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Real Estate as a Hedge against Inflation

Bachelor's thesis

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Declaration of Authorship

I hereby declare that I compiled this thesis independently, using the listed resources and literature. I have not used this thesis to obtain any other academic title.

I agree with my work being used for study and scientific purposes.

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Abstract

In recent years, real estate has gained vast popularity as an investment tool, as it has exhibited attractive returns both in its direct, and indirect form. Investments are generally sought after for their potential for profit generation as well as protection from the loss of purchasing power of one's capital. The extent to which individual assets hedge investors from inflation has become a widely discussed topic with conclusions varying across different studies. This thesis endeavors to update the research by observing asset returns and inflation in 4 countries, the Czech Republic, Switzerland, the USA, and China, and analyzing the performance of individual assets in terms of inflation hedging by employing the latest data in a regression model. The studied period covers Q1 2009 - Q3 2022, where all data are in the form of annual returns, benched by individual quarters. With the main focus on real estate, comparison with the performance of other assets is included, namely bonds issued by governments of the observed countries, REITs performance, represented by the FTSE EPRA Developed Index, and stock returns, in the form of the S&P 500 index. The study then categorizes each investment tool based on its inflation-hedging properties.

JEL Classification	G11, E31, R30, HR39,
Keywords	inflation, hedge, real estate, investment, stock, bonds, REITs, investment return

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Abstrakt

V posledních letech se investice do nemovitostí díky svému potencionálu generovat atraktivní zisky staly oblíbeným investičním nástrojem i diversifikací portfolia. Obecně jsou investice vyhledávány jako zdroj zisku, ale také ochrana proti ztrátě kupní síly kapitálu vlivem inflace. Míra, do které jednotlivé investice poskytují proti inflaci ochranu, podnítila mnoho diskuzí a výzkumů, jejichž závěry se značně liší. Cílem této práce je rozšířit dosavadní výzkum o mezinárodní srovnání vybraných zemí za použití nejaktuálnějších dat. Mezi sledovanými zeměmi jsou Česká Republika, USA, Švýcarsko a Čína, pro něž jednotlivá pozorování pocházejí z období 1. čtvrtletí 2009 - 3. čtvrtletí 2022. Zkoumaná data mají formu ročních návratností, měřených mezi čtvrtletími navazujících let. Přesto že se práce soustředí zejména na nemovitosti, analýza poskytuje srovnání s ostatními investicemi, jmenovitě do dluhopisů, REITs a akcií. Na závěr studie kategorizuje každou investici podle příslušné schopnosti chránit investory před inflací.

Klasifikace JEL	G11, E31, R30, HR39,
Klíčová slova	inflace, nemovitosti, investice, akcie, dluhopisy, návratnost investice, hedge
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Acronyms

REITs Real Estate Investment Trusts

OECD The Organization for Economic Cooperation and Development

CR the Czech Republic

Switz Switzerland

Chapter 1

Introduction

The ability of assets to prevent investors from the loss of purchasing power due to the general trend of rising prices, commonly referred to as *inflation hedging*, has become a topic of extensive discussion and research. Among the most frequently studied assets, real estate exhibits the most persuasive results in terms of inflation hedging, followed by the performance of bonds. Stocks, on the other hand, often fail to incorporate changes in both the anticipated and unanticipated components of inflation, with some empirical results even implying they act as a *perverse hedge*. However, due to the non-uniform approach to proxying the expected rate of inflation and measuring asset returns, namely those of real estate, opinions about hedging qualities of individual assets fail to reach a unified conclusion.

The principal aim of this thesis is to extend and complement the existing research on the effectiveness of real estate as a protection against inflation by using the most up-to-date data, as well as providing a cross-country overview and comparison with other assets. The desired outcome is to determine the extent to which individual assets are able to reflect inflation in their returns, and thus help investors avoid the loss of purchasing power. Based on the performance in the tests, assets should be categorized as complete, partial or ineffective hedges against inflation, or as the case may be due to inconclusive results, indeterminant.

The thesis is structured as follows: Chapter 2 provides an overview of the most relevant literature from this field of research, Chapter 3 describes key concepts used within the test, while Chapter 4 endeavors to explain the logic behind inflation hedging. Individual investment methods are characterized in Chapter 5. The empirical part begins with the description of data and methodology in Chapter 6, while Chapter 7 includes an overview and analysis of the results. The thesis is wrapped up by a comparison and conclusion.

Chapter 2

Literature Overview

Since the 1970s, the relationship between returns on assets and inflation has attracted considerable attention and has inspired numerous researchers to meticulously observe and analyze this phenomenon. Altogether, the studies provide a complex examination of inflation-hedging instruments' behavior, with assets ranging from different types of real estate (residential, commercial, farmland) to stocks, bonds, or human capital. Due to the wide diversification of methods, data sets, and approaches involved in the analysis, the results fail to reach a unified conclusion in terms of the inflation-hedging qualities of individual assets. Overall, real estate performed as a reliable hedge against both expected and unexpected components of inflation in most cases. Up to a few exceptions, the same can be stated about bonds (represented by T-Bills), though the returns were not always as clearly beating inflation as those of real estate. Contrary to that, stocks obtained less favorable results for investors, and sometimes even got the label of a *perverse hedge*. Below is a more detailed overview of some of the most relevant and influential literature from this field of research.

(Hartzell et al. 1987) study the ability of a commingled real estate fund (CREF) to hedge investors against inflation by employing two tests, using T-bills as the basis for expected inflation. One of the tests stems from (Fama and Schwert 1977) method, while the other is based on a non-constant real estate rate, moving along with an integrated moving average process. To analyze the effects of including real estate in an investor's portfolio, they combine real estate with government bonds, resulting in a diversified portfolio comprising more than 300 properties, whose quarterly-period holdings are utilized in the study. In the observed period of 10 years, 1973-83, the inflation rate reached 5% or more, yet the results strongly confirm that a fund containing a variety of real estate assets provides a complete hedge against both expected and unexpected inflation. The same conclusion was reached by (Bond and Seiler 1998), who focus on the effectiveness of residential real estate in hedging against inflation over the 1969-94 period. Their goal is to uncover factors that constitute the nominal returns generated by real estate investments by using the Added Variable Regression Methodology (AVRM). Their approach is unique in the way that they decompose the nominal real estate returns into inflation and non-inflation-related factors, the latter representing the variables of interest. Nominal residential real estate returns are proxied by the percentage change in existing housing sales prices. This gets further regressed on 9 variables, which are assumed to influence the nominal return. The reported results imply that the returns appreciate with increases in inflation. Moreover, the other observed variables showed to have significant effects on house returns, which helps to reveal some factors other than inflation that affect real estate returns, e.g. mortgage rates, construction costs, disposable income, and more. Returns on residential real estate are also analyzed by (Fama and Schwert 1977), who compare them with stocks and bonds. Their analysis stems from Irving Fischer's (Fisher 1930) theory, which explains the nominal interest rate as the sum of an expected real return and an expected inflation rate, provided the market is efficient. The privately held residential real estate return is expressed as the rate of inflation of the Home Purchase Price component of the CPI, Their results indicate that, of all the assets of interest, only private residential real estate provides a complete hedge against both components of inflation between the years 1953-1971. The ex-post-real return to real estate proved to be unrelated to the ex-post inflation rate, as the average nominal real estate return moves proportionately with both components of the inflation rate. The evidence for government debt instruments, bonds, and bills suggests that these assets serve as a complete hedge against expected inflation. Common stock returns show a negative correlation with the expected as well as unexpected inflation rates, albeit the results for the latter proved little consistency. Thus, during the 1953-1971 period, stocks acted as a poor hedge against inflation. At the same time, however, the authors conclude that expected returns on stocks never wandered so low during high inflation as to reach lower values than treasury bill rates. To assess how the hedging qualities differ across individual real estate types, (Rubens et al. 1989) observe portfolios including residential, business, and farmland properties in the time frame 1960-86. To present a clear source of raise in value, they divide asset returns into income and appreciation components. The results for the return measures against actual inflation suggest that only real estate can be considered a complete hedge against actual inflation and T-bills are the only other asset showing at least some hedging capability. The remaining assets exhibit such large standard errors that their ability to hedge against inflation is deemed indeterminant. In the case of expected inflation, a complete positive hedge was only achieved by business real estate and T-bills, while farmland, residential real estate, and long-term financial assets fall within the indeterminant category. Contrary to that, unexpected inflation was positively hedged against by residential real estate and farmland, while being negatively hedged by all stocks and long-term bonds. These two types of assets performed poorly even in the analysis by (Ibbotson and Siegel 1984), who compare them with the hedging abilities of T-bills and real estate in the period from 1947 to 1982. Their real estate composite index consists of business, residential, and farmland properties. Having regressed various assets on inflation, the results indicate that real estate is an excellent hedge against inflation, compared to stocks and bonds which tend to be negatively affected by inflation. In conclusion, the authors emphasize the pricing inadequacies when measuring real estate returns.

Overall, real estate investment exhibits the most attractive hedging qualities among the studied assets. Despite that, REITs, whose underlying asset is real estate, are labeled as a perverse inflation hedge in most cases, with their nominal returns negatively related to both inflation components. Therefore, their behavior resembles that of stock returns, rather than real estate. (Liu et al. 1997) examine this investment tool from the global perspective by studying country-specific real estate trusts and funds as well as stocks of companies engaged in real estate operating/development. Their results confirm the previously held belief that REITs returns exhibit an inverse relationship with changes in the rate of inflation.

This study extends and complements the existing research by updating the time period studied, using the most up-to-date data, as well as providing a cross-country overview and comparison with other assets. Employing the model devised by (Fama and Schwert 1977), the results are used to determine the extent to which individual assets shield investors from both inflation components.

Chapter 3

Key Concepts used in the Text

3.1 Inflation

The phenomenon of inflation has become a widely studied topic in the field of economics, varying in the way individual academics and researchers perceive this concept and what approach they employ in their studies. For instance, the leader of the monetarism school, Milton Friedman, defined inflation as a monetary phenomenon caused by an excessive money supply. (Friedman 1995) This basically forms the gist of monetarist theories about inflation, maintaining the view that increases/decreases in the money supply constitute the most significant factor influencing inflation. They deem all fiscal policies to be irrelevant in efforts to control inflation. (Lagassé , Paul 2000) Contrary to that, Keynesian economists assert that inflation follows from demand pressures in the economy, rather than the money supply, which for them only represents one determinant of aggregate demand. Generally, inflation in economics denotes an overall trend of rising prices in a country's economy. Consequently, this increase leads to a lower purchasing power of money, as each currency unit can purchase fewer goods and services. The price hike usually roots from an increase in the supply of money done by monetary authorities in the form of printing more money, legally devaluing a currency, or through the banking system by purchasing government bonds from banks on the secondary market. Regardless of the exact trigger, money loses its value. Based on the mechanism causing this devaluation, inflation gets categorized into three groups. Demand-pull inflation occurs when consumers' increased spending exceeds the production capacity of the economy, thus creating a demand-supply gap, offset by higher prices. Cost-push inflation often results from a negative economic shock to the supply of key commodities, leading to increased costs for the finished products or services, and driving up consumer prices. Finally, built-in inflation originates from a wage-price spiral, where workers' expectations of a constant upward trend in prices lead to demands for higher wages to maintain their living standards. Consequently, this induces higher prices of goods and services, followed by the exact same procedure. Despite its clear disadvantage of lower purchasing power, an optimal level of inflation encourages spending, stimulates the economy, and leads to appraised asset values. Based on the goods and services contained in the observed basket, various indices are calculated to serve as inflation indicators. Most inflation statistics stem from the Consumer Price Index (CPI) or the Wholesale Price Index (WPI), the latter including items at the producer level, such as raw materials.

