85	0,88
S&P500	0,69	0,65	0,65	0,70	0,59	0,54	0,35	0,48	n/a	0,72	**1,00**	0,86
Russell 2000	0,71	0,53	0,66	0,80	0,55	0,50	0,26	0,23	n/a	0,76	0,87	**1,00**
	Bottom left: trailing 10-year period											

Source: Own illustration, data trailing from 31st of March 2023, data retrieved from Nareit database, data on indices retrieved from Yahoo Finance database

Generally speaking, the correlations are stronger on the short-term period of 3 trailing years than on the long-term period of 10. There can be a wide range of causalities causing this observation, including a change in relationships between the sectors, caused by, for an example, changing market conditions. Although the correlations in the different periods is not wide off each other and in most cases still provide the same conclusion, the differentiation is great enough to cause merit and food for thought. A factor that must be considered is the sample size of the calculations.

The correlation coefficients are calculated on monthly data for total return, only constituting 36 data points on the short-term, but constituting 120 data points for the long-term coefficients. Intuitively, when there are more data points for a longer period of time, there are more opportunities for the return of the sectors to deviate in their response to market conditions, creating merit for a naturally lower correlation coefficient. Stressing the argument, research shows that turbulent periods with significant events tend to increase correlations (Chesnay & Jondeau, 2001), while the short-term period of 3 trailing years have been a period of volatility and very significant macroeconomic events such as Covid-19 and a war in Ukraine, causing investors to react similarly across asset classes creating generally stronger correlation coefficients. The correlation coefficients of the long-term period must therefore be considered to provide the truest picture of the interdependent correlations, while the short-term coefficients offer an additional perspective in periods of volatile and changing macroeconomic conditions.

Commencing with the correlation coefficients of Office, Retail, Residential and Healthcare, they appear to be the strongest, both intersectoral and with the indices included. The strong correlations suggest that the sectors are responding similarly to macroeconomic changes and the development of the overall economy as they also strongly correlate with the indices, which can have a range of causalities. First, the sectors bear some similar traits, as they all constitute traditional property types that are an essential part of living, which makes them necessary and less susceptible for cyclical changes. Second, the sectors, with Residential being the exception, have long-term lease terms providing predictable cash-flows and stability, further diminishing their susceptibility of cyclical changes. Tapping further into the sectors' interdependencies, thought scenarios and economic developments such as job growth have a very obvious effect on Office REITs, but will also affect both Retail, Residential and Healthcare. If job growth were to increase strongly in a region, there would also be an increased demand of homes to house the growing workforce, the need of hospitals to take care of this workforce as well as a growing economy paving the way for stores, centers and malls in the region.

Analyzing the correlation coefficients of Mortgage REITs, they appear to be very strongly correlated to the indices, as well as the REIT sectors mentioned above with the traditional and

essential property types. A factor providing the greatest causality for this condition is interest rates. Mortgage REITs uses short-term funding to invest in long-term fixed rate mortgage-securities, hence when interest rates increase, short-term funding becomes more expensive diminishing mortgage REITs' net interest margins. As with mortgage REITs, broad indices will decrease once interest rates increase and vice versa, as funding and thereby also cost of borrowing will become more expensive. Looking at the mortgage correlation with the indices, it is apparent that the correlation is very strong on short-term with coefficients of 0,85 and 0,88 to S&P500 and Russell2000 respectively, while being a little weaker yet still strong long-term. Some of the explanation to this could simply be the difference of the interest rate environments. In a big portion of the long-term period, the interest rates have been unprecedently stable, causing little effect on mortgage REITs in the period, while the broader stock market have benefitted from other factors such as technological advancements and a thriving economy. Short-term, we have experienced hiking interest rates to combat inflation, which in turn have cemented the strong correlation between the mortgage REITs and the broader stock market.

Looking for the weakest correlations in the matrix, and thus the sectors with the best diversification perspectives, there are four sectors that stick out: Self Storage, Infrastructure, Lodging/Resort and Data Centers with average correlation coefficients in the matrix of 0,44, 0,43, 0,58 and 0,53 respectively on the long-term period (Data Centers on the short-term period). Commencing with Self Storage REITs, they generally have a weak positive correlation with the REITs with traditional property types as well as the indices, constituting a long-term correlation coefficient of 0,44 and 0,43 with Office and Retail REITs respectively, while constituting coefficients of 0,35 and 0,26 with the S&P500 and Russell 2000. Looking for similar traits in the other sectors with weak correlations, it is noticed, that none of the four sectors are deemed to have long-term lease terms, with Self Storage and Lodging/Resort having the shortest lease terms of all sectors, and with Infrastructure and Data Centers having medium-term lease terms. Although shorter lease terms are and should not be considered a linear relationship with weak correlation to the broader stock market, it does bear some merit. As shorter lease terms allow REITs to adjust rents in a more dynamic fashion, it naturally makes them less cyclical because of their ability to adjust rents on the basis of a wide range of factors such as recessions, interest rate

environments and such. To further stress the argument, and thereby increase the explanation degree of the sectors weak correlations, the four sectors have less traditional property types, whose use and purpose is deemed less cyclical, with Lodging/Resort being the exception. While the use of storage facilities, cell towers and data centers are not deemed to be affected gravely by neither recessions or economic booms, leisure traveling and tourism is highly affected by the overall state of the economy, providing a good explanation as to why Lodging/Resort is moderately strong correlated with the indices, and weak correlated to the rest of the three sectors with generally weak correlations.

5. Inflation

In order to fulfill the research objectives of this thesis, it is essential to grasp the importance of macroeconomic dynamics and their impact on the broader economy, the public securities markets, and the real estate industry. While numerous macroeconomic factors significantly influence the overall economy, this study focuses specifically on those factors directly relevant to the scope and purpose of the research. Although factors such as unemployment rate, job growth, and demographics play vital roles in shaping both the economy and the real estate industry, this study does not delve into detailed analysis of such. Instead, this section provides an in-depth understanding and analysis of inflation, exploring the effects on the economy with particular emphasis on REITs and the real estate sector.

Commencing with the very definition, Shapiro, MacDonald & Greenlaw (2022) defines inflation as "…a general and ongoing rise in the level of prices in an entire economy." (Shapiro, MacDonald, & Greenlaw, 2022, p. 220). When interpreting the definition, there should be a significant focus on "general and ongoing", as there may occur price rises in an economy in certain industries and for certain products, but it might as well be related to a shift in supply and demand, where some products increase in price while others decrease. Inflation, however, should be seen as the indication of an economy in which there is a broad and general pressure for prices to rise across products and industries, eroding the purchase power of one unit of currency.

While refraining from an extensive exploration of historical causes and factors of inflation, it is essential to acknowledge that understanding the historical and general causes of inflation can enhance our comprehension of its implications on the economy and the public securities markets. Thus, inflation can be attributed to numerous factors and manifests in various forms such as demand-pull- and cost-push inflation (Shapiro, MacDonald, & Greenlaw, 2022). Demand-pull inflation occurs when the overall demand surpasses the overall available supply, creating excess demand and thus competition between consumers for limited goods, effectively pushing prices upwards. The circumstance can be caused by a multitude of factors such as increased consumer spending, governmental spending and expansionary monetary policies, general growth or even demographic factors such as population growth. Cost-push inflation, on the other hand, occurs when costs such as wages, energy, and raw material expenses rise, forcing businesses and suppliers to pass on the extra production costs to the consumer by increasing the price of their goods and services. Furthermore, in addition to pull-demand and cost-push, inflation can be caused by excessive growth in money supply as most frequently seen in developing countries such as Zimbabwe in 2008, while external shocks can initiate inflation globally (Shapiro, MacDonald, & Greenlaw, 2022). External shocks can, as most previously seen by Russia's invasion of Ukraine in 2022, cause supply disruptions, rises in commodity prices as well as exchange rate fluctuations. With Russia's invasion of Ukraine, key global supply chains were disrupted with commodity-, and in particular energy prices, rising rapidly causing inflation worldwide.

5.1. Consumer Price Index

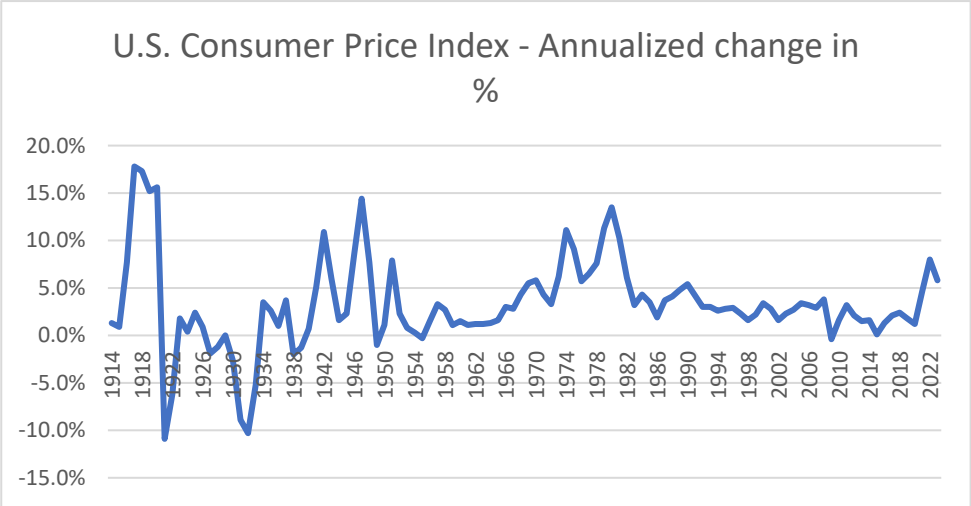
In order to track, discuss and analyze the historical cycles and movements of inflation, an index and proxy for inflation must be chosen. Thus, we have chosen the Consumer Price Index ("CPI") as our measure for tracking inflation as it is widely utilized and commonly acknowledged as one of the most precise measures of inflation (U.S. Bureau of Labor Statistics, n.d.). The Consumer Price Index tracks family expenditure by tracking the cost of a "basket of goods", making the index an expression of a general development in prices. The basket of goods consists of eight, weighted major categories, designed after a normal family's general expenditures. The categories stretch from housing, food & beverages, and transportation, to medical care, education, and apparel. The index is calculated on the prices of 80.000 specific products grouped into the eight major

categories, which are weighted differently in the index, with housing, food & beverages, as well as transportation, with the largest weights of 42%, 15% and 15% respectively.

5.2. Historical inflation

Examining the historical development of inflation, *Figure 17* below provide a clear indication of a volatile inflationary environment, with the figure depicturing the annual change in prices denominated in %. Commencing with the long-term perspective, the first two inflation surges in the examined period, stretching back to 1914, is self-explanatory in a historical context, as they are right after the start of the world wars which severely disrupted the supply chains and the overall supply and access to common products (Shapiro, MacDonald, & Greenlaw, 2022). Evident in the figure, the inflation peaks in 1918 with an inflation rate of 17,3%, followed by two periods of severe deflation following the deep recession in 1921 and the great depression in the early 1930's. Fast forward to the 1970's and 1980's, periods of high inflation is once again observed following oil price shocks as well as expansionary monetary policies (Shapiro, MacDonald, & Greenlaw, 2022). However, what makes for interesting reading in particular for this study, is the period following the inflation of the early 1980's, as there is observed a relatively stable level of inflation up until 2021, with the peak inflation of the period amounting to 5,4% in 1990, and a small deflationary period being observed following the great recession. What makes for interesting reading, is the fact that we are observing significant inflation in 2021 and 2022 for the first time since the start 1980's following the Covid-19 pandemic and Russia's invasion of Ukraine, entering a period of inflation with no recent data for comparisons, as well as an apparent lack of investor experience when it comes to tackling the topic of surging inflation (Neville, Draaisma, Funnell, Harvey, & Van Hemert, 2021).

Figure 17 – historical CPI change in %



Source: (Federal Reserve Bank, n.d.)

5.3. Inflation effect on asset classes

When analyzing how inflation is expected to affect various asset classes in theory, it is essential to acknowledge the uncertainty surrounding these relationships, as the assets in any given time-series analysis with inflation will simultaneously be affected by a wide array of outside factors. The prevailing common belief suggests that in the presence of inflation, fixed-income securities such as bonds typically decline in value with their fixed yield becoming less valuable in real terms. Conversely, stocks, foreign currencies, commodities, and real estate are thought to maintain their worth in real terms; stocks represent ownership stakes in tangible assets and is expected to pass on higher input costs to consumers; foreign currencies tend to appreciate when domestic prices escalate; commodities and real estate prices are integral components of overall inflation and the CPI itself, exerting their own influence on inflationary trends.