3.2 CPI Index

The Consumer Price Index is used by the Bureau of Labor Statistics (BLS) to measure the difference in the prices of consumer goods and services purchased by urban households. These items together constitute a representative basket, whose price fluctuations are observed and recorded over time. The basket contents stem from the Consumer Expenditure Surveys, where the public provides information about their purchases. To collect data about daily-need items purchased frequently, another 12,000 respondents keep diaries listing a complete record of what they bought within 2 weeks. Thereby, individual items get different weights assigned to them to determine their importance in the CPI index. The basket covers all expenditure items, arranged in numerous categories, as well as some government-charged user fees and certain taxes. Each month, the BLS collects a sample of 80,000 prices, factoring in different weights, changes in quality, product features, as well as substitution effects, further providing the numbers with seasonal adjustments. The calculation for annual CPI then follows the formula where the value of the basket in the current period gets divided by the value of the basket in the prior period, multiplied by 100. The resulting number typically exceeds 100, as prices tend to follow an upward trend. To calculate the inflation rate, the BLS then uses the values of the current and prior CPI index. Depending on the selected period, the final number represents the inflation rate, typically expressed in percentages. The main purpose of the CPI data is to provide the government with a basis for its policy actions, further impacting the pace of the economy, mortgage rates, subsidies, financial market as well as the labor market, where an inverse relationship is believed to exist between the CPI index and unemployment rate, i.e., by boosting the economy, CPI hikes will likely occur in tandem with the strong labor market, marked by low unemployment, such as the US situation after the COVID-19 pandemic. Despite its indisputable importance for the world economy, the index has received criticism for either under or over-estimate the inflation rate. Remarks have also been made about the absence of third-party reimbursements for health care, as the index only considers consumer spending. Moreover, the widely used CPI-U index only takes the urban population into account, thus failing to properly represent all demographic areas.

3.3 Inflation Hedge

The main purpose of investing in a financial market is to generate profits with littlest risk possible. Investors typically purchase financial assets and hold them for certain time in pursuit of a positive revenue, which arises when the price of the asset at the end of the holding period exceeds the one at the opening. Though some investments may seem to provide a decent return at first sight, once inflation gets accounted for, the investor might eventually incur losses. Inflation hedging is an investment strategy aimed at protecting the value of an investment from a decreased purchasing power due to price level hikes. There are certain assets endowed with the ability to outperform the market during periods of inflation. The most common strategies for beating inflation include buying bonds issued by the government, whose principal and interest payments are indexed to inflation in a way that they fluctuate in tandem with the changes in the CPI. A typical example of these is represented by the Treasury Inflation-Protected Securities (TIPS) issued by the US Government. However, in case interest rates increase, prices of fixed coupon bonds go down in value. Adding stocks or real estate to one's portfolio might significantly strengthen inflation protection. In general, diversification of investments across different types of assets represents a widely recommended and employed investment strategy.

3.4 Fisher Effect

The economic theory, composed by the American monetary economist Irving Fisher (1930), states that nominal interest rate can be expressed as the sum of an expected inflation rate and expected real return, regardless of asset type. Hence, provided the market processes all information available at time t-1 rationally and efficiently, the price of any asset will be set in a way that the expected nominal return on the asset of interest from time t-1 to t equals the sum of the expected real return and the best possible estimate of expected inflation in this time interval. (Fama and Schwert 1977) The gist to be apprehended is that the market uses information available at time t-1 to accurately assess the expected inflation rate and to appropriately determine the expected rate of real return on the given asset, while taking potential risk premium into account. This theory has found significant use in banking, where it essentially means that real interest rate depicts the purchasing power of money as it grows over time, while nominal interest rate mirrors the financial return obtained on the given money deposit. Extending this even further, the relationship plays a crucial role in monetary policies, as it clearly implies that an incentive from a central bank, leading to higher inflation, will result in an increase in the nominal interest rate.

3.5 Investment Returns

The return on investment, commonly known as ROI, evaluates the efficiency of an investment by calculating the amount of return relative to the initial cost. The formula involves subtracting the cost of investment from the current value of the investment, the whole divided by the cost of investment. The resulting percentage value can easily be compared with those of other assets, thus providing investors with an insight into the profitability of investments in different kinds of assets.

3.6 Bonds

Bonds are debt securities, allowing borrowers to raise capital from investors in return for a fixed coupon payment. Typical issuers of this financial instrument include governments, states, and municipalities, aiming to finance large projects and operations, or companies thriving to expand their business, acquire new property and equipment as well as conduct research and development. The borrower issues bonds at a specific face value per bond, which also represents the amount that will be paid back to the lender once the bond matures. Throughout the holding period, the issuer pays an interest rate to the bondholder, denoted as a coupon rate. Intervals of this payment may differ, however, the most common is semiannual frequency. The maturity date then marks the day the lender receives the original face value of the asset. Nevertheless, it is not obligatory to purchase and hold the bond until this time. In fact, bonds get traded daily on the open market, where, by factors of supply and demand, their price fluctuates. Moreover, the current price is also affected by the prevailing interest rate in the economy, where fixed-rate corporate bonds compete with those issued by the government; if the latter comes with a lower coupon rate, investors in the market will bid up the price of the corporate bond until it reaches a premium equalizing the economy's interest rate. Thus, bond prices and interest rates show an inverse kind of relationship. Bond investments are closely intertwined with the term yield to maturity, representing the total return expected, should the bond be held until the maturity date. Expressed as an annual rate, the YTM then represents the internal rate of return on the investment. The main purpose of this figure is to provide a comparison between individual bonds relative to others on the market. Overall, bonds tend to fluctuate less than stocks and should optimally make up at least some part of a diversified portfolio.

3.7 Stocks

Stock, otherwise known as equity, is a security representing a partial claim to assets and profits of the issuing corporation, as indicated by the term for stock units, the so-called *shares*. Companies issue stocks to raise capital to grow their business or finance new projects. The number of stock units held by a shareholder relative to the total number of outstanding shares determines the proportion of their ownership. From a legal point of view, corporations are treated as legal persons and their property is legally separated from that of shareholders. Based on the type of stock, ownership comes with the right to receive potential dividends, sell shares on the market, and the voting power, which increases with the number of stock units held. There are two main types of stocks, common and preferred. The former typically grants the investor the right to vote at meetings and receive dividends, while the latter generally provides no voting rights, however, investors have higher claims on assets and precedence in case of company liquidation due to bankruptcy. Stock investors' principal aim is to benefit from the profits generated by the company, whose amount also lays the foundation of the stock value. In some cases, stock issuers pay out regular dividends, thus providing additional profits for the investors. Should the company prefer to reinvest the money into growth and development, the retained earnings still remain reflected in the stock value. The major US stock exchanges include the New York Stock Exchange (NYSE) and Nasdaq.

3.8 Real Estate

Real estate refers to physical land with all the structures attached to it or built on it. The term gets often interchangeably used with land and real property, although the true meanings may slightly differ; land encompasses the airspace and the earth's surface down to the center, together with all minerals, trees, and water, whereas real property covers real estate, plus ownership and usage rights. Real estate can be further subdivided into 5 main categories, based on the purpose of use. These include residential, commercial, industrial, land, and special-purpose real estate. Due to its ability to offer steady income and capital appreciation, real estate has become a popular investment method to diversify investors' portfolios. Real estate investment will be further elaborated on in later chapters of this thesis.

3.9 REITs

Real estate investment trusts are companies engaged in owning or financing income-producing real estate throughout different property sectors. They allow anyone to invest in real estate portfolios through purchases of stocks, mutual funds, or exchange-traded funds (ETFs). Equity REITs, which this thesis focuses on, operate or own income-producing real estate, thereby generating income, which gets distributed to investors in the form of dividends. They are required to pay out at least 90% of their income to shareholders, who, in turn, are committed to paying the income tax on these profits. REITs have historically proved to ensure a steady income while staying almost uncorrelated with other assets, which makes them a popular portfolio diversifier.

Chapter 4

Hedging against Inflation: Theory

For investment assets to serve as good inflation hedges, it is essential that a positive correlation exists between their nominal interest rate and inflation. The theory by Irving Fisher suggests that the nominal interest rate can be expressed as the sum of the expected real return and inflation rate (Fisher 1930), meaning the expectations about nominal returns contain the market assessment of the expected inflation to a certain extent. Hence, should the market efficiently and rationally process the information available at time t-1, asset prices should be set in a way that the sum of the expected real return and the most accurate estimate of the inflation rate in the time period from t-1 to t will total the expected nominal rate of return in the same timeframe. (Fama and Schwert 1977) This can be described by the equation:

$$E(N_{kt}|\theta_{t-1})) = E(R_{kt}|\theta_{t-1}) + E(\delta_t|\theta_{t-1}) \quad (1)$$

where N_{kt} represents the nominal return on asset k from time *t-1* to *t*, R_{kt} stands for the expected real return on asset *k*, given the information available at time *t-1* and δ_t is the best possible estimate of the inflation rate, based on information available at time *t-1*.

This suggests that the market uses information available at the prior period to precisely assess the expected rate of inflation and to form expectations about the real return on asset k, taking possible risk adjustments into account, which differs across individual asset types. Consequently, the market determines the price of the asset so that equation (1) holds, that is, the sum of the expected inflation rate and real return forms the expected nominal rate of return. The relationship between nominal return and inflation rate may then be captured by estimating the following regression model:

$$N_{kt} = \alpha_k + \beta_k(\delta_t|\theta_{t-1}) + \epsilon_{kt} \tag{2}$$

where ϵ_{kt} represents an independent and identically distributed error term with zero conditional mean and constant variance. Given this regression estimates the conditional expected value of the dependent variable, the nominal return rate, as a function of the independent variable, the expected rate of inflation, a statistically significant coefficient on $beta_k$ of the size of 1 is compliant with the hypothesis that the expected nominal return on asset k fluctuates proportionately with the expected inflation rate in a one-to one correspondence.