When planning for, and protecting against, inflation, Chen, Roll, & Ross (1986) states that investors might be willing to compromise on their asset return, given that their holdings provide some inflation protection. However, as demonstrated by Fang, Liu, & Roussanov (2022), recent research suggests that empirical evidence of this very “risk premium” have been elusive, questioning the actual effect inflation has on the various asset classes. In the study conducted by

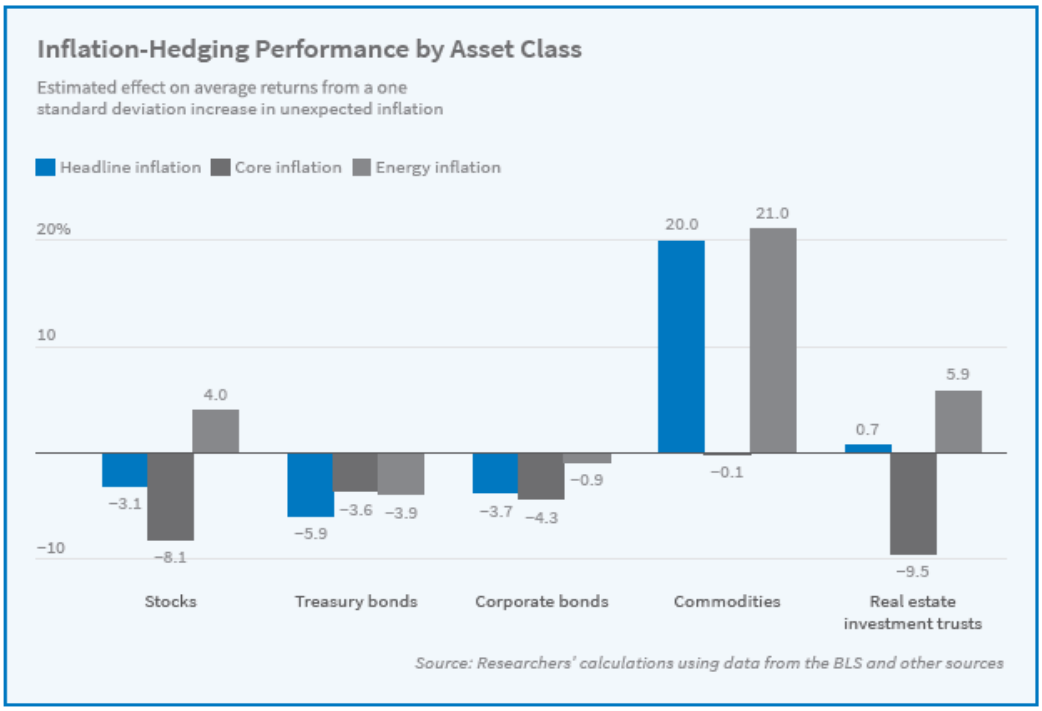
Fang, Liu, & Roussanov (2022), the authors challenge the common belief of inflations' effect on various asset classes by segregating inflation into three categories: headline-, core-, and energy inflation, with headline inflation including all price rises as measured by the CPI, core inflation having excluded energy and food prices, and lastly energy inflation only measuring the price rises of energy. By segregating inflation into categories, the study succeeds in shedding new light on the problematizations of inflation, as each inflation category affects each asset class differently. The study conclusion can be summarized by *Figure 18* below, which displays the estimated effect on average return on each asset class, when you increase the standard deviation of inflation with one, exemplifying an unexpected rise in inflation.

The results provide a thorough and nuanced picture of how each inflation category is expected to affect each asset class, with the inflation categories differentiating in their effects. Commencing with the bonds, namely the treasury- and corporate bonds in this study, it is evident that all three inflation categories affect the bonds negatively, as expected and in line with common belief. Where the conclusion become really interesting, and contradict some of the common beliefs, is when we analyze the findings related to stocks and REITs. While increasing the standard deviation of energy inflation in the research yields an estimated increase in average returns for stocks, commodities and REITs, core inflation does the exact opposite for stocks and REITs. Inspecting the graph for REITs, it is evident that an increased average return of 5,9% is expected for energy inflation, while core inflation provides the opposite estimation of a decrease of -9,5%, dragging the headline inflation down to a 0,7% increase. The same trend is observed for stocks.

Thus, concluding on how inflation is expected to affect the various asset classes in scope, there seems to be a discrepancy between common belief and what recent study suggests. Utilizing the findings of Fang, Liu, & Roussanov (2022), inflations' effect on bonds remains in line with the expectations, as all three inflation categories is estimated to decrease the average return of the bonds. Focusing on the effect on stocks, only an increase in energy inflation is estimated to increase the average return of stocks, with both core- and headline inflation estimated to decrease the average return. A similar effect is observed on REITs, as energy inflation is estimated to increase the average return, core inflation is estimated to decrease average return and headline

inflation is estimated to insignificantly increase average return. Lastly, the average return of commodities is estimated to increase drastically with an increase in both headline- and energy inflation, while core inflation is estimated to have no significant effect. In short, stocks, commodities, and REITs evidently have energy inflation hedge attributes, while commodities appear to be the only asset class with headline inflation hedge attributes. Further, no asset class in the research seems to offer core inflation hedge opportunities.

Figure 18 - Inflation effect on various asset classes



Source: Fang, Liu, & Roussanov (2022)

6. REIT portfolio performance

In this chapter, Markowitz' Modern Portfolio Theory (MPT) model – also called the Mean-Variance Optimization model – will be used as the framework for processing and evaluating historical monthly returns from a selectively chosen group of assets, where an optimal portfolio is constructed on behalf of historical data in the period from 2007-2019. The intention with the portfolio optimization is to conclude whether REITs have added additional performance to a traditional portfolio of stocks, bonds and commodities. The results will be based on the potential allocation towards REITs in the optional portfolio composition. The optimal portfolio construction

will be conducted from three different investor perspectives, each with individual constrains which reflects different types of investors with different investment strategies, focusing mainly on differences in timeframe and risk tolerance. Furthermore, an out-of-sample test will be conducted on historical data from the period 01.01.2020-01.05.2023, with the purpose of testing how well the previously constructed portfolio would have performed on a period that has been excluded from the initial data foundation.

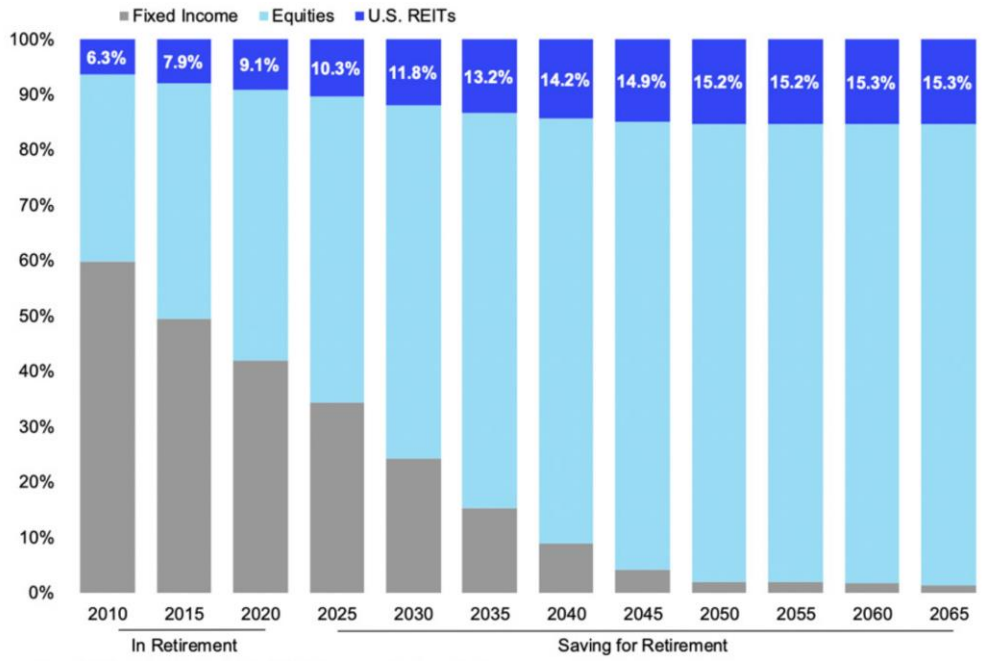
6.1. Investor perspectives

As commonly acknowledged, different investors have different approaches to risk. Even though it is assumed that every investor is risk averse, some will seek a riskier portfolio than others, given they are somewhat compensated with a higher expected return. Therefore, no optimal portfolio in general will be the optimal portfolio for all investors. Although it is mathematically feasible to calculate an optimal portfolio in general by constructing the portfolio with the highest Sharpe ratio on historical return data, it is not practically feasible to assume that all types of investors will choose this very portfolio, even though every other portfolio construction will not be optimal measured by their Sharpe ratio. In this thesis, we will approach an optimal portfolio through different investor perspectives with different levels of risk aversion. In order to determine which perspectives this thesis will be focusing on; it is evident that there are a million different investor perspectives to choose from and that they are dynamic and ever-changing. To create somewhat of a framework to group these perspectives into three general pools, retirement maturity will be utilized as a proxy for how different age brackets in general allocates their mixed asset portfolios to fixed income assets and equities. The three general investor groups will then in the portfolio optimization be characterized by constraints of allocation to bonds, which in general practices acts as a risk mitigation tool because of their low volatility (Puhle, 2008), allowing us to form three general investor groups with different levels of risk aversion.

Below *Figure 19* originates from a study performed by Wilshire Funds Management in 2020 which was commissioned by NAREIT. Although there are reservations regarding bias towards allocation to REITs in the figure as the study was commissioned by NAREIT, the figure will be used solely for the purpose of setting up constraints of allocation to bonds in order to group investor

perspectives. As depicted by the figure, the closer you are to retirement, the higher an allocation to fixed income assets is generally expected and vice versa. Grouping the investor perspectives into general pools, it is assessed to be adequate to create a group with the highest allocation to fixed income depicted in the figure, a group with the lowest allocation to fixed income as well as one in between. Thus, the three groups of investor perspectives used in this analysis will be named and constrained in the portfolio optimization as follows; *Conservative*: min. 60% allocation to bonds, *Average:* min. 5% and max. 15% allocation to bonds, *Aggressive:* max. 2% allocation to bonds.

Figure 19 - asset allocation vs. retirement maturity



Source: Wilshire Funds Management (2020)

6.2. Data selection & collection

6.2.1. Timeframe and data collection

The MVO model requires a substantial amount of data since the calculations of expected portfolio return, std. deviation and Sharpe ratio are all based on historical returns for each of the included assets, described in section 5.2.2 below. Yahoo Finance has been used as the primary source for the data collection, with Capital IQ and Nareit as secondary sources. An overview of the assets

including the source for the data is shown in *Table 3* in the upcoming section. The data has been collected for the period ultimo April 2007 to ultimo April 2023, which is afterwards split into 2 separate data samples, where the first period is used to construct the optimal portfolio, and the second is used as the 'test sample'. The timeframe of 01.05.2007-31.12.2019 is utilized as the in-sample dataset, while the timeframe of 01.01.2020-01.05.2023 is utilized for the out-of-sample test. The relatively long timeframe has been preferred for this thesis, since it allows the construction of the optimal portfolio composition to include historical performance over a longer period, including both the great recession, as well as periods with economic recovery, which is argued to provide a better data foundation for the construction of a long-term optimal portfolio composition. The reason for the period to start from ultimo April 2007, and not from the beginning of the year, is entirely due to the fact that data from the Ishares Iboxx High Yield Corporate Bond ETF (HYG) was not available prior to this date.

6.2.2. Asset composition

The following section displays the selected assets that was found relevant to be included in the empirical analysis, showcasing the thoughts and reasoning behind the choices of each included asset. All assets have selectively been added to the portfolio composition, with the intention of creating a solid foundation for the portfolio optimization, that considers a broad range of asset types and classes. However, it is important to notice, that this selection process will introduce some sort of selection bias, which might affect the results obtained in the empirical analysis. The selection bias is acknowledged to become a factor as the inclusion/exclusion of the different assets/asset types is based on subjective assumptions on how a highly diverse mix of asset classes is best represented. The included assets are shown in *Table 3* below and consist mostly of various indices across all major asset types within a traditional investment portfolio. To minimize the selection bias, and to create the best prerequisites for a diversified portfolio, we have chosen to exclude individual stocks from the portfolio, which instead are broadly represented within the inclusion of the different equity stock indices.

Table 3 - Asset Composition

Asset	Ticker	Type	Source
Ishares MBS ETF	*MBB*	*Bond*	*Yahoo! Finance*
Ishares iBoxx High Yield Corporate Bond ETF	*HYG*	*Bond*	*Yahoo! Finance*
Ishares 20+ Year Treasury Bond ETF	*TLT*	*Bond*	*Yahoo! Finance*
FTSE Nareit ALL REITs	*FNAR*	*REIT Index*	*NAREIT*
S&P 500	*SPX*	*Equity index*	*Yahoo! Finance*
Russell 2000	*RUT*	*Equity index*	*Yahoo! Finance*
Silver	*COMEX^SI*	*Commodity*	*Capital IQ*
Gold	*COMEX^GC*	*Commodity*	*Capital IQ*
Vanguard Real Estate Index Fund	*VNQ*	*Real Estate index*	*Yahoo! Finance*
Nasdaq 100	*NDX*	*Equity index*	*Yahoo! Finance*

To represent the 'fixed income' contribution to the asset composition, three different ETF's have been included to the portfolio. Each ETF reflects the returns of different types of U.S. Bonds, where ticker 'MBB' is reflecting the results of mortgage bond returns, 'HYG' is included to reflect high-yield corporate bond performance – also called "junk bonds" – with higher risks and usually higher potential returns, and lastly, 'TLT' that follows the U.S. 20+ year treasury bonds, which is added as the "safe haven" investment choice. Mortgage bonds are a type of debt security backed by the mortgage loans of homeowners, which are generally considered to be less risky than other types of bonds, since they are backed by tangible assets (Johnson, 2023). The treasury bonds are backed by the full faith and credit of the U.S. government, making them virtually risk-free.

The Russell 2000, S&P 500 and Nasdaq 100 has been included as the representation of the broader stock market. Each index tracks the performance of different company types in the U.S. and is assumed to collectively represent a diversified mix of stocks in various sectors. The S&P 500 tracks the 500 largest listed companies in the U.S., the Russell 2000 tracks the performance of 2000 small-cap companies and Nasdaq 100 tracks the performance of the 100-largest non-financial companies in the U.S. and is included since it is widely used as a benchmark for the performance of tech - and growth companies. Silver and Gold have been included to represent commodities in the portfolio composition. Both Silver, and especially Gold, are usually considered to be a store of value and are widely seen and used as a hedge against inflation. Also, the fact that both Gold and Silver have a relatively low correlation to the other assets enables some potential diversification attributes.

To represent and reflect the performance of the real estate sector, both Nareit ALL Equity REITs (FNAR) and Vanguard Real Estate Index Fund (VNQ) has been found relevant to include. VNQ mostly consist of REIT's, which makes the performance of VNQ largely comparable to the performance of REITs, however, still including other real estate investment types. The reasoning behind adding both VNQ and REITs is to test where investors would be better off placing their investments in case the optimal portfolio construction suggest any form of distribution towards any of the two real estate indices. It is important to notice that an investor would already be somewhat exposed to the real estate market through investments in broader indices, such as the S&P 500. Data from Nareit (Barwick, 2019) shows that REITs weight in the S&P 500 index amounts to approximately 3% in 2019. Therefore, any allocation towards S&P 500 would create some sort of exposure towards the real estate market, even without any allocation directly to FNAR and VNQ.

6.2.3. Data distribution

As described previously, when optimizing a portfolio with the Mean-Variance Optimization model, it is a prerequisite that the dataset is approximately normally distributed. However, the very lack of complete normal distribution of return data in general is one the biggest points of critique of Markowitz' work as described previously, why it must in advance be considered very unlikely that the total return data of all and every included asset is completely normally distributed. The term "approximately normally distributed" is up for interpretation, and it greatly depends on the level of significance you utilize in your statistical and/or financial model. In this section, it is deemed adequate to inspect the distribution of the return data graphically in order to check for normality, as well as discussing key metrics such as skewness and kurtosis. To make the return data as normally distributed as possible, the portfolio optimization will be performed on the natural logarithm of every data point, linearizing percentage changes and thereby stabilizing the variance, making the datasets more normally distributed.

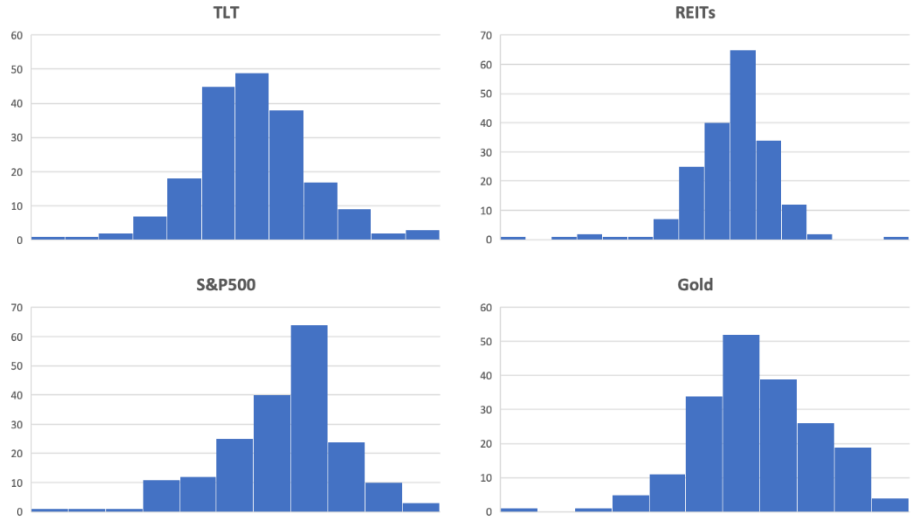
To test the data for normal distribution, the entire analysis period of 01.05.2007-01.05.2023 have been utilized to calculate key metrics for every asset on the natural logarithm of their monthly total return. Furthermore, as seen below, there have been created four histograms with a

representative from each asset type, including TLT representing bonds, REITs representing real estate, S&P500 representing equity indices as well as gold representing commodities.

Table 4 – Key metrics

Asset	Ticker	# of data points	Minimum	Maximum	Mean	Median	Std. Deviation	Kurtosis	Skewness
iShares MBS ETF (MBB)	MBB	192	-5,2%	4,3%	0,20%	0,15%	1,2%	4,62	- 0,42
iSHares iBoxx $ High Yield Corporate Bond ETF	HYG	192	-17,2%	11,0%	-0,46%	-0,50%	3,2%	7,02	- 0,52
iShares 20-year bond ETF (TLT)	TLT	192	-15,4%	11,7%	0,17%	0,22%	4,0%	1,27	- 0,08
FTSE Nareit All REITs	^FNAR	192	-36,0%	24,7%	0,38%	0,84%	6,6%	6,81	- 1,40
S&P500	SPX	192	-18,4%	12,1%	0,70%	1,41%	4,7%	1,33	- 0,77
Russell 2000	^RUT	192	-24,7%	16,8%	0,41%	1,47%	6,1%	2,01	- 0,77
Silver	COMEX^SI	192	-22,3%	25,7%	0,27%	0,08%	7,3%	0,75	0,07
Gold	COMEX^GC	192	-21,1%	13,0%	0,51%	0,08%	5,1%	1,17	- 0,33
Vanguard Real Estate ETF	VNQ	192	-36,9%	28,7%	0,38%	1,23%	7,0%	6,18	- 1,11
Nasdaq 100	NDX	192	-17,8%	14,1%	1,02%	1,83%	5,5%	0,67	- 0,62

Figure 20 - Histograms



Commencing with the histograms, it is apparent that all four exhibit slightly longer tails than expected for a perfect normal distribution, suggesting the presence of some outliers or extreme values. Additionally, all histograms display a slight left-skewness, indicating a concentration of observations towards the right side. However, the departure from symmetry is not significant, and the overall distributions align reasonably well with the characteristics of a normal distribution, resembling the bell curve. Turning to the key metrics of kurtosis and skewness provided in *Table 4* it is evident that all assets, except silver, exhibit negative skewness values, suggesting a slight left skewness in return distribution. Notably, silver demonstrates a skewness of 0,08, indicating almost perfect symmetry in its returns. Among the assets, REITs display the largest negative skewness of -1,40, implying a relatively stronger concentration of returns towards the right side of the

distribution. However, the negative skewness values for all assets are relatively small, indicating that the departure from symmetry is not substantial. Analyzing kurtosis, a kurtosis of 3,0 resembles a perfect mesokurtic distribution, while values below and above 3,0 resembles a platykurtic and leptokurtic distribution respectively (Hayes, 2021). Observing the kurtosis values provided in *Table 4*, it is evident that the datasets vary in terms of being relatively platykurtic or leptokurtic, while none of the assets exhibit a perfect mesokurtic distribution, which aligns with the expected behavior of financial return data. Notably, assets such as MBB, HYG, REITs and VNQ demonstrate excess positive kurtosis, with values above 3,0 indicating a slight leptokurtic distribution with fatter tails and a flatter structure relatively to a mesokurtic distribution. Conversely, assets such as TLT, S&P500, Russell 2000, Silver, Gold and NDX exhibit excess negative kurtosis, with values below 3,0 suggesting a relatively platykurtic distribution with lighter tails and a steeper structure relatively to a mesokurtic distribution.

While the assets vary in terms of the degree of excess positive and negative kurtosis, it is argued that all assets are within a reasonable range of a normal distribution when combined with their skewness levels, which show that the return of all assets are adequately symmetrical. Thus, it is both argued and assumed, that the return data of all included assets in the model is "approximately normally distributed", fulfilling the prerequisite of performing the portfolio optimization using the MVO-model.

6.2.4. Risk-free rate

In order to determine the risk-free rate used in the modelling in this thesis, the 10-year US treasury note is commonly used in financial modelling (Corporate Finance Institute, 2023). With the perspective of this thesis being US REITs and US investors, and with the US treasury being one of the most creditworthy security issuers in the world with basically no risk of default, the 10-year treasury note is the natural selection of a proxy for the risk-free rate in this thesis. In order to estimate the risk-free rate, it is recognized that the modelling is done on data for a rather long period of time where the rate of the treasury note have changed significantly throughout the analyzed period, thus it is assessed that the current rate of the note is not a sufficient expression of the risk-free rate for computation. Instead, monthly historical data of the rate in the entire

analysis period of 01.05.2007-01.05.2023 have been retrieved from Yahoo Finance, where an average rate of the entire period have been calculated. Hence, the risk-free rate that will be used for computation in this thesis is 2,54%.

6.3. Portfolio optimization

The optimal portfolio is constructed using Excel, where the Solver function has been used to maximize the Sharpe Ratio by allowing changes in the variable parameters, being the weights of each individual asset in the portfolio. *Table 5* below illustrates the optimal portfolio constructed for the analyzed period. As mentioned, three additional portfolios – each with their previously mentioned constraints – has been constructed, with the intention of considering different investment strategies and their associated level of risk-tolerance. The three additional and different investor perspectives are intended to contribute to a comprehensive analysis and discussion of the results gathered from the MVO model. Furthermore, an equally weighted portfolio has been included as the fourth and final alternative, mainly for comparison purposes, and since such portfolios are often used as a benchmark for evaluating actively managed portfolios, which should significantly outperform this easy and quick-to-implement alternative. The inclusion of these additional portfolios will be included after a breakdown of the initially constructed and unconstrained portfolio. In addition, the results from the "in-sample" dataset, which constitute the data foundation for the optimal portfolio composition, is sought to be stress tested for the prediction accuracy of the model, as well as showcasing how market conditions affect the optimal portfolio composition for all investor perspectives included in the analysis.

Table 5 – Optimal portfolio

Asset	Optimal portfolio
Ishares MBS ETF (MBB)	63,93%
Ishares iBoxx High Yield Corporate Bond ETF (HYG)	0,00%
Ishares 20+ Year Treasury Bond ETF (TLT)	9,34%
FTSE Nareit ALL REITs (FNAR)	0,00%
S&P 500 (SPX)	0,00%
Russell 2000 (RUT)	0,00%
Silver (COMEX^SI)	0,00%
Gold (COMEC^GC)	1,54%
Vanguard Real Estate Index Fund (VNQ)	0,00%
Nasdaq 100 (NDX)	25,19%
Sum of Weights (%)	100,00%
Expected Portfolio Return, Monthly (%)	0,49%
Portfolio Std. Deviation, Monthly (%)	1,39%
Sharpe Ratio	**0,199807**
Expected Portfolio Return, Anually (%)	6,02%
Portfolio Std. Deviation, Anually (%)	4,80%
Sharpe Ratio	**0,725508**

Commencing with the optimal portfolio, highlighted with the light-green background, the portfolio indicates a strong overweight in the Mortgage Bond ETF (MBB) with a 63,93% in the optimal allocation. The computations furthermore indicate a following 25,19% allocated towards the Nasdaq 100 index (NDX), 9,34% allocated in the Ishares 20+ Year Treasury Bond ETF (TLT), and lastly, 1,54% allocated in Gold. The abovementioned portfolio-composition has historically provided an average monthly return of 0,49% with a relative monthly portfolio std. deviation of 1,39%, resulting in a Sharpe Ratio of 0,199807. These monthly results have been annualized to better evaluate on the performance, where the optimal portfolio provides a yearly average return of 6,02%, a standard deviation of 4,80% and thereby a Sharpe Ratio of 0,725508. The most noticeable mention is the relatively low portfolio specific standard deviation, which must be recognized as the primary reason to why this conservative portfolio is performing the best relative to the associated risk. The low standard deviation is somewhat expected since the portfolio composition solely consists of indices instead of including individual stocks. Furthermore, the fact that approximately 73% is collectively allocated towards bonds suggest a fairly conservative portfolio, where the low standard deviation - relative to the expected return - is the main driver for the optimal construction. It is obviously also noted that the optimal portfolio does not suggest any allocation towards REITs, which initially indicates that the inclusion of REITs to a traditional

portfolio would not have added any additional performance, at least when considering the impact of selection bias, specifically related to the assets that is chosen to be included in the analysis, as well as the time period chosen.

With the purpose of analyzing the performance and attribution of each asset, *Table 6* below is created, showcasing a selection of calculated performance metrics for all assets, including their own individual Sharpe- and Sortino Ratio. The Sortino Ratio is predominantly similar to the Sharpe Ratio on the fundamental level, since both are financial ratios that are used to evaluate the risk-adjusted performance of either an individual asset – as shown in the table below – or a portfolio as it whole. Where the Sharpe Ratio measure the excess return per unit of risk taken, The Sortino Ratio focuses solely on the downside risk, meaning that the standard deviation is calculated only for the returns below the risk-free rate. Thus, the Sortino Ratio can be a useful measurement for investors who are more concerned with the downside risk of an investment or a portfolio. For instance, investors who are nearing retirement would arguably be more interested in preserving their capital, or at least being more conservative in terms of their risk-tolerance, than generating high returns.

Table 6 – Key metrics

Asset	Ticker	# of data points	Minimum	Maximum	Mean	Median	Std. Deviation	Sharpe Ratio	Sortino Ratio
iShares MBS ETF (MBB)	MBB	152	-3,3%	4,3%	0,30%	0,21%	0,9%	0,0928	0,14367
iSHares iBoxx $ High Yield Corporate Bond ETF	HYG	152	-17,2%	11,0%	-0,55%	-0,58%	3,2%	-0,2347	-0,29600
iShares 20-year bond ETF (TLT)	TLT	152	-15,4%	11,7%	0,39%	0,27%	3,9%	0,0466	0,07306
FTSE Nareit All REITs	^FNAR	152	-36,0%	24,7%	0,48%	0,84%	6,6%	0,0412	0,04252
S&P500	SPX	152	-18,4%	10,4%	0,69%	1,39%	4,3%	0,1111	0,13184
Russell 2000	^RUT	152	-23,5%	14,3%	0,47%	1,53%	5,7%	0,0457	0,05768
Silver	COMEX^SI	152	-22,3%	17,3%	0,09%	-0,70%	7,0%	-0,0167	-0,02730
Gold	COMEX^GC	152	-21,1%	13,0%	0,44%	0,08%	5,1%	0,0576	0,06260
Vanguard Real Estate ETF	VNQ	152	-36,9%	28,7%	0,38%	0,08%	5,3%	0,0236	0,02577
Nasdaq 100	NDX	152	-17,8%	12,3%	1,01%	1,85%	5,1%	0,1569	0,19931

From *Table 6* above, it appears that NDX have the highest individual Sharpe and Sortino ratio, indicating the highest risk-adjusted return. While the performance of MBB is highly driven by the low standard deviation, the risk-adjusted return of NDX is to a greater extent affected by the relatively high monthly mean return of 1,01%, which is significantly higher than the mean return of the other included assets. MBB is showing a strong stability compared to the rest of the assets, which obviously results in the significantly lowest standard deviation, making it attractive to be included in the portfolio for risk-lowering purposes. However, since the Sharpe Ratio measures the

risk-adjusted return, which is higher for NDX than MBB, the reasons to the overweight of MBB must be found in the correlation to the other assets. The same is argued to be the reason for the optimal allocation towards both TLT and Gold, which both have relatively low Sharpe- and Sortino Ratios, however, most likely providing diversification benefits. The performance metrics further indicates a relatively weak performance of REITs in the analyzed period, mainly due to the high standard deviation, also shown in the huge differences in min. and max. values. The same picture seems to be drawn for VNQ, indicating that the real estate sector in general have experienced substantial variations on returns for the period. A correlation matrix, illustrated in *Figure 21* below, has been conducted to further investigate and conclude upon each asset's attribution towards the optimal portfolio.