To fully assess the hedging capabilities of assets, it is essential to investigate the relationship between asset returns and the unexpected component of the inflation rate between *t-1*and t as well. Equation (1) may thus be expanded followingly:

$$E(N_{kt}|\theta_{t-1}, \delta_t)) = E(R_{kt}|\theta_{t-1}) + E(\delta_t|\theta_{t-1}) + \gamma_k[\delta_t - E(\delta_t|\theta_{t-1})] \tag{3}$$

which may be estimated by the model

$$N_{kt} = \alpha_k + \beta_k(\delta_t|\theta_{t-1}) + \gamma_k[\delta_t - E(\delta_t|\theta_{t-1})] + \mu_{kt} \tag{4}$$

The hypothesis that the average nominal return on asset k varies with the unexpected rate of inflation in a one-to-one correspondence then requires that the coefficient γ_k be statistically indistinguishable from 1. According to Fisher's theory, all assets should have the coefficient for the expected inflation rate, that is, β_k, equal to 1. However, the anticipation of the coefficient size for the unexpected inflation rate, γ_k, largely issues from intuition and differs across individual assets. For instance, nominal bills maturing at time t have a predetermined nominal value at time *t-1*, thus, the return from time *t-1* to t has little flexibility and cannot respond to the unexpected level of inflation. Contrary to that, common stocks and real estate are believed to provide a hedge against inflation, meaning the coefficient γ_k should attain positive values. The obtained results may then be used to evaluate the hypothesis about asset hedging capabilities. A β_k coefficient of 1 implies the asset provides a complete hedge against expected inflation, meaning its expected nominal return fluctuates in tandem with the expected inflation rate in a one-to-one ratio, and there is no correlation between the expected inflation rate and real return on the given asset. A coefficient of γ_k equal to 1 implies the same conclusion for the unexpected inflation. An asset is considered a complete hedge against inflation, when both coefficients are equal to one, that is, $\beta_k = 1$ and $\gamma_k = 1$. In that case, nominal return varies in one-to-one correspondence with both components of the inflation rate, and the *ex post* real return and inflation rate are uncorrelated. However, this does not necessarily mean the real return stays constant as other, inflation unrelated, factors may affect the nominal returns in large or small magnitude relative to the changes caused by inflation. This essentially connotes that an asset might seem to hedge against inflation completely (have both coefficients equal to 1), while at the same time, inflation would only explain a small part of the fluctuation in nominal returns. Hence, the variance of the real return, represented by the variance of the real disturbance μ_{kt}, might be substantial relative to the variance of both components of the inflation rate.

Chapter 5

Investment

5.1 Investment and Uncertainty

An investment is a commitment of funds for a time period with the aim of deriving a return high enough to compensate an investor for the time their funds are committed, and the risk involved. (Reilly et al. 1970) This essentially means employing one's capital, such as effort, time, and mostly money, with the outlook of a higher future payoff. The term also refers to the core medium or procedure intended to appreciate over time, e.g., stocks, bonds, real estate, and other types of investment. Clearly, any good or asset purchased is then not intended for consumption, but rather to be held over the time deemed necessary for the underlying factors, mostly economic, to make its value increase. These variables are seldom influenceable by individuals while being believed to take major control over asset value fluctuation.(Benjamin et al. 2001) For instance, about 60% of the variance in real estate prices is assumed to be caused by macroeconomic variables, such as the nominal interest rate.(McCue and Kling 1994) Consequently, all types of investments carry a certain level of inherent risk, also known as financial exposure, indicating the amount an investor may lose, should the actual outcome of the investment negatively differ from the expected gains.

In order to assess the likelihood of an adverse event, which may eventually lead to lower profits, or even losses, risk analysis is often employed to identify imminent risks, measure their levels, and suggest a solution to mitigate the unfavorable outcome. Based on the nature of the analyzing procedure, either a quantitative or qualitative method is applied.

Investors and economists often perceive investment as a sacrifice of the present value for future uncertainty, offset by a reasonable amount of return reflecting, among other things, the level of risk and liquidity. Thereafter, these three factors, i.e., the expected risk, liquidity, and return, represent the main variables, upon whose performance an investor forms their decision. Typically, higher returns get associated with higher risks taken and vice versa.(Harrington 1983) Based on the intended time horizon, investors also take the level of liquidity into account, which expresses the promptness and difficulty to convert the given instrument into money (or another convertible asset). Although liquidity and other financial factors represent only a small fraction of the extensive list of variables investors consider, they accompany a large majority of financial instruments. (Bradbury et al. 2019) and dominate as short-term investment influences. (Meyer and Kuh 1957)

Based on one's priorities, goals, and intentions, market participants may opt for the most convenient type of investment, that balances the desired profit with the level of risk they are willing to take. The next section provides an overview of the three most common ways individuals use with the aim of capital appreciation.

5.2 Stock Investment

As defined in the first part of this thesis, stocks are securities representing fractional ownership of the issuing corporation. These shares get traded daily on the stock market, comprising several stock exchanges, such as the leading U.S. New York Stock Exchange (NYSE) or the Nasdaq. Although there exist different types of stocks, this work will focus on common stocks.

5.2.1 Stock Market

The stock market represents an association of traders, who buy and sell shares of stocks, either in the form of securities listed on the public stock exchange or shares of private companies traded through equity crowdfunding platforms. The bourse, also referred to as a stock exchange, links together investors, governments, and companies, providing them with a marketplace to close their mutual deals. Due to the open-market character and rigid regulatory rules, the exchange assures its participants of a fair price, transparency, and a high level of liquidity. Although most exchanges now only operate electronically through a computer network, there still exist some physical bourses, where transactions are agreed upon and implemented on a trading floor by the so-called open outcry, allowing buyers and sellers to compete for the best price order in person. The U.S. leading bourse, the NYSE, combines these two approaches, thus operating in a hybrid form, both online and physically. Opposed to that, the NASDAQ exchange only works electronically, however, the principles remain unchanged.

When considering the optimal stocks to purchase, investors may base their decisions on technical, or fundamental analysis. The latter refers to a study of the overall economy, financial strength, or industry environment and involves the scrutiny of assets, liabilities, earnings, and expenses, while the former stems from observing statistical trends, such as the fluctuation of stock prices and volumes. The goal of the fundamental analysis is to calculate the real value, considering both macroeconomic and microeconomic variables, thus identifying stocks currently traded at a lower, or higher price than the *fair value* as indicated by the market and state of the company. Opposed to that, rather than aiming to determine the intrinsic value of the stock, the technical analysis attempts to identify trends and patterns discernible from charts to predict future stock behavior.

The value of a company, as determined by the stock market, is referred to as market capitalization, or market cap, calculated by multiplying the number of shares outstanding by the current stock price. Based on this number, companies get categorized as small-cap, mid-cap, or large-cap ranging from ($300 million -$2 billion), ($2 billion - $10 billion), ($10 billion +) respectively. Investors typically view larger-cap companies as safer, as it indicates a stable, well-established company. The first market cap is established during the initial public offering (IPO) on the primary market, representing the process when a privately held company issues its share to the public. Becoming a public company involves the transfer of private ownership to shareholders purchasing the stock. The opening price then depends on the IPO valuation, provided by an investment bank, stemming from factors such as demand, industry comparables, growth prospects, or corporate narrative. Once the company has sold its initial offering on the primary market, securities may further be traded on the secondary market, including major ones such as the NYSE, the LSE, or the Nasdaq. From that moment on, the share's price fluctuates as investors trade the shares among themselves. The highest price a buyer is currently willing to pay per share is referred to as a bid price, rising with an increasing number of investors interested in buying. On the other side of the market, the lowest price a seller will accept per share is called the asking price, representing market supply; the more superfluous the stocks are, the lower the price will fall, as sellers find it hard to find buyers. Naturally, the bid price exceeds the asking price, resulting in a gap known as the bid-ask spread. A wide difference between these two indicates an illiquid market, where traders struggle to agree on a deal favorable for both. Contrary to that, a tight spread typically means buyers and sellers mutually trade with ease.

5.2.2 Stocks and Inflation

Though the price is ultimately set by the supply and demand equilibrium, these are influenced by a wide variety of daily economic events, some having a larger effect than others. (Chen et al. 1986) Inflation belongs to one of the most discussed drivers of macroeconomic policies, impacting the outlook for companies' profitability and investors' expectations, eventually reflected in the stock market. A moderate level of inflation is considered vital for sustained economic growth. For instance, the Fed strives to keep inflation at its target of a 2% annual growth. Ideally, the stock market should see its prices rise at around 1% - 3% per year, proportionately to the inflation rate, thus creating a healthy environment with a relatively unchanging dollar value, stable demand for goods and services as well as rationally foreseeable prices. When inflation exceeds the anticipated level, the process itself might indicate a rise in corporate profits, thus boosting stock prices. However, governments endeavor to keep up with their target and react to an unprecedented change in the price level accordingly. A widely used remedy is to cool down the economy through higher interest rates. Although it usually takes longer for the change in interest rates to impact the whole economy, the stock market's reaction tends to be immediate. Illustrated on the US, when the Fed pursues a hawkish policy of interest rates, borrowing becomes more expensive for financial institutions, and ultimately, through a ripple effect, for all consumers and companies in the economy. Consequently, consumers are left with lower disposable income, resulting in lower spending, which causes businesses' revenues and profits to decrease. This, in turn, may lead to bearish market sentiment on the stock market, as investors alter their expectations about the future growth and profitability of individual corporations. Particular sectors react more sensitively to changes in the Federal Funds Rate than others. (Garg 2008) This leads to the common diversification method of constructing a portfolio by combining stocks across different industries, though there has been some controversy about how many stocks constitute a diversified portfolio. A widely accepted theory states there is no point in increasing a portfolio size beyond 10 or so securities (Evans and Archer 1968) However, this number differs across studies, thus failing to provide a unified answer.(e.g. (Statman 1987))

Nevertheless, these immediate changes tend to last only temporarily and, over the long time horizon, adjust according to the ongoing world events and expectations. In general, inflation raises doubts and uncertainty about future interest rates, thus contributing to higher market volatility. Whether the stock market is able to beat inflation with its returns will be further explored in the practical part of this thesis.

5.3 Bond Investment

Bonds represent a debt-raising financial instrument providing borrowers with a loan from investors, who then become debtholders, or creditors. They are widely used by governments, companies, and other entities with the aim of raising capital for new projects, growth, debt refinancing, and other purposes. The issued bond contains the loan terms, including interest payments to be executed (based on the coupon rate), and the maturity date, at which the principal amount must be returned. The face value, also called par value, represents the price determined by the issuing institution, which is obliged to repay this amount on the maturity date. As a premium for the loan, investors receive regular payments set by the fixed coupon rate, as stated on the issue date of the bond. This yield is obtained by dividing the coupon payments by the face value of the bond. For example, a \$1000 par-value bond with \$40 annual interest payments will have a coupon rate of 4%. The amount strongly depends on the prevailing rate of inflation, the sum of which, together with the interest rate, constitutes the rate of nominal return. Therefore, higher inflation rates push the nominal yields upwards and vice versa. Another factor taken into account when determining the yield is the credit rating of the issuer. While U.S. government securities represent a risk-free asset, corporate bonds typically offer higher yields for the additional risk of a default taken. The creditworthiness originates from an official rating from AAA to D executed by qualified agencies. Nominal yield may differ from the current yield, based on the actual price someone would purchase the bond on the free market. Bonds' market value accounts for multiple factors, such as the prevailing interest rate, the financial health of the issuer as well as the time to maturity. Bonds sold at a price above their face value are referred to as premium bonds. This situation typically arises when the bond's rate exceeds the current market interest rates, or in case of excellent credit rating of the issuing company. Therefore, there exists an inverse relationship between bond prices and interest rates. Falling interest rates in the economy cause bond prices to increase, as their fixed coupon outperforms that of the newly issued bonds, thus turning the *older* bonds into a more attractive, premium product, resulting in a price increase on the secondary market. The same principle applies to raising interest rates, enticing investors to buy newly issued bonds promising higher coupons, which in turn downgrades the older bonds with lower yields, leading to their depreciation on the market and sales at a discounted price. Apart from nominal and current yields, calculations of yield to maturity (YTM), bond equivalent yield (BEY), and effective annual yield are also implemented for an assessment of investment return.