Figure 21 – Correlation matrix

	MBB	HYG	TLT	REIT	SPX	RUT	Silver	Gold	VNQ	NDX
MBB	1,000									
HYG	-0,083	1,000								
TLT	0,609	0,102	1,000							
REIT	0,090	-0,751	0,030	1,000						
SPX	-0,131	-0,699	-0,291	0,749	1,000					
RUT	-0,200	-0,692	-0,331	0,751	0,917	1,000				
Silver	0,036	-0,101	-0,018	0,041	0,060	0,074	1,000			
Gold	0,237	-0,144	0,190	0,142	0,039	0,018	0,478	1,000		
VNQ	0,119	-0,740	0,025	0,988	0,724	0,723	0,046	0,134	1,000	
NDX	-0,137	-0,659	-0,316	0,641	0,916	0,833	0,107	0,008	0,630	1,000

The correlation matrix clearly illustrates the diversification strengths of the bonds, which all reflects a negative correlation to the equity indices and a low correlation to both gold and silver. Therefore, the reasons to the substantial allocation towards MBB in the optimal portfolio is explained partly by the extremely low standard deviation, together with the negative or almost non-existing correlation towards all other asset classes. Additionally, regarding the allocation towards Gold and TLT, both show a low or even negative correlation towards the other asset classes, which again benefits the strength of the composite portfolio, despite having a lower Sharpe Ratio than other alternatives. Finally, it should be noted that REITs show a relatively low correlation towards the other equity indices, when compared to the others internal correlation, indicating that if the risk-adjusted return would have been higher, some sort of allocation towards REITs could be optimal, despite already allocating towards other equity indices.

6.3.1. Optimization from investor perspectives

As the optimal portfolio is constructed without any constrains, the model suggests the optimal relative risk/return relationship for any level of risk and return requirement, since the model maximizes returns for a given level of risk, while minimizing risk for a given level of return. However, while it is natural and obvious to assume, that every investor seeks to minimize their risks, factors such as time to retirement and general level or risk tolerance is argued to critically affect the investment strategies among different investor groups, which could potentially result in different criteria and perceptions of an optimal portfolio. For instance, younger investors – who is assumed to have a long time-horizon on their investments – is likely to be more accepting of an increase in standard deviation/risk, in order to achieve a higher expected return. Therefore, as mentioned briefly in the introduction to this chapter, a conservative, average and aggressive portfolio has been constructed, where constrains has been applied for the percentage of allocation towards bonds. Besides for the equally weighted portfolio, where weight percentage allocation is predetermined, the same course of action has been practiced for the remainder of the portfolios. Thus, the Sharpe Ratio has been maximized while keeping the portfolio weights variable. *Table 7* below illustrates the optimal performance of each of the constructed portfolios, each highlighted with their own background color.

Table 7 - Optimal portfolios with investor perspectives

			Min. 60% bonds	*5-15% bonds*	*Max. 2% bonds*
Asset	**Optimal portfolio**	**Equally weighted**	**Conservative**	**Average**	**Aggresive**
Ishares MBS ETF (MBB)	63,93%	10,00%	63,93%	0,00%	0,00%
Ishares iBoxx High Yield Corporate Bond ETF (HYG)	0,00%	10,00%	0,00%	0,00%	0,00%
Ishares 20+ Year Treasury Bond ETF (TLT)	9,34%	10,00%	9,34%	15,00%	2,00%
FTSE Nareit ALL REITs (FNAR)	0,00%	10,00%	0,00%	0,00%	0,00%
S&P 500 (SPX)	0,00%	10,00%	0,00%	0,00%	0,00%
Russell 2000 (RUT)	0,00%	10,00%	0,00%	0,00%	0,00%
Silver (COMEX^SI)	0,00%	10,00%	0,00%	0,00%	0,00%
Gold (COMEC^GC)	1,54%	10,00%	1,54%	16,81%	20,12%
Vanguard Real Estate Index Fund (VNQ)	0,00%	10,00%	0,00%	0,00%	0,00%
Nasdaq 100 (NDX)	25,19%	10,00%	25,19%	68,19%	77,88%
Sum of Weights (%)	100,00%	100,00%	100,00%	100,00%	100,00%
Expected Portfolio Return, Monthly (%)	0,49%	0,38%	0,49%	0,82%	0,89%
Portfolio Std. Deviation, Monthly (%)	1,39%	2,65%	1,39%	3,49%	4,10%
Sharpe Ratio	**0,199807**	**0,063266**	**0,199807**	**0,175449**	**0,164467**
Expected Portfolio Return, Anually (%)	6,02%	4,65%	6,02%	10,35%	11,17%
Portfolio Std. Deviation, Anually (%)	4,80%	9,19%	4,80%	12,09%	14,21%
Sharpe Ratio	**0,725508**	**0,505896**	**0,725508**	**0,645883**	**0,607313**

Commencing with the conservative portfolio, restricted by a minimum of 60% allocated between the three different types of bonds, the composition is obviously identical to the optimal portfolio, since the total allocation towards bonds far exceeds the minimum requirement of 60% set for the conservative portfolio. The average portfolio, however, shows a quiet different picture. The constrains limits the portfolio to allocate a maximum of 15% into bonds, which forces the portfolio to relocate the majority of what has so far been allocated towards bonds, forcing the average portfolio to substantially differ from the conservative and optimal portfolio. Given the constrains, the optimal 'average' perspective now suggests a 68,19% allocated in NDX, 16,81% in Gold and finally 15% in TLT. The deviations are, not surprisingly, shown in the substantial variations in both the expected return and standard deviation, where the average portfolio is providing a 10,35% expected annual return, significantly higher than the 6,02% from the optimal portfolio. However, a corresponding increase in the portfolio standard deviation, that has close to tripled from 4,80% to 12,09% causing a slight decrease in the Sharpe Ratio from 0,7255 to 0,6459, when compared to the optimal portfolio.

No allocation is continuously suggested for REITs despite the constrains, indicating that investors have historically been better off increasing the allocation percentage in both Gold and NDX. The portfolio is obviously suggesting the maximum of 15% allocated in bonds, however, TLT has been preferred before MBB, which is somewhat surprising considering the optimal portfolio has less than the 15% allocated in TLT. The reason to why TLT is suggested before MBB must be found in the underlying correlations, where TLT have a stronger negative correlation to NDX than MBB, which is even more important for the average portfolio since it consists mostly of NDX. The picture seems to be predominantly similar for the aggressive portfolio, where the difference in the allocation towards bonds is split between Gold and NDX, which obviously affects the expected return positively, however, proportionally larger negative effect on the standard deviation.

With the current asset composition, allowing the opportunity to allocate towards three different types of bonds, two commodities in terms of Gold and Silver, the real estate sector from REITs and VNQ, and lastly, equity indices in the form of RUT, SPX and NDX, the analysis have shown that no optimal portfolio composition, notwithstanding the different investor perspectives, is suggesting

any allocation towards REITs in the analyzed period, strongly indicating that REITs do not add additional performance to a traditional investment portfolio. The conducted analysis has, however, illuminated that REITs have a lower correlation to the other equity indices, relative to the others and their interrelationships, which makes REITs more suitable to be included together with other equity indices. However, REITs are still far from contributing in the way that both bonds and commodities are in terms of increasing diversification and decreasing portfolio risks. It became clear from the calculations in the performance metrics that REITs particularly suffer from a relatively high standard deviation, which has not been offset in a correspondingly high return in the analyzed period. A potentially impactful factor for including REITs, which the MVO model does not take into consideration, is related to the distribution of total return, which in many cases are quite different for REITs compared to the broader stock market, as REITs typically offer significantly higher dividend yields than stocks, providing an alternative source of income for the investors.

6.4. Portfolio optimization – Sectoral REIT segmentation

The initial results of the portfolio optimization did not suggest any allocation towards the Nareit ALL REITs index. However, this section aims to investigate whether the inclusion of REIT sub-sectors in the portfolio optimization would lead to a different outcome, allowing to focus only on historically high-performing sub-sectors. The structure of this section involves evaluating and discussing which sub-sectors should be included in the asset composition for the optimization process. The selection of sub-sectors is based on the comprehensive sectoral analysis presented in Chapter x.x, primarily considering historical performance and correlation coefficients. Ultimately, a new optimal portfolio is constructed and analyzed to determine if any allocation is suggested towards the included REIT sub-sectors. This analysis intends to clarify whether these sub-sectors have historically contributed to additional performance in a traditional investment portfolio for the chosen period.

6.4.1 Selection of sub-sectors

As mentioned, the selection of the REIT sectors to be included in the asset composition would be based on the previously conducted sectoral analysis. The inclusion is based mostly on the

historical performance, while also including considerations related to the correlations with the other sectors and the stock market indices. Thus, the following section would rely on the results shown in *Figure 14*, presenting the short-and mid-term sectoral performance, *Figure 15* illustrating the long-term performance, and lastly, F*igure 16* which includes the correlation coefficients between both sectors and stock indices in form of S&P 500 and Russell 2000, which were used as a proxy for the general correlation towards the broader stock market.

Self-Storage

Self-Storage was found to be one of the best performing sectors on a mid and long-term basis. *Figure 14* shows that while self-storage did perform substantially worse than the S&P 500 on the 1-year period, it is still one of the better performing REIT sectors for this period. On the other hand, when considering the 3-year period from the same figure, self-storage is back amongst the best performers with a positive yearly average return of 23,1%, far outperforming both the S&P 500 and most of the other REIT sectors. Lastly, when considering the long-term perspective, shown in F*igure 15*, presenting the average returns on a 10-year period, self-storage is again showing substantial strength compared to both other REIT-sectors and the S&P 500, with an average yearly return of 14,7%, only surpassed by the industrial sector. Another important factor for including self-storage is the very low correlations to other sectors and the stock indices. *Figure 16*, presenting the correlation coefficients, shows that self-storage has the far lowest correlation to the stock indices, being 0,35 for the S&P 500 and 0,25 for the Russell 2000, indicating a very low general correlation to the broader stock market. In addition, self-storage was also found to have the lowest general correlation level to the other sub-sectors. Therefore, on behalf of the presented results, self-storage is argued to be an obvious choice to be included in the asset composition.

Industrial

The sectoral analysis concluded the industrial sector to be the best performer on the 10-year period, indicating strong long-term results. In addition, the industrial sector shows similar results to self-storage on the short-term 1-year period, which means a less negative return than most other REIT sectors, and very promising results on the 3-year period, far outperforming the stock

indices with an annual average return of 19%. The correlation matrix shows a rather neutral correlation to both other REIT sectors and the stock indices, with correlation coefficients around 0,60. The industrial sector is likewise chosen to be included, especially due the strong performance on a mid-to long-term period, reflected in the results for the 3 and 10-year period.

Retail

The final REIT sector that was chosen to be included in the analysis is the retail sector. Retail was shown to have performed best of all REIT sectors on a short- to mid-term period. For the 1-year period, retail has the least negative return of -5,3%, only outperformed by the S&P 500 index with a -4,8% return. On the 3-year period, the retail sector has performed best of all, thereby substantially outperforming the stock indices. However, reflecting upon the performance for the 10-year period, the retail sector has shown less-promising results, with a yearly average of 5,5%. In terms of correlations to the other REIT sectors and stock indices, a similar picture as for the industrial sector is evident, indicating a rather neutral correlation. The retail sector has been included as the short-term top performer, opposite to both the self-storage and industrial sector, with the purpose of including a more diverse mix of assets.

6.4.2 Portfolio optimization

The optimal portfolio has been constructed using Excel, proceeding with the exact same course of actions used in the previous section. However, now with the inclusion of the selected REIT sectors of interest as a replacement for the Nareit ALL REIT (FNAR) index that has been used so far. The analysis includes the previously constructed investor perspectives and their respective restrictions in terms of bond-allocation. This section has been structured to first present and reflect upon the results from the MVO-model optimization, focusing on outlaying the results in comparison to the previously constructed portfolios, highlighting potential similarities and variations. *Table 8* below presents the results of the portfolio optimization.

Table 8 - Optimal portfolios including REIT sectors

			Min. 60% bonds	*5-15% bonds*	*Max. 2% bonds*
Asset	**Optimal portfolio**	**Equally weighted**	**Conservative**	**Average**	**Aggresive**
Ishares MBS ETF (MBB)	63,93%	8,33%	63,93%	0,00%	0,00%
Ishares iBoxx High Yield Corporate Bond ETF (HYG)	0,00%	8,33%	0,00%	0,00%	0,00%
Ishares 20+ Year Treasury Bond ETF (TLT)	9,34%	8,33%	9,34%	15,00%	2,00%
Self-Storage (REIT)	0,00%	8,33%	0,00%	15,25%	20,74%
Industrial (REIT)	0,00%	8,33%	0,00%	0,00%	0,00%
Retai (REIT)	0,00%	8,33%	0,00%	0,00%	0,00%
S&P 500 (SPX)	0,00%	8,33%	0,00%	0,00%	0,00%
Russell 2000 (RUT)	0,00%	8,33%	0,00%	0,00%	0,00%
Silver (COMEX^SI)	0,00%	8,33%	0,00%	0,00%	0,00%
Gold (COMEC^GC)	1,54%	8,33%	1,54%	13,34%	16,00%
Vanguard Real Estate Index Fund (VNQ)	0,00%	8,33%	0,00%	0,00%	0,00%
Nasdaq 100 (NDX)	25,19%	8,33%	25,19%	56,41%	61,26%
Sum of Weights (%)	100,00%	100,00%	100,00%	100,00%	100,00%
Expected Portfolio Return, Monthly (%)	0,49%	0,39%	0,49%	0,83%	0,90%
Portfolio Std. Deviation, Monthly (%)	1,39%	3,57%	1,39%	3,41%	3,95%
Sharpe Ratio	**0,199807**	**0,051102**	**0,199807**	**0,182129**	**0,173120**
Expected Portfolio Return, Anually (%)	6,02%	4,83%	6,02%	10,47%	11,29%
Portfolio Std. Deviation, Anually (%)	4,80%	12,37%	4,80%	11,82%	13,67%
Sharpe Ratio	**0,725508**	**0,390720**	**0,725508**	**0,670772**	**0,639549**

The conducted portfolio optimization yields several significant observations. Firstly, it is notable that the optimal portfolio remains unchanged even after the inclusion of REIT sectors, implying that none of the three sectors under consideration warrant any allocation. This finding suggests that, based on historical performance and correlation coefficients, these sub-sectors do not demonstrate compelling investment opportunities within the designated period, relative to the other assets. Consequently, the equally weighted portfolio, which distributes assets evenly across all constituents, experiences a slight deterioration in performance when the REIT sectors are introduced. This outcome can be attributed to a reduced allocation in the best-performing assets relative to the optimization conducted in the preceding section. Moreover, the conservative portfolio, characterized by a conservative risk profile and a preference for fixed income instruments such as bonds, remains unaffected by the inclusion of REIT sub-sectors. This similarity with the optimal portfolio can be attributed to the optimal portfolio's allocation towards bonds, which aligns with the conservative portfolio's investment strategy.

However, distinctions emerge when evaluating the outcomes of both the "average" and "aggressive" portfolios due to the constraints imposed on the maximum allocation to bonds. The average portfolio suggests an allocation of approximately 15% towards REITs, specifically within

the sub-sector of self-storage. This allocation differs from the previously constructed "average" portfolio, as the 15% allocated to self-storage is offset by a proportional reduction in the allocation towards the NDX asset. Likewise, the aggressive portfolio exhibits a similar pattern to the average portfolio. The additional 13% of freed-up allocation previously constrained by the maximum bond allocation is distributed relatively evenly among the three assets: self-storage REITs, Gold, and Nasdaq 100. These findings offer valuable insights into the composition and performance of the optimized portfolios when REIT sub-sectors are incorporated. The absence of allocation towards the included sub-sectors in the optimal portfolio implies that these sectors do not exhibit promising performance characteristics during the specified period. Conversely, the average and aggressive portfolios display variations, suggesting potential benefits from including self-storage REITs, Gold, and Nasdaq 100, when considering different levels of risk-tolerance. These observations underscore the significance of considering sub-sector performance and asset allocation in portfolio construction, thereby informing investors in their pursuit of optimal investment strategies.

With the purpose of elaborating further on the absence of allocation towards the included REIT sectors, *Table 9* and *Figure 22* below, containing the calculated performance metrics for the included assets and the correlation coefficients, respectively, will be used as the foundation for further investigation of the performance characteristics and reasonings for the suggested optimal portfolio composition.

Table 9 - Key Metrics

Asset	Ticker	# of data points	Minimum	Maximum	Mean	Median	Std. Deviation	Sharpe Ratio	Sortino Ratio
iShares MBS ETF (MBB)	MBB	152	-3,3%	4,3%	0,30%	0,21%	0,9%	0,0928	0,14367
iSHares iBoxx $ High Yield Corporate Bond ETF	HYG	152	-17,2%	11,0%	-0,55%	-0,58%	3,2%	-0,2347	-0,29600
iShares 20-year bond ETF (TLT)	TLT	152	-15,4%	11,7%	0,39%	0,27%	3,9%	0,0466	0,07306
Self-Storage sub-sector (REIT)	-	152	-25,2%	19,8%	0,94%	1,56%	6,5%	0,1132	0,11320
Industrial sub-sector (REIT)	-	152	-82,5%	53,3%	0,30%	1,42%	12,0%	0,0074	0,00742
Retail sub-sector (REIT)	-	152	-45,9%	36,1%	0,17%	0,78%	8,1%	-0,0048	-0,00522
S&P500	SPX	152	-18,4%	10,4%	0,69%	1,39%	4,3%	0,1111	0,13184
Russell 2000	^RUT	152	-23,5%	14,3%	0,47%	1,53%	5,7%	0,0457	0,05768
Silver	COMEX^SI	152	-22,3%	17,3%	0,09%	-0,70%	7,0%	-0,0167	-0,02730
Gold	COMEX^GC	152	-21,1%	13,0%	0,44%	0,08%	5,3%	0,0429	0,06260
Vanguard Real Estate ETF	VNQ	152	-36,9%	28,7%	0,46%	1,16%	7,0%	0,0359	0,03942
Nasdaq 100	NDX	152	-17,8%	12,3%	1,01%	1,85%	5,1%	0,1569	0,19931

Figure 22 - Correlation Matrix

Correlations	MBB	HYG	TLT	Self-Storage	Industrial	Retail	SPX	RUT	Silver	Gold	VNQ	NDX
MBB	1,000											
HYG	- 0,083	1,000										
TLT	0,609	0,102	1,000									
Self-Storage	0,175	- 0,538	0,154	1,000								
Industrial	0,028	- 0,730	0,015	0,689	1,000							
Retail	0,070	- 0,713	0,030	0,789	0,875	1,000						
SPX	- 0,131	- 0,699	- 0,291	0,491	0,700	0,680	1,000					
RUT	- 0,200	- 0,692	- 0,331	0,505	0,707	0,685	0,917	1,000				
Silver	0,036	- 0,101	- 0,018	- 0,049	0,120	0,050	0,060	0,074	1,000			
Gold	0,237	- 0,144	0,190	0,093	0,190	0,138	0,039	0,018	0,478	1,000		
VNQ	0,119	- 0,740	0,025	0,823	0,873	0,958	0,724	0,723	0,046	0,134	1,000	
NDX	- 0,137	- 0,659	- 0,316	0,379	0,619	0,582	0,916	0,833	0,107	0,008	0,630	1,000

Commencing with the individually computed Sharpe Ratios, it is observed that the Nasdaq 100 index retains its position as the top performer, exhibiting a ratio of 0,1569. However, the second highest Sharpe Ratio is attributed to the self-storage sector, elucidating the allocation towards this sector for both the average and aggressive portfolios. The relatively elevated Sharpe Ratio of self-storage is primarily driven by its monthly mean return of 0,94%, which is only surpassed by NDX. Additionally, self-storage demonstrates the lowest standard deviation among the three included REIT sectors, although it still falls on the higher end when compared to the other assets. As mentioned earlier, the optimal portfolio recommends an overweight position in MBB, despite its lower Sharpe Ratio compared to self-storage. This is justified by analyzing the correlation coefficients presented in *Figure 22*, which indicate a negative correlation between MBB and NDX. Therefore, while self-storage exhibits a low correlation, the suggested allocation for the optimal portfolio remains balanced between MBB, serving as a "safe haven" investment and portfolio diversifier, and NDX, representing the best performing asset.

In conclusion, the analysis of the optimal portfolio composition incorporating REIT sub-sectors reveals several key findings. First, based on the previously conducted sectoral analysis, self-storage, industrial and retail REIT sectors was argued to be included for the further optimization process due their compelling returns and their respective correlation to the broader stock market. Despite these results, the optimal portfolio concluded that the inclusion of REIT sectors does not warrant any allocation towards REITs, indicating that these sectors do not present compelling investment opportunities compared to the other assets based on historical performance and correlation coefficients. The equally weighted portfolio experiences a slight decline in

performance when REIT sectors are introduced due to reduced allocation in the best-performing assets. However, the conservative portfolio remains unaffected by the inclusion of REIT sectors due to its alignment with the optimal portfolio's bond allocation strategy.

Notably, the average and aggressive portfolios exhibit variations in response to the constraints on maximum bond allocation. The average portfolio suggests an allocation towards self-storage REITs, while the aggressive portfolio allocates additional funds to self-storage REITs, gold, and Nasdaq 100. These variations imply potential benefits in including self-storage REITs, gold, and Nasdaq 100 based on different risk-tolerance levels. The analysis of Sharpe Ratios highlights the Nasdaq 100 index as the top performer, followed by the self-storage sector. The relatively high Sharpe Ratio of self-storage is driven by its substantial monthly mean return and lower standard deviation compared to the other REIT sectors. Despite having a lower Sharpe Ratio, an overweight position in MBB is still recommended due to its negative correlation with NDX.

6.5. Out-of-Sample testing of the optimal portfolio composition

As mentioned in the introductory part of the analysis, the return data has been split into an in-sample dataset and an out-of-sample dataset. Out-of-sample testing is a concept within statistical modelling that is used to test and evaluate the accuracy of a model's prediction ability (Samuelsson, 2023). The practice involves splitting the data into a training set, which is used as model fitting data, and a testing set, used as the unseen data to test the prediction accuracy of the model. Thus, the following section will contribute as a test for validity of the optimal constructed portfolios from the previous sections, focusing on how the optimal portfolios performs in a separate and more recent period. The out-of-sample testing has been performed for both the initially created portfolio, as well as the portfolio that allows for REIT sector allocation.

Initially created portfolio

Table 10 below displays both the optimal portfolio construction for the out-of-sample data, including the previously constructed investor perspective restrictions, and lastly, highlighted with the yellow background, the results for the in-sample optimal portfolio. In addition, *Table 11*

constitute a selection of calculated performance metrics, which will be used to analyze and comment on the results.

Table 11 - Out-of-sample test portfolio

Asset	Optimal portfolio	Equally weighted	*Min. 60% bonds* Conservative	*5-15% bonds* Average	*Max. 2% bonds* Aggresive	*Previous optimal alloation* Out of Sampe testing
Ishares MBS ETF (MBB)	0,00%	10,00%	0,00%	0,00%	0,00%	63,93%
Ishares iBoxx High Yield Corporate Bond ETF (HYG)	0,00%	10,00%	60,00%	5,00%	0,00%	0,00%
Ishares 20+ Year Treasury Bond ETF (TLT)	0,00%	10,00%	0,00%	0,00%	0,00%	9,34%
FTSE Nareit ALL REITs (FNAR)	0,00%	10,00%	0,00%	0,00%	0,00%	0,00%
S&P 500 (SPX)	0,00%	10,00%	0,00%	0,00%	0,00%	0,00%
Russell 2000 (RUT)	0,00%	10,00%	0,00%	0,00%	0,00%	0,00%
Silver (COMEX^SI)	0,00%	10,00%	4,02%	0,00%	0,00%	0,00%
Gold (COMEC^GC)	63,20%	10,00%	2,93%	58,75%	63,20%	1,54%
Vanguard Real Estate Index Fund (VNQ)	0,00%	10,00%	0,00%	0,00%	0,00%	0,00%
Nasdaq 100 (NDX)	36,80%	10,00%	33,06%	36,25%	36,80%	25,19%
Sum of Weights (%)	100,00%	100,00%	100,00%	100,00%	100,00%	100,00%
Expected Portfolio Return, Monthly (%)	0,87%	0,28%	0,34%	0,82%	0,87%	0,10%
Portfolio Std. Deviation, Monthly (%)	3,83%	3,53%	1,56%	3,59%	3,83%	2,88%
Sharpe Ratio	**0,183636**	**0,032571**	**0,111579**	**0,183421**	**0,183636**	**- 0,020215**
Expected Portfolio Return, Anually (%)	10,89%	3,37%	4,10%	10,29%	10,89%	1,25%
Portfolio Std. Deviation, Anually (%)	13,27%	12,24%	5,40%	12,43%	13,27%	9,98%
Sharpe Ratio	**0,820750**	**0,275555**	**0,759977**	**0,023491**	**0,820750**	**- 0,375716**

Table 10 - Key Metrics

Asset	Ticker	# of data points	Minimum	Maximum	Mean	Median	Std. Deviation	Sharpe Ratio
iShares MBS ETF (MBB)	MBB	40	-5,2%	4,2%	-0,17%	0,01%	1,8%	- 0,0938
iSHares iBoxx $ High Yield Corporate Bond ETF	HYG	40	-6,9%	9,6%	-0,11%	-0,20%	3,2%	- 0,0362
iShares 20-year bond ETF (TLT)	TLT	40	-11,0%	7,3%	-0,65%	-0,82%	4,6%	- 0,1426
FTSE Nareit All REITs	^FNAR	40	-23,4%	9,8%	-0,02%	1,08%	6,9%	- 0,0029
S&P500	SPX	40	-13,2%	12,1%	0,75%	2,14%	5,9%	0,1273
Russell 2000	^RUT	40	-24,7%	25,7%	0,18%	1,02%	7,6%	0,0236
Silver	COMEX^SI	40	-17,8%	25,7%	0,95%	1,27%	8,1%	0,1175
Gold	COMEX^GC	40	-7,9%	10,4%	0,76%	0,11%	4,4%	0,1725
Vanguard Real Estate ETF	VNQ	40	-22,3%	11,3%	0,05%	1,36%	7,0%	0,0068
Nasdaq 100	NDX	40	-14,4%	14,1%	1,04%	1,59%	7,0%	0,1491

First, and most importantly, the test of the performance of the previous optimal allocation shows and expected portfolio return of 1,25% annually, with a portfolio standard deviation of 9,98% annually. Obviously, these results are far from appealing and significantly different to the results from the in-sample data, where the optimal portfolio was showing a 6,02% annual return with a portfolio standard deviation of 4,80%. The extremely weak performance of the previously constructed asset allocation is likewise shown in the negative Sharpe Ratio of -0,3757. Since 63,93% is allocated towards MBB in the previous optimal portfolio, the performance of the portfolio is highly dependent on the returns of this singular asset which has performed very poorly in the out-of-sample period, with a mean return of -0,17% monthly. Besides that, both the optimal portfolio for the in – and out-of-sample period is suggesting an allocation towards NDX, due to the relatively high monthly mean return. The optimal portfolio for the out-of-sample period is highly

gold-heavy, with an optimal allocation of 63,20%, substantially more than the 1,54%, which were allocated towards gold in the in-sample optimization. As mentioned in the previous section, both gold and bonds serve as a great portfolio diversifier, with very low or even negative correlations to the other asset classes, including the NDX. Where the bonds, especially MBB, were outperforming gold in the in-sample period, the out-of-sample results are showing the direct opposite, with MBB as the worst and gold as the best performing assets, shown in the Sharpe Ratio calculations in *Table 11.* It is, therefore, a somewhat similar portfolio construction with a heavy allocation towards a more conservative asset, which also act as a portfolio diversifier, and the rest allocated in a stock index, in both cases NDX, since it in both periods has the highest mean returns.