The YTM stands for the anticipated return in case an investor holds the bond till its maturity date and corresponds to the internal rate of return expressing the profitability of investments. The calculation follows from the formula for the current rate with the difference that the YTM factors in the time value of money. The rate is calculated using the same concept as net present value, which, in simple terms, represents the difference between today's value of expected cash flows and today's value of invested cash. When setting the NPV equal to zero, the resulting yield represents the internal rate of return on investment, equivalent to the YTM. Bond equivalent yield (BEY) allows investors to compare the performance of fixed-income securities, which last for a minimum of one year and produce annual yields, with the yield of discounted, no-coupon bonds issued below par. The BEY formula subtracts the market price of the bond from the face value and multiplies the result by 365/d, where d stands for the number of days until maturity. This essentially annualizes the discount bond and produces a rate of return comparable with traditional, annual-coupon bonds. The effective annual yield then assumes that the coupon is selling at par and all coupon payments are reinvested at the same interest rate. However, due to frequent changes in interest rates, this is not always possible. Altogether, different kinds of yield are used to assess and compare the profitability of individual investments.

5.4 Real Estate Investment

Real estate investment refers to the purchase, selling, or management of properties intended for other purposes than a personal primary residence. Although there exists a wide range of real estate types to invest in, the most common properties may be divided between the residential and commercial categories. Residential investment involves property or land intended for living, as specified by local zoning laws. Contrary to that, commercial zoning sets the land use purpose as for operating a business generating revenue, such as an office, factory, warehouse, or a retail store. Investors seek real estate for numerous advantages, such as its tendency to steadily appreciate over time, thus providing the opportunity of capital gains, represented by the difference in purchase, and selling price, significantly influenced by the supply and demand in the market. Another way to benefit from owning real estate is to receive rental payments as pre-determined by a rental agreement or lease, which, in contrast to the volatile stock market, represents a steady stream of income.

Due to its low correlation with stocks and bonds, real estate is often considered a good diversification in one's portfolio. However, the issues of appraisal smoothing and imperfect marketability make it difficult to directly compare these three investment types.(Ibbotson and Siegel 1984) It is also possible to invest in real estate indirectly, through real estate investment trusts (REITs), which represent companies that own, manage, operate, or finance real estate. Unlike physical real estate, REITs typically offer a highly liquid investment, as they get daily traded on the stock market.

5.4.1 Direct

Direct real estate investing refers to the purchase of a specific property or a stake in one. This may be implemented using debt or equity, and alone or through crowdfunding. Crowdfunding collects small amounts of capital from individual investors, thus pooling a large sum of money which may then be invested. This gives individuals a chance to participate in large projects using leverage. Debt investors provide capital to the property owners and receive a fixed rate of return determined by the interest rate on the loan secured by the property. These loans typically accompany development projects and tend to have a shorter holding period compared to equity investments, thus suiting investors who are uncomfortable with engaging in long-term deals. Debt investment is also appreciated for its predictability, as the frequency and yields are predetermined by the contract. Another reason investors might choose debt over equity is the lower risk accompanying the loan, as the property of interest acts as insurance in case of a default, when the lender gets the right to file for foreclosure. At the same time, however, the lower risk comes with capped returns as specified by the interest rate on the loan, resulting in the sacrifice of the potential for higher gains in exchange for a safer investment. Investors may also face exposure to prepayment risk in case of an early mortgage payoff, which can interrupt the expected cash flows. Contrary to debt investment, equity investors do not act as lenders, but rather become stakeholders in a specific property, the size of which is, in case of crowdfunding, proportionate to the amount of money they provide relative to the overall sum. Returns are then derived from the rental income generated by the property, or else a share of appreciation value in case the property is sold. Equity investment provides almost limitless opportunities for earnings potential, which, however, is offset by an increased level of risk stemming from the uncertainty about the property's ability to perform as expected. In terms of the time horizon, investors need to withstand a longer time frame as compared to debt deals, possibly extending even over 10 years, which significantly reduces the level of liquidity in one's portfolio.

Overall, direct investing offers a large variety of benefits, such as complete control over what assets investors devote their capital to, certain tax reliefs based on specific situations, great opportunities for capital appreciation as well as a method to diversify one's portfolio of stocks and bonds, as there will likely be ceaseless demand for real estate, regardless of what is happening on the stock market. At the same time, however, this type of investment usually requires a significant amount of upfront capital, longer time horizons, and a reduced level of liquidity.

5.4.2 Indirect

Indirect real estate investing refers to the purchase of shares in a fund or companies that engage in real estate activities. A company that owns, maintains, operates, or finances income-generating real estate is referred to as a real estate investment trust (REIT), which will become the focus of this work. These collect capital from numerous investors, resulting in a large pool of money available for investment. Thus, individuals gain access to dividends from real estate investments without the need to actually buy, manage or finance one themselves. Properties in REIT portfolios range from apartment buildings to hotels, office buildings, retail centers and others. REITs that are publicly traded on securities exchanges may be bought and sold in the same manner as stocks, thus representing a liquid financial instrument with real estate as the underlying asset. Revenues then mostly come from space leases and rental payments and are distributed among shareholders in the form of dividends. In case of mortgage REITs, the pooled capital is lent to property owners and operators, followingly generating earnings through the net interest margin, representing the difference between the interest earned and funding expenses. In order to get classified as a REIT, companies need to meet various requirements, specifying how much capital must be invested in real estate, the number of individuals engaged in the trust, or the minimum fraction of taxable income to be distributed among investors. Overall, REITs provide an easy way to invest in real estate due to their listing on public exchanges, while offering attractive returns and stable cash flow through dividends. Moreover, they serve as a good portfolio diversification tool. On the other and, the conditions for REIT qualification require that a maximum of 10% of taxable income may be reinvested to buy new assets, thus reducing the potential for capital appreciation. In addition, some REITs may be subject to high management and transaction fees and the dividends get taxed as regular income.

Chapter 6

Data and Methodology

6.1 Data

To obtain the level of inflation for each country in the given time period, the Consumer Price Index (CPI) issued by the Bureau of Labor Statistics is used. Inflation measured by the CPI is defined as the change of the prices of a basket of goods and services purchased by a typical household. As this work endeavors to assess annual returns benched by individual quarters, the required rate of inflation, δ_t, is derived as the natural logarithm of the CPI value of the same quarter in years t and *t-1*, representing quarters of two consecutive years. The data was obtained from the OECD database in the form of an index with 2015 as the base year and includes all items. The time horizon of the availability of this data differs for individual countries.

To assess the hedging abilities of assets against expected and unexpected inflation, the anticipated inflation rate for each time period is needed. For this purpose, the OECD inflation forecast data is used, predicting the yearly change in the inflation rate between the same quarter of two subsequent years. The unexpected inflation rate is then calculated as the difference between the actual and expected inflation values.

The return on privately held residential real estate, N_t, is derived from the Residential Property Price Indices (RPPIs), also referred to as House Price Indices (HPIs), representing the changes in selling prices of residential properties (houses, apartments, detached houses) purchased by households. The dataset covers both new and existing dwellings valued in the market price including the land they are located on. The dataset for this work was retrieved from the OECD database in the form of a quarterly index with 2015 as base year.

The yearly return was then established as the natural logarithm of the ratio of index values at years *t* and *t-1*.

Bond returns were based on the data provided by Investing.com, which updates the current yields of bonds traded on the secondary market. For the purpose of this thesis, returns on bonds with 1-year maturity were obtained on a monthly basis, from which the annual yield for each quarter Â´was calculated as an average of the 3 corresponding months.

Annual stock returns are based on the S&P 500 index value, comprising the 500 most significant companies traded on the NYSE and NASDAQ stock exchanges. The returns are based on the difference in opening prices between consecutive time periods. The data was obtained from Yahoo Finance Data.

Annual REITs returns are based on the FTSE EPRA/NAREIT Developed index, designed to track the performance of listed real estate companies and REITs worldwide. The weighted index comprises 375 constituents located in different countries and engaged in all kinds of real estate. The subsectors with the largest weight include industrial, residential, and retail REITs.

As this thesis aims to study each country separately, the data were stored in individual datasets and treated as time series.

The timeframe for the study is limited by the availability of the House Price Index, whose first observation for the Czech Republic dates back to Q1 2008. As the aim is to compare individual countries, it is vital to observe variables over the same time period. Therefore, the timeframe was set as Q1 2009 - Q3 2022, resulting in 55 observations for each variable. The values are recorded in the form of percentage changes from one period to another, therefore, no further logarithmic transformation was conducted.

6.2 Methodology

The methodology stems from the proposition by (Fama and Schwert 1977), who studied the following model

$$N_{kt} = \alpha_k + \beta_k E(\delta_t|\theta_{t-1}) + \gamma_k(\delta_t - E(\delta_t|\theta_{t-1}) + \mu_{kt},$$

where N_{kt} represents nominal return on asset k at time t, $E(\delta_t|\theta_{t-1})$ stands for the expected rate of inflation at time t, given information at time *t-1*, $\delta_t - E(\delta_t|\theta_{t-1})$ represents the unexpected rate of inflation and μ_{kt} is the error term.

Asset hedging effectiveness against both inflation components may then be assessed based on the respective coefficients. A coefficient β_k equal to 1 means the asset is a perfect hedge against the expected inflation level, that is, its nominal returns move in a 1-to-1 correspondence with the expected rate of inflation. Hedging against the unexpected rate of inflation is based on the coefficient γ_k. In case it is equal to 1, the asset provides a perfect hedge against the unexpected inflation rate. If both coefficients equal 1, the asset is considered a complete hedge against inflation. As the outcomes may differ from these target values, some assets may also be categorized as partial hedges, specifically when the coefficients range between 0 and 1. Obtaining coefficients of -1 implies an asset acts as a perverse hedge.

To account for the possible autoregressive effect of asset returns, the return from the previous period *t-1* was also included in the form of a lagged dependent variable. Moreover, since economic time series often include a trend, a time variable was also included to avoid spurious regression. The resulting model then has the form:

$$N_{kt} = \alpha_k + \phi_k N_{kt-1} + \beta_k E(\delta_t|\theta_{t-1}) + \gamma_k(\delta_t - E(\delta_t|\theta_{t-1}) + time + \mu_{kt}$$

As price effects tend to take some time to affect asset appreciation, the model was also tested in the form with 3 lags of both the expected and unexpected levels of inflation included. However, the coefficients were only different from zero for the lagged dependent variable, that is, none of coefficients on the independent variables (the change in the expected and unexpected level of inflation) could be interpreted to describe their effects on the dependent variable. Moreover, the linear hypothesis test, used for the hypothesis that the lags of the changes in inflation rates were insignificant and could be omitted from the equation, showed a p-value above the significance level, leading to the conclusion that indeed, the lags were redundant in the regression.

Chapter 7

Empirical Results

The model described in the previous section was used to obtain empirical results for the hypotheses. Nominal returns on each asset were used as the dependent variable and tested using data for individual countries. The results were then summarized for an inland as well as cross-border comparison.

7.1 Czech Republic

The development of returns and inflation over the studied time period was first visualized in a graph.

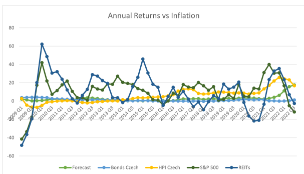

Figure 7.1: CR Returns vs Inflation

Annual returns of REITs and S&P 500 exhibit extreme volatility, with values exceeding the inflation forecast significantly, but also plummeting below zero. Bond returns, on the other hand, move almost in line with the expected inflation rate, which confirms the hypothesis by (Fama and Schwert 1977) that nominal bond yields might serve as a good proxy for the expected inflation rate. As the real estate returns are measured as changes in the House Price Index of the same quarter between two consecutive years, the graph nicely depicts the extreme spikes in residential real estate prices since Q3-2020 and indicates this asset would reliably hedge against inflation up to Q1-2022, when returns and inflation changed their trending direction and collided. At the same time, however, the observations start with the annual change between Q1 of 2008 and 2009, which was when the Czech real estate market suffered significant deterioration and decreases after the peak in 2007, resulting in negative nominal annual returns. Therefore, it is not so clear whether, overall, real estate was able to shield investors from inflation over this period. Below is a detailed analysis of individual assets and their hedging qualities.

7.1.1 Real Estate

As the proposed model is of an AR(1) type, the strict exogeneity assumption is violated. Stationarity of the dependent variable was checked by implementing the Augmented Dickey-Fuller test on the *hpi* variable, representing real estate returns. The null hypothesis, stating that data contains a unit root, was rejected by the p-value of 0.03. Therefore, we can assume the data on the dependent variable to be stationary with no unit root present. The Breusch-Pagan test for heteroskedasticity returned a high p-value of 0.775, thus confirming the assumption of homoskedasticity. Having estimated the model, the Breusch-Godfrey test was applied to the obtained residuals and resulted in a low p-value, confirming the presence of autocorrelation. For that reason, robust standard errors were used for statistical interpretation.

The regression yielded results depicted in table 7.1., where *hpii* stands for the lagged return on real estate, *ex* is the expected rate of inflation, *Uinfl* is the unexpected inflation component and time controls for spurious results due to an upward trend observed within the variables.

Table 7.1: CR Real Estate

	Dependent variable:
	hpi
hpii	0.977***
	(0.078)
ex	−0.137
	(0.089)
Uinfl	−0.956
	(1.827)
time	0.013
	(0.024)
Constant	0.313
	(0.536)
Observations	54
R^2	0.980
Adjusted R^2	0.978
Residual Std. Error	0.987 (df = 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

The R-squared is high likely due to the autoregression (1) used in the model as well as the time variable. The inclusion of time also hinders the possibility to state the exact portion of the variance in the dependent variable explicable by the observed independent variables.

The p-values imply that only the lag of real estate return is significant. The change in the expected level of inflation may be deemed significant at a 90% significance level. As the data is expressed as annual changes between two quarters, the coefficient on the *ex* variable implies that a 1% increase in the expected rate of inflation between the same quarter of years t and t-1 is associated with a 0.14% decrease in the return on residential real estate investment. Raises in the unexpected component of inflation are estimated to be reflected by an even larger drop in real estate returns by 0.96%. However, once the standard error is accounted for, the coefficient ranges between values both above and below 0. It is therefore difficult to conclude what effect the unexpected inflation actually has. Based on the proposition by (Fama and Schwert 1977) stating that an asset provides a perfect hedge against inflation, expected o unexpected, if the respective coefficient is equal to 1, real estate cannot be considered a complete inflation hedge in the Czech Republic. At the same time, however, the high standard error of the γ coefficient hinders us from making a firm conclusion.

7.1.2 Bonds

First, the model regressing bond returns on the returns from the previous period (the lagged variable) was tested. The ρ coefficient attained a value very close to 1 with a significant p-value, implying the presence of a unit root. For that reason, the model was estimated using the first-differences method, where the difference between two consecutive variables is taken as a new variable. The time variable was excluded by this transformation from the model, as it is reflected in the intercept. The differences are then regressed in the original model. After differencing, the Augmented Dickey-Fuller test rejected the null hypothesis on bond returns, thus implying stationary data. When testing for heteroskedasticity using the Breusch-Pagan test, the results showed a p-value of 0.008, rejecting the hypothesis of homoskedasticity. The robust standard errors were therefore used. The Breusch-Godfrey test for autocorrelation detection showed an insignificant p-value, probably due to differencing. Table 7.2. shows the results for the regression using bond returns.

Table 7.2: CR Bonds

	Dependent variable:
	db
db1	0.180*
	(0.094)
de	0.051**
	(0.020)
du	0.078
	(0.407)
Constant	−0.024
	(0.036)
Observations	53
R^2	0.100
Adjusted R^2	0.045
Residual Std. Error	0.233 (df = 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

Compared to the real estate results, the effect of previous bond returns does not have such a significant effect on the current yield. Unexpected inflation is associated with increases in the dependent variable, however, in terms of magnitude, the coefficient is quite negligible. Moreover, the relatively large standard error hinders us from making any firm conclusions. Intuitively, the γ coefficient for bond returns should not exhibit any remarkable values as bond yields for time *t* are fixed at time *t-1* and therefore, cannot flexibly react to further changes in the unexpected inflation rate. Increases in the expected rate of inflation are estimated to positively affect bond returns, which complies with the fact that the government sets its bond yields based on the anticipated inflation. As this variable was significant, we can describe Czech bonds as a partial hedge against expected inflation. However, following the proposition that the β and γ coefficients should equal 1 in order to provide a complete inflation hedge, bonds seem to have failed in confirming this hypothesis.

7.1.3 Stocks

The same model was used to observe stock returns and their relation to inflation. The ADF test on stocks showed a p-value of 0.01, thus indicating data stationarity. The Breusch-Pagan test confirmed homoskedasticity. Neither did the Breusch-Godfrey test reveal any signs of autocorrelation checked up to order 3. The model yielded the following results:

Table 7.3: CR S&P 500

	Dependent variable:
	sp
sp_1	0.650^{***}
	(0.087)
ex	-1.061^{**}
	(0.430)
Uinfl	13.889
	(19.670)
time	0.050
	(0.093)
Constant	5.889^{**}
	(2.518)
Observations	54
R^2	0.577
Adjusted R^2	0.542
Residual Std. Error	8.764 (df = 49)
F Statistic	16.699^{***} (df = 4; 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

Based on the β coefficient, stocks move in a 1:1 correspondence with the expected inflation rate, however, in the inverse direction. As the coefficient is significant, we can conclude stocks act as a perverse hedge against expected inflation in the CR. The most striking result is the one of the unexpected inflation rate, as an increase of 1% is associated with a 13.8% increase in the SP500 return. This would actually be in line with the proposition that certain stocks, namely those of companies that are net debtors, benefit from higher unexpected inflation. Nevertheless, the estimate is distorted by the larger standard error and low significance, making the result indeterminant. We can therefore maintain that stock returns are inversely related to the expected inflation rate and arguably positively to the unexpected rate of inflation, though with not so much confidence.

7.1.4 REITs

The data on REITs returns resulted in a low p-value of 0.01 for the ADF test, and was, therefore assumed stationary. The Breusch-Godfrey test rejected heteroskedasticity. However, serial correlation in the error terms was found significant. Therefore, robust standard errors were used.

Table 7.4: CR REITs

	Dependent variable:
	reit
reit_1	0.691***
	(0.064)
ex	−0.572
	(0.345)
Uinfl	15.117
	(26.914)
time	−0.015
	(0.139)
Constant	4.807
	(3.771)
Observations	54
R^2	0.637
Adjusted R^2	0.608
Residual Std. Error	10.910 (df = 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

The results strongly resemble the performance of stocks. The effect of the unexpected level of inflation is again quite striking, yet insignificant with a large standard error. The expected inflation rate is significant at the 90% significance level and shows a negative relationship between the expected inflation rate and REITs returns. Therefore, REITs may not be considered as an inflation hedge against the expected level of inflation, in fact, even act as a perverse hedge.

7.1.5 Summary

Table 7.5: Assets in the Czech Republic

Czech Republic				
	α	ϕ	β	γ
Real Estate	0.313	0.977***	-0.137	-0.956
	(0.536)	(0.078)	(0.089)	(1.827)
Bonds	-0.024	0.18*	0.051**	0.078
	(0.036)	(0.094)	(0.02)	(0.407)
Stocks	5.889**	0.65***	-1.061**	13.89
	(2.518)	(0.087)	(0.43)	(19.67)
REITs	4.807	0.691***	-0.572	15.117
	(3.771)	(0.064)	(0.345)	(26.914)

Note: $\alpha - intercept, \phi - past\ \ returns, \beta - exp.\ \ infl, \gamma - unex.\ \ infl.$

In conclusion, with the exception of bond returns, increases in the expected inflation rate (β coefficient) are associated with decreases in the nominal return on assets. Previous appreciation of assets is expected to be positively reflected in the consecutive return, as indicated by the coefficient ϕ, which was the only variable significant in every regression. The unexpected inflation rate mostly showed a positive co-movement with asset returns, however, attained such high standard errors that results remain inconclusive. The reason might be the remarkably accurate expected rate of inflation, proxied by a forecast conducted by OECD, which only differed by 0.1% from the actual inflation at maximum. Consequently, there was little space left for the unexpected inflation rate to be reflected in the nominal asset returns. Following the proposed interpretation by (Fama and Schwert 1977) that an asset provides a perfect hedge against the expected and unexpected inflation rate if the respective coefficients attain the value of 1, we can conclude that none of these assets exhibited complete hedging properties. Although the unexpected rate of inflation seems very convenient for asset returns based on the estimates, the extraordinarily high standard errors and p-values make their hedging capabilities indeterminant.

7.2 Switzerland

The figure of returns shows frequent fluctuation in REITs and S&P 500 returns. Returns on bonds seem to be matching the expected rate of inflation almost perfectly. Real estate returns seem to attain slightly higher values but still in line with the inflation forecast. The extent to which inflation changes are incorporated in the nominal returns was estimated based on the proposed model for each asset.