From the results stated in the abovementioned, the out-of-sample test indicate severe differentiations in the portfolio compositions, which have resulted in a negative Sharpe Ratio for the previously constructed portfolio. Thus, showing significant limitations for the model and the process of using historical data to construct an optimal portfolio for future returns. Therefore, it must be seen as an inherent weakness of the Mean-Variance Optimization model (MVO) that historical returns are treated and used as an expectation for the future. However, it must be acknowledged that the optimal portfolio has been constructed on a larger dataset than the out-of-sample test, which, however, is common practice when in terms of ratio for the training/testing data (Samuelsson, 2023). It is possible that we would have seen more similar and better results, had it been tested on a longer period, since the results are more affected by spikes in performance both positively and negatively. This is contributing to the conclusion that the MVO has limitations in terms of predicting an optimal composition for future short- to mid-term period. While the results are far from convincing in terms of performance, the model could be used as a useful tool to reflect upon asset composition, especially with a view to creating a diversified portfolio. The results did show some similarities in terms of asset composition, since the optimal portfolios were created with a similar allocation towards a stock-index, which had the highest returns, and either bond or commodity, which for the period had stable returns and served a purpose related to diversification due to their low or even negative correlation to the stock indices.

REIT sector portfolio

Table 12 below displays the results from the out-of-sample testing on the portfolio that includes the selected REIT sectors; Self-storage, Industrial and Retail, which includes both the optimal portfolio allocation for the out-of-sample period, as well as the performance of the previously constructed optimal portfolio from the in-sample-period. *Table 13* is likewise included, presenting the calculated performance metrics for the individual assets.

Table 12 - Out-of-sample sector portfolios

			Min. 60% bonds	*5-15% bonds*	*Max. 2% bonds*	*Previous optimal alloation*
Asset	**Optimal portfolio**	**Equally weighte**	**Conservative**	**Average**	**Aggresive**	**Out of Sampe testing**
Ishares MBS ETF (MBB)	0,00%	8,33%	0,00%	0,00%	0,00%	63,93%
Ishares iBoxx High Yield Corporate Bond ETF (HYG)	0,00%	8,33%	60,00%	5,00%	0,00%	0,00%
Ishares 20+ Year Treasury Bond ETF (TLT)	0,00%	8,33%	0,00%	0,00%	0,00%	9,34%
Self-Storage (REIT)	32,82%	8,33%	13,37%	30,63%	31,94%	0,00%
Industrial (REIT)	0,00%	8,33%	0,00%	0,00%	0,00%	0,00%
Retail (REIT)	0,00%	8,33%	0,00%	0,00%	0,00%	0,00%
S&P 500 (SPX)	0,00%	8,33%	0,00%	0,00%	0,00%	0,00%
Russell 2000 (RUT)	0,00%	8,33%	0,00%	0,00%	0,00%	0,00%
Silver (COMEX^SI)	1,42%	8,33%	3,96%	1,42%	1,42%	0,00%
Gold (COMEC^GC)	52,33%	8,33%	0,00%	48,59%	52,33%	1,54%
Vanguard Real Estate Index Fund (VNQ)	0,00%	8,33%	0,00%	0,00%	0,00%	0,00%
Nasdaq 100 (NDX)	13,43%	8,33%	22,67%	14,37%	13,43%	25,19%
Sum of Weights (%)	100,00%	100,00%	100,00%	100,00%	99,12%	100,00%
Expected Portfolio Return, Monthly (%)	0,95%	0,40%	0,37%	0,90%	0,95%	0,10%
Portfolio Std. Deviation, Monthly (%)	3,78%	4,00%	1,61%	3,54%	3,78%	2,88%
Sharpe Ratio	**0,209775**	**0,059673**	**0,128109**	**0,209591**	**0,209775**	**- 0,020215**
Expected Portfolio Return, Anually (%)	12,08%	4,91%	4,51%	11,40%	12,08%	1,25%
Portfolio Std. Deviation, Anually (%)	13,10%	13,85%	5,59%	12,26%	13,10%	9,98%
Sharpe Ratio	**0,922334**	**0,354645**	**0,807053**	**0,249822**	**0,922334**	**- 0,375716**

Table 13 - Key Metrics

Asset	Ticker	of data poin	Minimum	Maximum	Mean	Median	Std. Deviation	Sharpe Ratio
iShares MBS ETF (MBB)	MBB	40	-5,2%	4,2%	-0,17%	0,01%	1,8%	- 0,0938
iSHares iBoxx $ High Yield Corporate Bond ETF	HYG	40	-6,9%	9,6%	-0,11%	-0,20%	3,2%	- 0,0362
iShares 20-year bond ETF (TLT)	TLT	40	-11,0%	7,3%	-0,65%	-0,82%	4,6%	- 0,1426
Self-storage	-	40	-12,7%	13,3%	1,23%	1,80%	6,8%	0,1795
Industrial	-	40	-17,9%	13,8%	0,88%	1,19%	7,5%	0,1164
Retail	-	40	-55,6%	21,4%	-0,09%	0,24%	11,6%	- 0,0076
S&P500	SPX	40	-13,2%	12,1%	0,75%	2,14%	5,9%	0,1273
Russell 2000	^RUT	40	-24,7%	25,7%	0,18%	1,02%	7,6%	0,0236
Silver	COMEX^SI	40	-17,8%	25,7%	0,95%	1,27%	8,1%	0,1175
Gold	COMEX^GC	40	-7,9%	10,4%	0,76%	0,11%	4,4%	0,1725
Vanguard Real Estate ETF	VNQ	40	-22,3%	11,3%	0,05%	1,36%	7,0%	0,0068
Nasdaq 100	NDX	40	-14,4%	14,1%	1,04%	1,59%	7,0%	0,1491

Since the optimal allocation for the portfolio including sub-sectors remained unchanged from the initial portfolio, the same conclusions can be drawn in this regard. However, notable variations arise when considering the optimal portfolio constructed for the out-of-sample period. These variations suggest that 32,82% should be allocated to self-storage, 1,42% to silver, 52,33% to gold, and 13,43% to NDX. The allocation to self-storage in the optimal portfolio can be explained by its

highest mean return among all included assets, coupled with a relatively low standard deviation, resulting in a correspondingly high Sharpe Ratio. Consequently, compared to the initially created portfolio, the optimal REIT sector portfolio suggests lower allocations to both NDX and gold, owing to the inclusion of self-storage.

However, despite these variations, both of the optimal portfolios for the out-of-sample period indicate that a more aggressive portfolio (absent of bond allocation) has exhibited superior performance when compared to the more conservative portfolio construction that performed well in the in-sample period. Thus, while the out-of-sample test results display similar prediction inaccuracies, the inclusion of self-storage in the allocation hints at the strength of REITs when evaluating performance at the sector level. Upon reflecting on the construction of portfolios from different investor perspectives, substantial variations emerge in comparison to the results for the in-sample period. While the conservative portfolio outperformed the more aggressive portfolio constructions during the in-sample period, as evidenced by the Sharpe Ratios, the opposite holds true for the out-of-sample period results. The optimal portfolio for this period aligns with the aggressive portfolio, excluding any allocation in bonds. The prediction accuracy of the MVO model is therefore found to more compelling for the aggressive portfolios when compared to the conservative portfolios, mainly due the substantial variation in the performance of the bonds from the in-sample to the out-of-sample period.

6.6 Partial conclusion

The analysis concluded that the optimal portfolio did not suggest any allocation in REITs, notwithstanding the different investor perspectives that were created to construct a conservative, average and aggressive portfolio with associated level of risk-tolerance, strongly indicating that REITs have not historically been able to add additional performance to a traditional investment portfolio. Since the previously presented sectoral analysis had shown substantial variations in the performance of individual REIT sectors within the Nareit ALL REIT index, an additional portfolio optimization process was found relevant to be conducted, including selectively chosen REIT sectors in the asset composition instead of the Nareit ALL REIT index, enabling the opportunity to selectively include historically high-performing sectors for the further optimization process. Self-

storage, Industrial and Retail was argued to be included for the secondary portfolio optimization due to their strong historical performance and their relatively low correlation to the broader stock market. The optimal portfolio for the sector-based portfolio optimization continuously concluded that no allocation in any of the included REIT sectors was suggested. However, from *Table 13*, presenting the calculated performance metrics for the individual assets, self-storage showed compelling results in both mean-return and Sharpe Ratio, indicating relative strength of this sector. When the different investor perspectives were reflected upon, variations were evident for the "average" and "aggressive" portfolios, which both suggested 15,25% and 20,74% allocated in self-storage, respectively, indicating that the inclusion of self-storage could have added additional performance for the more risk-tolerant investor.

Lastly, an out-of-sample test was carried out with the purpose of testing the prediction accuracy of the model, by evaluating on the performance of the previously constructed optimal portfolios on a new period with unseen historical data. The out-of-sample test presented clear evidence of prediction inaccuracy, shown in the results for the initially constructed optimal portfolio, which had generated a low and disappointing return, with a relatively high standard deviation, resulting in a negative Sharpe Ratio in the out-of-sample period. While the out-of-sample test indicated more accuracy for the more aggressive portfolios, substantial variation was evident across all portfolio perspectives, indicating strong limitations of the model and its ability to use historical return data to construct an optimal portfolio for future returns.

7. REITs as an inflation hedge

In times of heightened market volatility and uncertainty, effective inflation hedging strategies have become a vital concern for investors across various asset classes. While traditional hedging instruments such as futures, options, and derivatives are widely used in equities and fixed-income markets, the dynamics of the real estate sector present unique challenges and opportunities for implementing effective inflation hedging strategies. It is within this context that the analysis of the hedging capabilities of REITs assumes significant importance. This chapter aims to delve into the intricacies of REITs as hedging instruments and evaluate their efficacy in managing risk exposure. We will explore the underlying factors that influence the inflation hedging potential of REITs,

examine different hedging mechanisms employed in the real estate sector, and assess the advantages and limitations of utilizing REITs as a hedging tool. The analysis will be built upon the foundation of knowledge obtained throughout the previous sections, most notably section Chapter 5 that presents the historical inflation and its impact on different asset classes. Additional literature and data will likewise constitute the investigation of REITs' hedging capabilities. The chapter is structured to first present a brief summary of inflation hedging characteristics, followed by a section presenting the timeframe and the data that has been collected for the analysis. Lastly, REITs' hedging capabilities are sought to be analyzed by the construction of a regression analysis, reflecting upon the relationship between REITs and Headline, Core and Energy inflation, while comparing the results to hedging capabilities of stocks and commodities in similar constructions.

7.1. Inflation hedge characteristics

As previously mentioned in Chapter 5, inflation can be broken down into three different categories, being *Headline Inflation*, referring to the overall rate of price changes for a 'basket of goods', *Core Inflation*, which excludes certain volatile components of the total inflation factors, such as food and energy, with the purpose of excluding factors that can cause short-term fluctuations, and which are not directly related to the general economic condition. Lastly, *Energy Inflation*, which focus solely on energy prices related to oil, gas, electricity etc. We seek to evaluate and elaborate on the hedging capabilities within all three mentioned categories, thereby presenting comprehensive results on a very specific level with the intention of showing unprecedented insight on the performance of different REIT sectors as an inflation hedging component, while continuously comparing the results to other assets classes, including traditionally considered inflation hedging assets such as gold.

There are many opinions as of what makes the best inflation hedge, however, some general characteristics seem to be inevitable when researching prior studies and common opinions within the scholarly discourse. One of which is not surprisingly argued to be related to the correlation with inflation. More specifically the CPI, which is widely known and used as the proxy for inflation and will continue to do so for this section of the thesis. Obviously, a positive correlation with CPI would indicate that when inflation rise, the returns of the related asset tend to increase. A positive

correlation with CPI should therefore, as a singular factor, indicate appealing signs of hedging capabilities. However, studies have found that even traditionally considered inflation hedging assets, such as gold, usually does not strongly correlate with inflation, especially not on a short-term basis (Duggan, 2023), since various other factors tend to play their role in affecting the returns for a specific period, not to mention the different types of inflation and their respective affection on different asset classes in different economical periods. Another common acknowledgement is related to real asset characteristics. Real assets, such as real estate and commodities, are often argued to provide inflation hedging advantages, when compared to other asset classes, since these assets possess intrinsic value derived from either physical properties or tangible resources (Childers, 2022). The value of real assets is mostly affected by supply and demand, which is generally believed to be positively affected by an increase in inflation. For real estate, agreements with shorter lease-terms are especially considered to be able to mitigate some sort of inflation risks, since they to a great extend can readjust their rental agreements and thereby enabling the opportunity to pass cost inflation onto their tenants (Rego, 2022). Additionally, assets that tend to serve as a store of value is widely argued to be positively affected by rises in inflation. For instance, Gold has historically been considered a 'safe-haven' investment and a reliable store of value, since its scarcity, durability and widespread is believed to provide it with the potential of preserving purchasing power in high-inflation periods (Bromberg, 2023). In general, assets with limited supply or scarcity are argued to perform well in periods with high inflation, since demand might outpace the limited supply, naturally creating favorable conditions for increasing returns.

7.2. Timeframe and data collection

In this section, we seek to outline the thoughts and reflections regarding the data foundation and the timeframe which constitutes the framework around the following regression analysis and portfolio optimization process. The timeframe for the further analysis has been chosen to cover the years of from Primo 2021 to Ultimo April 2023. The chosen timeframe is argued to compactly cover the whole period of abnormal rise in inflation rates, giving the best data foundation in terms of analyzing and evaluating on the hedging capabilities of REITs. The current inflation level is the highest that we have experienced on a global level since the 1980's, which have entailed great

fluctuations and uncertainty for the world economy and the financial markets, greatly impacting the choices made in relation to the timeframe for this particular part of the analysis.

In terms of the data foundation, monthly data has been collected for all included asset classes, which is used for both the regression analysis and the portfolio optimization. Initially, daily return data was deemed most suitable for this analysis due to the relatively short timeframe and thereby relatively few datapoints. However, due to the lack of daily return data for REITs on a sector-based level, monthly returns will constitute the data foundation. While the monthly data to some extend compromises the strength of the data foundation due to having less data points for the analysis, we believe that the compromised data is offset in the ability to include REITs and their inflation hedging capabilities on a sector level, resulting in a more comprehensive analysis, with a more sophisticated scientific contribution. The analysis will, furthermore, constitute of 28 data points for each asset class, which far exceeds the rule of thumb minimum sample size requirement of 10 data points (Statistics Solutions, n.d.), however, above 30 observations are the general recommendation for regression analysis, which our dataset falls just shy of.

The data has been collected for every REIT sector, which will be included in both the regression analysis and the portfolio optimization. S&P 500 will constitute as the stock market proxy for the regression analysis, where TLT has been chosen to be included as the reflection of the Treasury Bond Yield. Lastly, gold has been chosen as the representation for commodities. Furthermore, a linear regression model will be used for this part, where every asset will be analyzed up against the CPI for Headline, Core and Energy inflation. Consequently, 12 variables are analyzed for each type of inflation, resulting in a total of 36 linear regression statistics across Headline, Core and Energy inflation. The statistics are included in a summarizing table separately for Headline, Core and Energy to be reflected and commented on. A multifactor regression model has not been deemed appropriate for this part since both Core and Energy Inflation is inherent in the overall Headline Inflation. The natural logarithm has been taken for all return data with the purpose of converting the data to better comply with the assumptions that a linear regression model is built on. Most noticeably, linear regression models assume an additive relationship between the analyzed variables (Statistics Solutions , n.d.). Since financial return data usually lacks in terms of

complying with the assumption of a linear relationship, the data transformation will strengthen the data foundation by making it more suitable to be analyzed and commented upon. Moreover, linear regression models assume multivariate normality (Statistics Solutions , n.d.), which the data transformation can help to approximately achieve.

7.3. Regression analysis

The objective of this section is to assess the inflation hedging capabilities of different asset classes, with emphasis on REITs and different REIT sectors, by analyzing their regression statistics for each of the inflation categories. By evaluating the relationship between asset returns and inflation, we aim to identify sectors or asset classes that have historically demonstrated stronger inflation-hedging characteristics. The analysis will utilize a rigorous econometric approach, employing regression models to capture the linear relationship between the returns of each asset class and changes in CPI. This method allows us to quantify the strength and significance of the relationship, providing insights into the effectiveness of these asset classes as potential inflation hedges. A significant focus of the regression analysis will be on the REIT sectors, which comprises different segments of the real estate market. By examining the inflation hedging capabilities of various REIT sectors, we can gain insights into which segments may offer better protection against inflationary pressures. To ensure the robustness of our analysis, we will consider multiple regression diagnostics, including measures of goodness-of-fit, statistical significance, and the examination of assumptions such as linearity, multicollinearity, and normality. By rigorously evaluating these criteria, we aim to provide a comprehensive and reliable assessment of the inflation hedging capabilities of different asset classes.

7.3.1 Linear regression analysis

As briefly mentioned, the linear regression has been conducted using Excel. The statistical results of primary interest are presented in the summarizing tables below, where *Table 14* reflects the results of the regression analysis for Headline Inflation, *Table 15* for the Core inflation, and lastly, *Table 16* that presents the results for Energy inflation. In the following, the results of the regression analysis for each inflation category are analyzed and commented upon, whereas the most important findings are briefly summarized in the partial conclusion. We have chosen to focus

on the Multiple R, R Squared, P-Value and the Coefficients for all regression models. The Multiple R indicates the correlation with the CPI, R Squared is used to reflect upon the explanation rate for each variable, which essential reflects the goodness-of-fit. The P-Value reflects the statistical significance of the variable, and lastly, the coefficients represent the expected change in the dependent variable from a change in the independent variable.

Headline Inflation

Table 14 - Headline inflation regression

Headline Inflation Regression	*Multiple R*	*R Square*	*P-Value*	*Coeffecients*	*Observations*
Office (REIT)	0,1087	0,0118	0,5818	2,7902	28
Industrial (REIT)	0,0060	0,0000	0,9758	0,1693	28
Retail (REIT)	0,0976	0,0095	0,6211	-2,1243	28
Residential (REIT)	0,0627	0,0039	0,7512	1,2377	28
Healthcare (REIT)	0,1075	0,0116	0,5861	2,5350	28
Lodging/Resort (REIT)	0,1439	0,0207	0,4652	-4,7239	28
Self Storage (REIT)	0,1317	0,0174	0,5040	3,2797	28
Infrastructure (REIT)	0,1441	0,0208	0,4644	3,7636	28
Data Centers (REIT)	0,0109	0,0001	0,9560	0,2841	28
S&P 500	0,0650	0,0042	0,7424	-1,1532	28
Gold	0,0756	0,0057	0,7021	1,1749	28
TLT	0,0034	0,0000	0,9863	-0,0538	28

Commencing with the Multiple R, the statistical results – presented in the table above – indicates a very weak correlation across all assets. The weak multiple suggests that the independent variable, being the Headline Inflation, have very limited predictive power of the variation observed for the dependent variables. Consequently, when reflecting upon the results for R Squared, the impact of Headline Inflation is limited on the different assets, indicating that there might be other factors that - to a possibly greater extend - influence the variance of the dependent variables. These factors could include company specific news and market sentiment. Even though all assets have relatively low numbers, variations are present. REITs generally have a higher Multiple R and R Squared, when compared to both S&P 500, Gold and TLT, resulting in a relatively stronger positive linear relationship and explanation rates. The relatively weak results of both Multiple R and R Squared is, however, somewhat to be expected, since it is argued, that a single-variable regression analysis would generally show relatively low numbers for these statistical measures, as the returns of the assets are impacted by an infinite number of factors, that all probably lacks explanatory/prediction power when analyzed alone in a single-factor model. Therefore, since the

goal and intention for this section is not to create a multi-variable regression analysis that reasonably explains the returns of the assets, but instead to solely focus on the impact of CPI and thereby the assets inflation hedging capabilities – it is to be expected that these numbers will tend to be relative low, which is a factor that is considered when the results are analyzed and reflected upon.

The P-value is a fundamental concept in statistical testing and is used to analyze the probability of observing results as extreme, or even more extreme, than the ones obtained in the data. The P-value is always considered and compared to the predetermined significance level, typically 0,05 (5%), to assess whether the variables are statistically significant. *Table 14* shows extremely high P-values which are far from the typically used significance level of 5%, indicating that there is not enough evidence to conclude that the independent variable has statistically significant impact on the dependent variables. While the P-values is affected by numerous factors, one of the most predominant factors is the sample size, as when the sample size increases, the impact of random error is reduced (Mcleod, 2023). Therefore, the very high and insignificant P-values are partly due to the very limited data foundation for the regressions analysis. The sample size is, however, not the only factor to influence the P-values, since it is also affected by the magnitude of the relationship between the variables, reflected in the results of the regression coefficients, where the effect size, meaning how extreme the values are – either negative or positive – is affecting the P-values positively.

The coefficients are an important statistical measure to reflect upon potential hedging capabilities, since a positive coefficient reflects the expected change in the dependent variable, being the returns of the assets, by changes in the independent variable – the Headline inflation. Reflecting upon the numbers from the output, the most extreme value is seen in the *Lodging/Resort* sector, which also have the highest Multiple R, R Squared, and lowest P-Value, indicating most statistical significance. However, since the value of the coefficient is negative, an increase in Headline CPI is expected to negatively impact the returns. *Infrastructure* and *Self-Storage*, on the other hand, are showing the most significant (positive) numbers, indicating some sort of inflation hedging capabilities, when compared to the other assets. *Gold*, which is often seen as a traditional inflation

hedge, is the only other assets outside of REITs which are shown to have a positive coefficient value, however, less significant that many of the REIT sectors – especially *Infrastructure* and *Self-Storage*.

Core Inflation

Table 15 - Core inflation regression

Core Inflation Regression	*Multiple R*	*R Square*	*P-Value*	*Coeffecients*	*Observations*
Office (REIT)	0,2017	0,0407	0,3033	-6,6924	28
Industrial (REIT)	0,1477	0,0218	0,4533	-5,3875	28
Retail (REIT)	0,2942	0,0866	0,1286	-8,2758	28
Residential (REIT)	0,1294	0,0167	0,5117	-3,3008	28
Healthcare (REIT)	0,1884	0,0355	0,3371	-5,7424	28
Lodging/Resort (REIT)	0,2843	0,0809	0,1425	-12,0693	28
Self Storage (REIT)	0,0541	0,0029	0,7846	1,7410	28
Infrastructure (REIT)	0,0252	0,0006	0,8987	-0,8513	28
Data Centers (REIT)	0,0985	0,0097	0,6179	-3,3162	28
S&P 500	0,2010	0,0404	0,3052	-4,6088	28
Gold	0,0077	0,0001	0,9689	-0,1550	28
TLT	0,0105	0,0105	0,6040	2,0992	28

Table 15 above, containing the statistical results of the Core Inflation regression analysis, shows quite different results from the Headline Inflation analysis. First, the Multiple R numbers remain to show a relatively weak correlation across all assets. However, when compared to the results from the Headline Inflation regression, a stronger correlation is evident. The REIT sectors of *Retail* and *Lodging/Resort* show the highest Multiple R values, indicating a stronger linear relationship. The R Squared numbers also remain relatively low, however – as previously mentioned – these must be seen in the context of the purpose of the analysis. Due to the relationship between Multiple R and R Squared, the same picture seems to be drawn for this statistical measure. The results from the R Squared ranges from almost 0% for *Gold* and upwards to 8,66% for *Retail,* indicating that the Core inflation has close to no explanatory power of the variability for the *Gold* returns, while the opposite is true for the *Retail,* as well as some of the other REIT sectors.

Reflecting upon the coefficients, the vast majority of the assets show negative values, indicating that when Core inflation increases, the returns of most of the assets tend to decrease, which is not at all surprising. Noticeably, *Retail* and *Lodging/Resort*, which had the most sensitivity to changes

in Core inflation, also have the most negative coefficients. This essentially means that changes in Core inflation is likely to affect these sectors the most – and negatively. The reverse seems to apply for *Self-Storage*, which has a positive value, and can thereby be expected to be positively affected by increases in Core inflation. The only other asset with a positive value is *TLT*, which is expected, since *TLT* reflects the Treasury Bond Yield, that naturally increases in periods with an increase in Core inflation, whereas the value of bonds decreases. The coefficient of *Gold* is close to zero, indicating that Core inflation has close to no effect on the returns of *Gold*. This might be explained by the characteristics of *Gold* and its ability to serve as an alternative store-of-value. The P-values are once again above the traditionally used significance level of 5%, meaning that Core inflation – as a single variable factor – cannot be acknowledged as a significant statistical indicator. The values are, however, lower for Core inflation when compared to Headline, while still suffering for the limited sample size for the regression analysis.

Energy Inflation

Table 16 - Energy inflation regression

Energy Inflation Regression	*Multiple R*	*R Square*	*P-Value*	*Coeffecients*	*Observations*
Office (REIT)	0,2573	0,0662	0,1863	0,6547	28
Industrial (REIT)	0,1383	0,0191	0,4826	0,3871	28
Retail (REIT)	0,1095	0,0120	0,5790	0,2363	28
Residential (REIT)	0,2280	0,0520	0,2433	0,4461	28
Healthcare (REIT)	0,2774	0,0770	0,1529	0,6487	28
Lodging/Resort (REIT)	0,0693	0,0048	0,7261	0,2256	28
Self Storage (REIT)	0,1922	0,0369	0,3272	0,4745	28
Infrastructure (REIT)	0,2176	0,0474	0,2659	0,5636	28
Data Centers (REIT)	0,0916	0,0084	0,6430	0,2365	28
S&P 500	0,0813	0,0066	0,6810	0,1430	28
Gold	0,0865	0,0075	0,6615	0,1333	28
TLT	0,0094	0,0094	0,6238	-0,1523	28

The statistical results for the Energy inflation regression models, shown in *Table 16* above, present yet another perspective to the inflation hedging capabilities of REITs. First, reflecting upon the Multiple R and the R Squared values, variations are once again present. *Retail* and *Lodging*, which had the highest Multiple R and R Squared values in the Core inflation regression analysis, are now showing some of the lowest values amongst the REIT sectors, indicating a relatively weaker linear relationship and explanatory power. *Office* and *Healthcare*, on the other hand, have the highest

Multiple R and R Squared values, indicating that Energy inflation better explains the variance of the returns for these sectors. REITs are generally showing higher relative values for both Multiple R and R Squared, when compared to the broader stock market (*S&P 500*), commodities (*Gold*), and *TLT*, meaning that the independent variable – Energy Inflation – better fits the observed variance for the REIT sectors. The coefficients almost entirely reflect positive values across the different asset classes, where only *TLT* shows a negative value. These results are a bit surprising, however, an explanation could be that a general rise in Energy inflation tends to indicate signs of strong economic growth. The P-values continue to indicate statistical insignificance on the 5% confidence level, meaning that Energy inflation does not have a strong predictive power for explaining the variations in the returns on a general level. The P-values of *Office* and *Healthcare* is, however, substantially lower than the remainder of the dependent variables, which indicate a stronger relative prediction accuracy for these sectors. The values are, once again, substantially affected by the limited data foundation in terms of sample size.