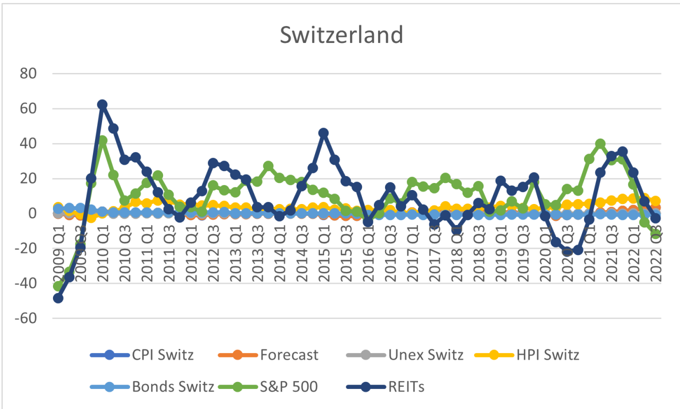

Figure 7.2: Returns vs Inflation

7.2.1 Real Estate

As the model includes an autoregression, the presence of a unit root was checked using the ADF test, which confirmed stationarity. The BP test revealed heteroskedasticity in the model, therefore, robust standard errors were employed for the estimation of the coefficients. The model then yielded the following results:

Table 7.6: SW Real Estate

	Dependent variable:
	hpi
hpii	0.815***
	(0.075)
ex	0.271
	(0.233)
Uinfl	3.948
	(6.680)
time	0.017
	(0.016)
Constant	0.160
	(0.677)
Observations	54
R^2	0.794
Adjusted R^2	0.777
Residual Std. Error	1.094 (df = 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

Past performance in the previous period is estimated to positively affect current returns. The expected rate of inflation is expected to raise the average return on real estate by 0.27% for each 1% increase. The unexpected inflation rate promises to be offset by significant increases in the nominal returns, however, the coefficient evinces such a large p-value and standard error, that no firm conclusion can be made. Even though real estate does not prove to be a complete hedge against inflation, the asset may be considered a partial hedge against the expected inflation.

7.2.2 Bonds

The data for 1-year bonds showed no sign of a unit root, as tested by the ADF test, nor did the model's residuals suffer from autocorrelation. However, the BP test revealed heteroskedasticity in the error term's variance, which is why robust errors were used. The table below summarizes the results:

Table 7.7: SW Bonds

	Dependent variable:
	bond
bond_1	0.972***
	(0.043)
ex	−0.011
	(0.020)
Uinfl	0.463
	(0.324)
time	0.0001
	(0.003)
Constant	−0.012
	(0.075)
Observations	54
R^2	0.983
Adjusted R^2	0.982
Residual Std. Error	0.094 (df = 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

Opposed to real estate, bond nominal returns are estimated to be eroded by increases in the expected inflation rate. More specifically, an increase in inflation of 1% is predicted to, on average, decrease the nominal bond returns by 0.01%. This inverse relationship is quite atypical for bond returns, however, it might come from the policy of negative interest rates in Switzerland since 2014, resulting in negative bond yields from this year on. Increases in the unexpected rate of inflation should be partially hedged by bonds, However, the asset cannot be considered a complete inflation hedge.

7.2.3 Stocks

The model used with the S&P 500 index as the dependent variable tested negative for any signs of heteroskedasticity or serially correlated errors. Moreover, the ADF test on the stock returns variable rejected the presence of a unit root, thus implying stationarity. The estimated effects are depicted in the following table:

Table 7.8: SW S&P 500

	Dependent variable:
	sp
sp_1	0.677^{***}
	(0.094)
ex	-1.064
	(1.478)
Uinfl	41.840
	(34.300)
time	-0.053
	(0.088)
Constant	5.834^{**}
	(2.774)
Observations	54
R^2	0.539
Adjusted R^2	0.501
Residual Std. Error	9.149 (df = 49)
F Statistic	14.309^{***} (df = 4; 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

Increases in the expected rate of inflation are estimated to decrease the average stock returns by 1.06%. The unexpected inflation rate, on the other hand, increases stock returns by 42% for each 1% increase, implying an ability of stocks to offset unanticipated inflation, which is proposed by the hypothesis that companies, that are net debtors, actually benefit from increases in unexpected inflation. Having accounted for the standard errors, we can conclude stocks provide a perfect hedge against the unexpected inflation rate, while exhibiting a rather inverse relationship with changes in the expected rate of inflation.

7.2.4 REITs

Robust errors were used for the model on REITs returns due to heteroskedasticity. The summary is provided in Table 7.8. The results indicate that an increase in the expected inflation rate is associated with an increase in nominal REITs returns. The same applies to the unexpected rate of inflation, whose coefficient actually implies a complete hedging ability against this inflation component. However, both standard errors make it impossible to make a definitive conclusion.

Table 7.9: SW REITs

	Dependent variable:
	reit
reit_1	0.671***
	(0.072)
ex	0.501
	(2.443)
Uinfl	1.705
	(55.030)
time	−0.111
	(0.184)
Constant	6.089
	(5.815)
Observations	54
R^2	0.617
Adjusted R^2	0.586
Residual Std. Error	11.354 (df = 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

7.2.5 Summary

Table 7.10: Assets in Switzerland

Switzerland				
	α	ϕ	β	γ
Real Estate	0.16	0.815***	0.271	3.948
	(0.677)	(0.075)	(0.23)	(6.68)
Bonds	-0.012	0.972***	-0.011	0.463
	(0.075)	(0.043)	(0.02)	(0.324)
Stocks	5.834**	0.677***	-1.064	41.84
	(2.774)	(0.094)	(1.478)	(34.3)
REITs	6.089	0.671***	0.501	1.705
	(5.8151)	(0.072)	(2.443)	(55.03)

Note: $\alpha - intercept, \phi - past\ \ returns, \beta - exp.\ \ infl, \gamma - unex.\ \ infl.$

All assets exhibit the tendency to be positively related to their past returns. The coefficient is significant at the 95% significance level for all investments. The estimated effect of the expected inflation rate shows both positive and negative relationships. Real estate is estimated to move in the same direction as the expected inflation rate, however, only provides a partial hedge. The striking effect of the unexpected component of inflation suffers from the same issues as in the study of the Czech Republic; large standard errors and low p-values, which likely arise due to a small dataset. Therefore, the assets need to be classified as inconclusive in terms of hedging against the unexpected inflation rate.

Compared to the Czech Republic, the independent variables, except for the lagged returns, showed even lower significance. Switzerland was included in the study as an example of a country with stable macroeconomic conditions, which is also reflected in the range of inflation values from -1.40% to 3.4% as compared to the Czech Republic, where the values range from 0.1% to 17.6%. Moreover, this country stands out due to its negative interest rates, bond yields, and stable real estate market, which has exhibited an upward trend since 2000 (figure 7.3). Therefore, the weak hedging ability of Swiss real estate is quite surprising.

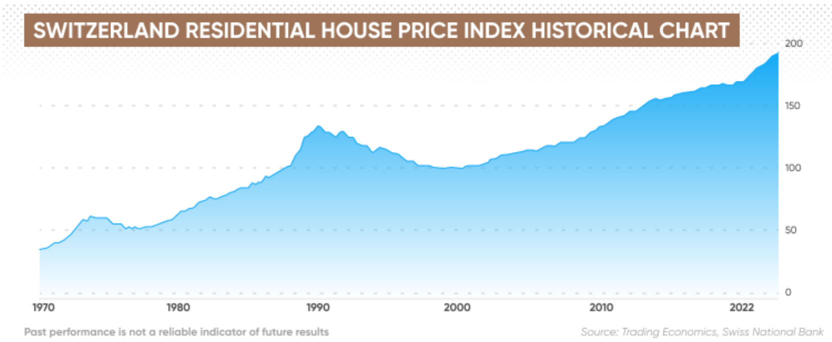

Figure 7.3: Swiss HP trend
source: Capital.com

7.2.6 USA

In the US, bond returns seem to be tightly connected with the expected rate of inflation, as might be anticipated. The graph indicates that returns on real estate exceeded the expected inflation rate in most periods. REITs and Stock returns exhibited volatility with returns above, but also below the inflation rate.

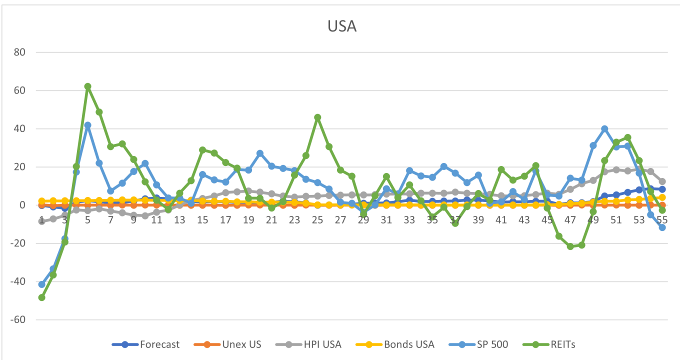

Figure 7.4: Returns vs Inflation

Real Estate

The data on real estate returns was first inspected for the presence of a unit root, which was rejected, as the ADF test implied stationarity. The BP test showed the variance of the error term was not constant, therefore, robust standard errors were used for computation. The effects of inflation on real estate returns are depicted in Table 7.9:

Table 7.11: US Real Estate

	Dependent variable:
	hpi
hpii	0.932***
	(0.053)
ex	0.036
	(0.119)
Uinfl	−2.528
	(1.879)
time	0.009
	(0.025)
Constant	0.309
	(0.504)
Observations	54
R^2	0.969
Adjusted R^2	0.967
Residual Std. Error	0.909 (df = 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

Clearly, real estate returns are expected to increase simultaneously with increases in the inflation rate, though only in a small magnitude. The unexpected inflation is estimated to have a negative effect on returns even in the better-case scenario when the standard error is accounted for. Therefore, real estate in the US can be considered as a partial hedge against expected inflation, while acting as a perverse hedge against unanticipated inflation.

Bonds

Having regressed the bonds returns on their lagged values, the test revealed the presence of a unit root. For that reason, first-differencing was used for estimation. The eliminated time varibale is reflected in the intercept.

Table 7.12: US Bonds

	Dependent variable:
	db
db1	0.480***
	(0.130)
de	0.085**
	(0.035)
du	−0.900*
	(0.477)
Constant	0.010
	(0.028)
Observations	53
R^2	0.376
Adjusted R^2	0.337
Residual Std. Error	0.199 (df = 49)
F Statistic	9.827*** (df = 3; 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

Previous bond returns seem to have a positive effect on current returns. A 1% increase in the expected inflation rate is estimated to increase nominal bond returns by 0.085%. Despite its small magnitude, the coefficient is still positive and significant at the 95% level. Contrary to that, the unexpected rate of inflation is associated with an inverse movement of bond returns. Each percentage increase will, on average, decrease the bond returns by 0.9%. The variable is significant at the 90% significance level. In light of the above, bonds provide a partial hedge against the expected rate of inflation, while negatively reflecting increases in the unexpected inflation.

Stocks

As in the previous cases, there was no unit root present in the S&P 500 data. In the US model, no signs of heteroskedasticity, nor serial correlation were detected.