7.4. Partial conclusion

The conducted regression analysis led to several interesting findings regarding the inflation hedging capabilities of REITs. First, from the Multiple R and the R Squared values, it was found that both Headline, Core and Energy inflation – in a single-variable regression model – had low general explanatory power and goodness-of-fit, since only a modest part of the variance in the dependent variables, being the different assets, could be explained by the independent variables, being Headline, Core and Energy Inflation, respectively. However, as mentioned, these results must be evaluated with care and respect to the context and the purpose of this analysis, which essentially was to evaluate only on the specific impact of inflation, with the purpose of illuminating potential inflation-hedging characteristics of REITs. Therefore, relatively low Multiple R and R Squared values were to be expected, as financial returns are impacted by a wide range of factors that naturally lack explanatory power when analyzed alone. We were likewise able to conclude that the P-Values, in all regression models, were generally far above the traditional confidence level of 5%, strongly indicating a lack in evidence towards concluding any statistical significance in the impact of the independent variables. Since the P-value is greatly impacted by the data foundation, it was deemed highly apt that the very limited sample size had severely influenced this insignificance.

Despite the overall insignificance, variations were indeed evident, strongly indicating that other factors – such as the strength of the relationship between the independent and dependent variables – did also have significant impact on the values. Therefore, despite the overall insignificance, the results provided relevant and meaningful data to analyze, reflect and discuss upon.

On a more specific level, we found that the results for the Headline inflation regression models were of most statistical insignificance, and thereby the hardest to draw conclusions upon. This was, however, to be expected, since the Headline inflation includes all inflation factors, which naturally limits the relative impact on the dependent variables. However, the results indicated the best explanatory power on the REIT sectors; *Lodging/Resort*, *Self-Storage* and *Infrastructure*, as these sectors were found to have the highest R Squared values, lowest P-values, and the most substantial coefficients. *Self-Storage* and *Infrastructure* both had positive coefficients, suggesting that an increase in Headline inflation would tend to affect these sectors positively, showing positive signs of inflation hedging capabilities. The results from the Core Inflation analysis were generally more significant when compared to the results of Headline, indicating a better general goodness-of-fit of the model. We found that the Core inflation had the greatest statistical significance and explanatory power on the REIT sectors of *Retail* and *Lodging/Resort,* which, however, both had negative coefficients. Self-Storage, on the other hand, were the only variable – despite from TLT – that were found to have a positive coefficient. However, the high P-value and low R Squared value made it hard to conclude on potential inflation hedging capabilities on this statistical stand. In general, we were able to conclude, that an increase in Core Inflation impacted the assets negatively. Lastly, from the regressions conducted on Energy Inflation, yet another picture was drawn. In terms of R Squared and P-values, these regressions showed the most statistical significance on a general level, indicating a better explanatory power on the dependent variables. The most significant results were found for the REIT sectors of *Office* and *Healthcare*, which had the highest R Squared and lowest P-values. However, despite *Lodging/Resort* and *Data Centers*, all REIT sectors had relatively significant results, when compared to the regressions of Headline- and Core Inflation. Surprisingly, we were able to conclude that all dependent variables –

besides from *TLT* – had positive coefficients, indicating that an increase in Energy Inflation tends to positively affect the assets.

8. Discussion

The authors of this thesis have sought to critically reflect upon and discuss potential limitations and restrictions of the methodological approaches utilized throughout the entirety of the paper. Within this discussion, we seek to first summarize on already discussed matters of significance, while commenting on the specific mitigating actions that has been carried out. Secondly, the use of the Mean-Variance Optimization Model will be discussed, specifically focusing on the limitations of the model, the prerequisite assumptions that the model assumes, while also relating the discussion to the results obtained in the empirical analysis. Furthermore, we seek to delve into potentially key limitations of using REITs as the sole representation of real estate in both the conducted portfolio optimization, and especially in the inflation hedging analysis, by reflecting upon both methodological and practical implications of this grazing. Conclusively, future recommended research points are highlighted with the intention of creating full disclosure of the current limitations and gaps inherent for this study, while also suggesting potential avenues for future research and thus encouraging further exploration and expansion of research within this topic.

8.1. Bias and Timeframe limitations

The mitigation of bias has been an important matter throughout the entirety of the process. The authors have continuously been seeking to minimize both internal and external bias by cross referencing, using reliable and acknowledged sources for data collection, as well as refraining from using opinion-based qualitative literature from Nareit and other external sources with such relation. We strongly believe that the first and most crucial part of tackling research bias is by acknowledging its existence, while also acknowledging the fact that not all bias is avoidable and requires mitigating actions to minimize. As noted in the methodology chapter, the external data that constitute the data foundation for both the portfolio optimization and the following inflation hedging analysis have been obtained through reliable external sources such as Bloomberg and

Yahoo Finance. Additionally, with the purpose of ensuring the highest objectivity level possible, the data has been cross-referenced between multiple reliable sources, including the abovementioned, to preserve a high-quality and unbiased data foundation for the analysis. Furthermore, potential bias related to the asset composition constructed for the portfolio optimization has been acknowledged and reflected upon. With the purpose of minimizing the selection bias for this process, the construction of the asset composition has been performed with respect to existing literature within this area to include a broad range of highly diverse asset classes to preserve diversification capabilities.

The choices that center around the timeframes of the conducted analyses is deemed to have become an impactful factor for the results obtained since both the portfolio optimization and the inflation hedging analysis relies on historical return data. As of the portfolio optimization, a relatively long timeframe was argued to entail a more solid data foundation for the construction of the optimal portfolio. While we stand by the choice and the arguments behind it, we are aware that even minor changes in the timeframe could potentially affect the results significantly. Thus, an alternative approach with a shorter timeframe would create another perspective to the obtained results and including both a short-term and long-term perspective might have drawn a more comprehensive picture of the performance of REITs and possibly impacting the current optimal allocations. In terms of the inflation hedging analysis, the timeframe for the analysis was chosen to include only a short-term perspective. The primary reason for this choice is related to the recent inflation rates, which has been abnormally high for the included period. Thereby, we believe – with respect to the purpose of the analysis – that focusing solely on this high-inflation period was the best approach. However, since it was not possible to collect daily return data for the REIT sectors, the choice of relying on such a short timeframe were found to significantly influence the data foundation, and consequently, the statistical significance of variables within the regression model.

8.2. Modern Portfolio Theory implications

The portfolio optimization has been constructed using the Mean-Variance Optimization Model (MVO), which is an essential part of the broadly used and acknowledged Modern Portfolio Theory

(MPT) (Markowitz H. , 1952). This revolutionary framework for portfolio construction and optimization has become a well-known and commonly used approach within the field of finance. This part of the discussion will seek to critically discuss and reflect upon the fundamentals of the model with a specific focus on the key assumptions, and their relevance and implications in real-world applications. One of the key assumptions of MPT is the assumption of efficient markets, which implies complete transparency of information, that available information is accurately and immediately reflected in asset prices, and lastly, that changes in prices occur randomly, making it impossible to beat the market on a consistent basis. In reality, such assumption is not very likely to hold, as fully efficient markets are close to impossible to achieve leading to various market inefficiencies. Furthermore, the MVO model relies on the assumption of normal distribution of returns as a prerequisite for the use of statistical measures, such as standard deviation and expected return, to describe the distribution on the return of the assets. As previously discussed in chapter 6.2.3, asset returns rarely comply with this assumption in the real world. As a mitigating action, the natural logarithm has been applied to the return to convert the data towards an approximately normalization. However, the assumptions are generally far from the reality despite the mitigating actions, which must be taking into consideration when the results are concluded and reflected upon.

The results and conclusion for this paper is solely based on analyses conducted on behalf of historical return data. One of the major critiques of MVO is the use of historical data as an indicator for future performance. The authors of this thesis share this standpoint of critique and acknowledge the fact that the optimal portfolio, constructed in chapter 6, implies a suggested allocation with a great portion of uncertainty and lacking predictive power on the future. The out-of-sample test was conducted with respect to this manner, where the results were found to significantly support this point of critique. While historical returns are argued to provide valuable and relevant insight into past performance, risk, and correlations of the different assets, the beforementioned limitations and challenges inherent in this practical approach are inevitable. Thus, an alternative approach could have included an in-dept analysis of the performance of the included assets on separate, predefined macroeconomic periods of interest, creating insights to the strength and weaknesses of REITs in different economic circumstances. For instance, when

referencing to the findings of the inflation hedging analysis, the signs of inflation hedging capabilities of some REIT sectors could indicate potentially promising returns in a high-inflation period.

8.3. The exclusion of Direct Real Estate Investments

Initially, the motivation and intention for this thesis was to examine the performance and hedging capabilities of both direct real estate investments and publicly traded real estate. However, due to implications in terms of data collection, we found it necessary to focus solely on REITs and thereby demarcate the thesis from including the perspective of direct real estate investments. As presented in section 4.1, direct real estate investments differ significantly in their characteristics and risk-return profile, when compared to the publicly traded REITs, which performance – in many aspects – has shown to be more associated with traditional stocks than traditional real estate. The exclusion of direct real estate investment alternatives is acknowledged to limit the representativeness of real estate as an asset class. This approach has, however, enabled a complete and adequate focus on REITs which has increased the comprehensiveness of the scientific contribution within this narrow scope.

The exclusion of direct real estate is particularly relevant to discuss in the context of the conducted analysis of inflation hedging capabilities. Several studies within this topic have found significant evidence to conclude upon promising results on inflation hedging capabilities of direct real estate. For instance, Demary (2009) found that direct real estate performed best in terms of inflation protection, when compared to REITs and other real estate equities, where *Retail* was found as the worst performing direct real estate sector, and both *Residential* and *Office* implied promising inflation hedging capabilities. Furthermore, as presented in section 7.1, some of the commonly known and acknowledge inflation hedging characteristics of real estate is primarily related to physical asset ownership, as present in direct real estate investments.

8.4. Future research points of particular importance

Conclusively, this section will constitute the authors recommendations towards future research on the topic. We acknowledge that research is an ongoing process, and future additional studies

within the area will contribute to the collective body of the current knowledge. First, the recent surges in inflation rates have made it impossible to include long-term effects on the assets included. Therefore, for future research, we suggest that a long-term perspective of the impact of inflation is sought to be analyzed to collectively present a more comprehensive data foundation to conclude upon. Additionally, to enhance the robustness and applicability of future research, efforts should seek to include and assess comprehensive data on direct real estate investment returns and thereby explore the opportunities of including direct real estate investment in both the portfolio optimization, but especially in the assessment of inflation hedging capabilities of real estate investments. Lastly, by exploring alternative methodologies or proxies for direct real estate returns, future research could help address the data limitations of this thesis, while simultaneously contributing to a more nuanced analysis on the performance of real estate as a complete asset class.

9. Conclusion

The main research objectives of this thesis were to determine whether REITs add performance to a traditional mixed-asset portfolio, while subsequently testing REITs ability to hedge against inflation comparably to other asset classes and traditional inflation hedges.

Concluding on the empirical analysis conducted in Chapter 6; our Mean-Variance Optimization model evidenced no allocation to REITs in the timeframe of 01.05.2007-31.12.2019, however stressed. The initial model added the Nareit ALL REITs index to the asset composition but yielded no allocation regardless of constraints and investor perspectives, instead optimally allocating 64% to mortgage bonds, 25% to Nasdaq 100 Index, 9% to treasury bonds and 2% to gold, with the optimal portfolio achieving a Sharpe ratio of 0,2 based on monthly data. To further test REITs performance ability in the composition, findings from the preliminary analysis in Chapter 4 was drawn upon, adding the REIT sectors of Self-storage, Industrial and Retail to the asset composition, on the grounds of sector performance and diversification characteristics illuminated in the previous chapter. Continuously, no allocation to REITs nor REIT sectors were evidenced in the optimal portfolio of the following model. Reviewing the presented key performance metrics of the assets, Self-storage showed compelling attributes in both mean return and Sharpe ratio, however

not reaching the efficient frontier despite diversification benefits. Instead, Self-storage was represented in the less-optimal portfolios of the “average” and “aggressive” investor perspectives, with allocations of 15% and 21% respectively. At last, an out-of-sample test of the models’ prediction accuracy showed significant limitations of the model and its prediction capabilities, in line with the biggest critique point of Modern Portfolio Theory being trying to predict future return on historical data. Although the obvious limitations of the model are acknowledged, we find grounds for concluding that *REITs cannot add performance to a traditional mixed-asset portfolio* in a historical perspective.

In addition to the empirical analysis of Chapter 6, a linear regression analysis was performed in Chapter 7 on the timeframe of 01.01.2021-01.05-2023, testing for REITs’ inflation hedge capabilities compared to various assets. The analysis was conducted on an individual REIT sector level, once again drawing upon the findings of Chapter 4, while S&P 500, Gold and TLT (20-year treasury bond ETF) were included for comparison. Further, inflation was in the analysis stratified into headline, core- and energy inflation, adding depth and perspective to the findings. Concluding on the statistical significance of the models, all models were statistically insignificant, evidencing low explanatory power and goodness-of-fit. The statistical insignificance was expected, with inflation only being a small factor of a multi-faceted reality affecting asset returns, while simultaneously conducting the computation on a very short time span and a less-than-ideal amount of data points. Putting the statistical insignificance aside, although acknowledging the implications on the research results, the analysis finds that the inflations’ explanatory power of REIT sectors was in general higher, while the coefficients simultaneously proved more significant, indicating a stronger lineary relationship compared to the remaining assets. Furthermore, the REIT sectors of Self-storage and Infrastructure generally showed higher coefficients across the inflation categories, while the coefficients of Gold were surprisingly very close to 0 on all three inflation categories, making the relationship appear completely insignificant in every regard. While findings of the regression analysis provide small indications that REITs, and more specifically individual REIT sectors, do *provide an inflation hedge against recent inflation surges* compared to the remaining assets included, this study *remains inconclusive* on the manner, stressing that the statistical

insignificance of the model do not offer sufficient statistical evidence to conclude upon this part of the research question.

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