Table 7.13: US S&P 500

	Dependent variable:
	sp
sp_1	0.664***
	(0.105)
ex	−0.605
	(0.789)
Uinfl	17.466
	(28.795)
time	−0.043
	(0.094)
Constant	6.913**
	(2.747)
Observations	54
R^2	0.529
Adjusted R^2	0.491
Residual Std. Error	9.245 (df = 49)
F Statistic	13.762*** (df = 4; 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

Stock returns from the previous period are estimated to significantly affect current nominal returns. The expected inflation rate shows an inverse relationship with stock returns, indicating they perform poorly as a shield form inflation. This is in line with the results provided by most studies concerned with this topic. The unexpected inflation rate coefficient exhibits a conspicuous effect, however, due to large standard errors and insignificant p-value, the results cannot be used for a definitive conclusion.

REITS

As there was serial correlation detected in the model, robust standard errors were used for estimation.

Table 7.14: US REITs

	Dependent variable:
	reit
reit_1	0.784***
	(0.056)
ex	−0.129
	(0.758)
Uinfl	−19.930
	(23.073)
time	−0.011
	(0.039)
Constant	2.390
	(3.045)
Observations	116
R^2	0.663
Adjusted R^2	0.651
Residual Std. Error	11.963 (df = 111)
Note:	*p<0.1; **p<0.05; ***p<0.01

REIT returns seem to be inversely correlated with both components of the inflation rate, as an increase in either of them is expected to erode the asset returns. Past REITs performance is estimated to have a positive effect on current returns. In conclusion, the results imply REITs act rather as a perverse inflation hedge.

Summary

Table 7.15: Assets in the US

USA				
	α	ϕ	β	γ
Real Estate	0.309	0.932***	0.036	-2.528
	(0.504)	(0.053)	(0.119)	(1.879)
Bonds	0.01	0.480***	0.085**	-0.9*
	(0.028)	(0.13)	(0.035)	(0.477)
Stocks	6.913**	0.664***	-0.605	17.466
	(0.028)	(0.13)	(0.035)	(0.477)
REITs	2.39	0.784***	-0.129	-19.93
	(3.045)	(0.056)	(0.758)	(23.073)

Note: $\alpha - intercept, \phi - past\ , \beta - exp.\ \ infl, \gamma - unex.\ \ infl.$

In the observed time period, all assets are estimated to increase in value if they did so in the period prior. Real estate and bonds provide a partial hedge against expected inflation, as their coefficients attained positive values. Moreover, the β coefficient for bonds is significant at the 95% level. Opposed to that, stocks and REITs exhibited a negative relationship with increases in the expected inflation rate, which evidently erodes their nominal returns. The unexpected rate of inflation showed a large variety of expected reflection in the assets' nominal returns, ranging from large increases in stock returns to considerable decreases in returns on REITs. An intriguing result was obtained for the γ coefficient for stocks, as the standard error implies this estimate of a 17% increase in returns for every 1% increase of the unexpected inflation rate should be quite accurate. However, the insignificance of this variable across all assets should be taken into consideration before reaching any conclusions. Overall, none of the assets performed as a complete inflation hedge. Only real estate and bonds could be considered partial hedges, as their returns are expected to move in the same direction as the expected rate of inflation.

7.2.7 China

At first glance, the returns on real estate vary along the expected inflation rate in China, exceeding the rate significantly in the Q3 2016-Q3 2017 period, while dropping below the line in 2015. Bond returns copy the line of the expected rate of inflation quite accurately, again confirming the hypothesis by (Fama and Schwert 1977) they might be used as a proxy for this variable. The analysis of individual asset performance follows below.

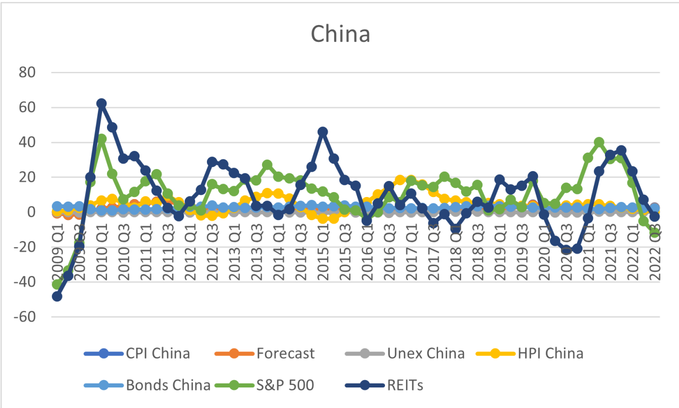

Figure 7.5: Returns vs Inflation

Real Estate

As the model includes an autoregression of real estate returns, it was first tested for the presence of a unit root. Although the ρ coefficient was not equal to 1, it still attained a very close significant value of 0.99, implying the possibility of non-stationarity. For that reason, first-differencing was used for estimation. The results are summarized in table 7.13, where *dh1* stands for the differenced lag of real estate returns, *de* and *du* represent the differences of the expected and unexpected inflation rates respectively.

Table 7.16: Chinese Real Estate

	Dependent variable:
	dh
dh1	0.619***
	(0.112)
de	0.420
	(0.404)
du	3.007
	(2.378)
Constant	−0.064
	(0.272)
Observations	53
R^2	0.417
Adjusted R^2	0.381
Residual Std. Error	1.967 (df = 49)
F Statistic	11.687*** (df = 3; 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

Increases in Chinese real estate in the previous period seem to have a positive effect on the current ones. The asset is estimated to provide a partial hedge against the expected rate of inflation, as the β coefficient is positive, yet not robust enough to cover the inflation completely. The unexpected inflation rate is associated with high increases in the nominal return, implying strong hedging qualities. Overall, real estate can be considered a perfect hedge against the unexpected inflation rate, while hedging only partially against the expected rate of inflation.

Bonds

Bond returns displayed no signs of nonstationarity, autocorrelation, or heteroskedasticity. The model yielded the following results:

Table 7.17: CH Bonds

	Dependent variable:
	bond
bond_1	0.759***
	(0.101)
ex	0.014
	(0.046)
Uinfl	−0.426
	(0.498)
time	0.003
	(0.004)
Constant	0.511
	(0.348)
Observations	54
R^2	0.610
Adjusted R^2	0.578
Residual Std. Error	0.442 (df = 49)
F Statistic	19.166*** (df = 4; 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

Increases in the expected inflation rate are expected to be reflected in bond returns as an increase of 0.014% for each 1% increase. Opposed to that, the unexpected inflation rate is estimated to erode the nominal returns by 0.426%. Consequently, Chinese bonds cannot be considered a perfect inflation hedge against either of the inflation rates.

Stocks

As the S&P 500 dataset remains the same for all countries, we can assume stationarity based on the previous results. The model did not violate either of the assumptions of autocorrelation or homoskedasticity. The following table depicts the results:

Table 7.18: CH S&P 500

	Dependent variable:
	sp
sp_1	0.699***
	(0.099)
ex	−1.236
	(0.937)
Uinfl	5.746
	(10.237)
time	−0.113
	(0.088)
Constant	9.849***
	(3.615)
Observations	54
R^2	0.539
Adjusted R^2	0.501
Residual Std. Error	9.148 (df = 49)
F Statistic	14.317*** (df = 4; 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

Opposed to bond returns, S&P 500 is estimated to reflect increases in the expected rate of inflation by a decrease in nominal returns by 1.26% for each 1% increase, thus acting as a perverse hedge. The unexpected inflation rate, on the other hand, should positively affect stock returns, which actually confirms a widely discussed hypothesis that unexpected inflation is of benefit to companies that are net debtors. Nevertheless, its standard error equaled almost twice the mean value and the variable was not significant. In light of the above, stocks act as a perverse hedge against the expected inflation rate, while exhibiting positive relationship with the unexpected rate.

REITs

The data on REITs returns was stationary, therefore, there was no need for differencing. The BP test for heteroskedasticity could not reject the null hypothesis, therefore, robust standard errors were not used either.

Table 7.19: CH REITs

	Dependent variable:
	reit
reit_1	0.778***
	(0.091)
ex	−3.090**
	(1.262)
Uinfl	4.705
	(13.008)
time	−0.230**
	(0.108)
Constant	16.546***
	(4.634)
Observations	54
R^2	0.624
Adjusted R^2	0.594
Residual Std. Error	11.785 (df = 49)
F Statistic	20.365*** (df = 4; 49)
Note:	*p<0.1; **p<0.05; ***p<0.01

The yielded results indicate that past REITs performance, the expected rate of inflation, and time all affect nominal REITs returns significantly. A 1% increase in the expected inflation rate is estimated to, on average, result in a decrease in the asset returns by 3.09%. This would imply that REITs act as a perverse hedge against Chinese expected inflation. Though the unexpected rate of inflation is expected to be positively reflected in the returns, its standard error and high p-value make this result inconclusive. Surprisingly, the effect of time proved to be significant in this model, moreover, it seems that REITs returns actually tend to decrease with time, which corresponds to the visual trend in Figure 7.5 at the beginning of this section.

Summary

Table 7.20: Assets in China

China				
	α	ϕ	β	γ
Real Estate	-0.064	0.619***	0.42	3.007
	(0.272)	(0.112)	(0.404)	(2.378)
Bonds	0.511	0.759***	0.014	-0.426
	(0.348)	(0.101)	(0.046)	(0.498)
Stocks	9.849**	0.699***	-1.236	5.77
	(3.615)	(0.099)	(0.937)	(10.237)
REITs	16.546***	0.778***	-3.09**	4.705
	(4.634)	(0.091)	(1.262)	(13.008)

Note: $\alpha - intercept, \phi - past\ \ returns, \beta - exp.\ \ infl, \gamma - unex.\ \ infl.$

All assets exhibit a positive relationship between their past and current returns. The β coefficient, representing the effect of the expected rate of inflation, attained positive values in the case of real estate and bonds investment, thus implying these may provide a partial hedge against the expected inflation rate. However, as none of the coefficients reached 1, which is the required value for effective hedging, the hypothesis about perfect hedging was rejected. Surprisingly, the γ coefficient was mostly positive and greater than 1, which would indicate that increases in the unexpected inflation rate are offset by the appreciation of nominal returns. However, with the exception of real estate, standard errors exceeded the mean values. Overall, real estate is the only asset that may be considered a partial hedge against both inflation components, based on the positive coefficients. Opposed to that, REITs and stocks performed as perverse hedges against the expected rate of inflation, even after accounting for the standard error.

7.3 Comparison

The following tables combine cross-border results for individual assets. In all regressions, the estimated effects of the unexpected inflation rate attained extremely large standard errors, likely arising due to the small dataset, limited by the availability of the House Price Index in the Czech Republic, whose first register dates back to 2008. This variable was also mostly found insignificant. This could be explained by the use of the official OECD forecast as a proxy for the expected rate of inflation, which was so accurate that it left little space for the rates of the unexpected rate of inflation, calculated as a difference between the actual inflation rate and the forecast. Consequently, the values of the unexpected rate of inflation only ranged from -0.3 to 0.2, and even attained the value of 0 in many cases. Therefore, it was difficult to capture its effect on returns. A vast majority of the estimates exhibited such large standard errors that it was impossible to categorize the assets based on their inflation-hedging qualities. The same problem emerges in the study by (Rubens et al. 1989), who point out that since real returns are treated as constants, the models should not be expected to explain large portion of the variation in returns, but only focus on the changes triggered by inflation. The following comparison provides an analysis of the performance of individual assets in all the studied countries. Based on the coefficient values and relative size of the standard error, the tables include a conclusion about which category each asset falls into in individual countries. The assets is labeled as a

- Complete hedge if both coefficients are greater than or equal to 1 even once the standard error has been accounted for.
- Perfect hedge against expected/unexpected inflation if β/γ coefficients respectively attain values greater than 1 even once the standard error has been accounted for.
- Partial positive hedge against expected/unexpected inflation if β/γ coefficients respectively are positive even once the standard error has been accounted for.
- Partial negative hedge against expected/unexpected inflation if β/γ coefficients respectively are negative even once the standard error has been accounted for.

- Perverse hedge against inflation if β and γ coefficients respectively attain negative values even once the standard error has been accounted for..
- Inconclusive if the standard error makes the mean estimate fluctuate both above and below zero, thus hindering us from making a definitive conclusion.

Real Estate

Table 7.21: Real Estate Comparison

Real Estate				
	α	ϕ	β	γ
Czech Republic	0.313	0.977***	-0.137	-0.956
	(0.536)	(0.078)	(0.089)	(1.827)
Switzerland	0.16	0.815***	0.271	3.948
	(0.677)	(0.075)	(0.23)	(6.68)
USA	0.309	0.932***	0.036	-2.528
	(0.504)	(0.053)	(0.119)	(1.879)
China	-0.064	0.619***	0.42	3.007
	(0.272)	(0.112)	(0.404)	(2.378)

Note: $\alpha - intercept, \phi - past\ \ returns, \beta - exp.\ \ infl, \gamma - unex.$

In all countries, past returns on real estate had a significant positive effect on returns in the current period, most notably in the Czech Republic, where they almost moved in a 1:1 correspondence. At the same time, the Czech Republic is the only country where this asset was inversely related to increases in the expected inflation rate, with an average estimate of 0.137% decrease for every 1% increase in the inflation rate. A poor hedging quality of real estate was also implied by the β coefficient for the USA. Both of these countries actually suffered from a real estate market crash originating from a housing bubble caused by extremely low mortgage interest rates and regulations in 2008. As the observed period of this study begins by the year 2009, the crisis might arguably still be present in the initial observations. Real estate seems to provide the most effective hedge in China, where an increase in the expected inflation rate by 1% should be reflected in the nominal return as a 0.42% increase. This might partially be caused by the extreme surges in Chinese house prices in 2013 and 2016, when returns on real estate significantly exceeded inflation. The relatively low hedging quality of real estate in Switzerland is quite surprising, as the housing market exhibited constant growth in prices in the observed period, while the inflation rate gradually attained even negative values. As for the unexpected rate of inflation, real estate in the Czech Republic is, again, negatively influenced by increases. The same holds for the USA, where every percentage increase in the unexpected inflation rate is estimated to erode the nominal return by 2.53 %, thus indicating that real estate should be seen as a perverse hedge, rather than an efficient investment. Real estate in Switzerland and China promise to protect investors from unexpected inflation. Overall, the β coefficient was mostly positive, thus corresponding to the general belief that real estate provides an inflation hedge, at least partially. Based on the provided estimates, investment in Chinese real estate performed the best among the studied countries both in terms of expected and unexpected inflation. The final characteristic of real estate investment in each country is provided in the table below, where *EI* represents expected inflation and *UI* unexpected.

Table 7.22: Real Estate Hedging Characteristics

Hedge against	EI	UI
Czech Republic	Partial negative	Inconclusive
Switzerland	Partial positive	Inconclusive
USA	Inconclusive	Partial negative
China	Partial positive	Perfect

Bonds

Table 7.23: Bonds Comparison

Bonds				
	α	ϕ	β	γ
Czech Republic	-0.024	0.18*	0.051**	0.078
	(0.036)	(0.094)	(0.02)	(0.407)
Switzerland	-0.012	0.972***	-0.011	0.463
	(0.075)	(0.043)	(0.02)	(0.324)
USA	0.01	0.480***	0.085**	-0.9*
	(0.028)	(0.13)	(0.035)	(0.477)
China	0.511	0.759***	0.014	-0.426
	(0.348)	(0.101)	(0.046)	(0.498)

Note: $\alpha - intercept, \phi - past\ \ returns, \beta - exp.\ \ infl, \gamma - unex.$

Increases in past bond returns are expected to raise nominal yields at time t in all studied countries. The extent to which increases in the expected inflation rate affect nominal bond yields is represented by the β coefficient. An intriguing result is that of Swiss bonds, which are expected to be inversely related to changes in the expected rate of inflation. Bond yields for this country exhibited compelling values, as they also included negative returns. The best expected-inflation hedging qualities are exhibited by bonds issued by the Czech and US governments. Moreover, the variable was significant at the 95% level in both cases. We can therefore consider bonds as an effective partial hedge in these states. Compared to other assets, bonds exhibited the lowest variance in terms of responsiveness to changes in the unexpected inflation rate. The intuitive explanation behind it is that nominal bond yields are fixed at the issuance date, that is, at *t-1* and are unable to react to any unexpected fluctuations in the inflation rate. In this regard, bonds cannot compete with the other observed assets, whose returns are a result of a flexible market price fluctuation rather than a predetermined yield. In conclusion, bonds do not perform as a perfect hedge against either component of the inflation rate in any of the observed countries, while providing a partial hedge against the expected rate of inflation in the Czech Republic and the USA. The category bonds in each country fall into is provided in the table below.

Table 7.24: Bonds Hedging Characteristics

Hedge against	EI	UI
Czech Republic	Partial positive	Inconclusive
Switzerland	Inconclusive	Partial positive
USA	Partial positive	Partial negative
China	Inconclusive	Inconclusive

Stocks

Table 7.25: Stocks Comparison

Stocks				
	α	ϕ	β	γ
Czech Republic	5.889**	0.65***	-1.061**	13.89
	(2.518)	(0.087)	(0.43)	(19.67)
Switzerland	5.834*	0.677***	-1.064	41.84
	(2.774)	(0.094)	(1.478)	(34.3)
USA	6.913**	0.664***	-0.605	17.466
	(0.028)	(0.13)	(0.035)	(0.477)
China	9.849**	0.699***	-1.236	5.770
	(3.615)	(0.099)	(0.937)	(10.237)

Note: $\alpha - intercept, \phi - past\ \ returns, \beta - exp.\ \ infl, \gamma - unex.\ \ infl.$

Stock returns from period *t-1* are yet again expected to have a positive effect on returns at time *t*. In terms of hedging effectiveness against the expected inflation rate of individual countries, represented by the β coefficient, neither of the yielded results was positive. In fact, increases in the anticipated inflation rate by 1% are associated with an average decrease of more than 1% in most of the countries, namely the USA, China, and the Czech Republic, in which case the variable was significant at the 95% level. Contrary to that, the effect of increases in the unexpected inflation showed estimates of disproportionate increases in nominal returns, which indicated strong hedging abilities against this inflation component. This is in line with the hypothesis that unexpected inflation might actually be of benefit to companies that are net debtors. The result is especially intriguing in the United States, as the standard error is almost negligible relative to the mean estimate. Based on estimates and their standard errors, S&P 500 returns hedge perfectly against the unexpected inflation rate in the USA and Switzerland. Overall, the yielded values reject the hypothesis that stocks provide a complete hedge against inflation, but rather indicate they act as a perverse hedge, which is consistent with previous studies analyzing this investment. Individual qualities are summarized in the table below.

Table 7.26: Stocks Hedging Characteristics

Hedge against	EI	UI
Czech Republic	Partial negative	Inconclusive
Switzerland	Inconclusive	Perfect
USA	Partial negative	Perfect
China	Partial negative	Inconclusive

REITs

Table 7.27: REITs Comparison

REITs				
	α	ϕ	β	γ
Czech Republic	4.807	0.691***	-0.0572	15.117
	(3.771)	(0.064)	(0.345)	(26.914)
Switzerland	6.089	0.671***	0.501	1.705
	(5.8151)	(0.072)	(2.443)	(55.03)
USA	2.390	0.784***	-0.129	-19.93
	(3.045)	(0.056)	(0.758)	(23.073)
China	16.546***	0.778***	-3.090	4.705
	(4.634)	(0.091)	(1.262)	(13.008)

Note: $\alpha - intercept, \phi - past\ \ returns, \beta - exp.\ \ infl, \gamma - unex.\ \ infl.$

The performance of REITs in terms of inflation hedging exhibited no more optimistic results than stock returns. Except for Switzerland, a rise in the expected inflation is associated with decreases in nominal REITs returns. The effect is best discernible in China, where the asset performs as a perverse hedge, even after accounting for the standard error. Opposed to that, REITs seem to provide an effective hedge against the unexpected inflation rate, yet again, due to large standard errors and p-values, the results are inconclusive. The implications of an inverse relationship between REITs returns and inflation are congruent with conclusions reached by previous studies, e.g. (Maurer and Sebastian 2002), (Park et al. 1990). Overall, the results reject the hypothesis that REITs provide a complete hedge against inflation. The only definitive statemnet can be made about China, where REITs act as a perverse hedge against the expected inflation rate.

Table 7.28: REITs Hedging Characteristics

Hedge against	EI	UI
Czech Republic	Inconclusive	Inconclusive
Switzerland	Inconclusive	Inconclusive
USA	Inconclusvie	Inconclusive
China	Perverse	Inconclusive

7.3.1 Average performance

As the interpretation of the regression is how changes in inflation components affect nominal returns, it is not possible to conclude if the nominal asset returns beat the actual inflation rate in the observed period or not. Moreover, as (Fama and Schwert 1977) and (Maurer and Sebastian 2002) point out, only a fraction of the total variation in returns is taken into account, as other, non-inflation factors, may have an impact on nominal returns. For example, if, based on the results, an increase in the expected rate of inflation by 1% is associated with a decrease in the Stock return by 0.5%, it can still be the case that, despite this inverse relationship, the nominal stock return exceeds the actual rate of inflation. To further inspect the values of returns and actual inflation, the observed time period was divided into 2 subperiods, for each of which average rates of inflation and returns for individual assets were calculated. The tables below provide the average annual returns on assets in periods Q1 2009 - Q1 2015 and Q2 2015 - Q3 2022 and the respective average rate of observed inflation.

Table 7.29: Average returns Q1 2009 - Q1 2015

Average Q1 2009 - Q1 2015				
	Czech R.	Switzerland	USA	China
Inflation	1,54	-0,11	1,54	2,47
1-Y Bonds	1,98	0,8	2,05	3,94
Real Estate	-0,57	3,40	0,41	2,60
S&P 500	10,22	10,21	10,21	10,21
REITs	13,53	13,53	13,53	13,53

Despite the empirical results provided by this study, which mainly implied that the assets of interest do not provide an effective hedge against the expected rate of inflation, the average annual nominal returns in the Q1 2009 - Q1 2015 period mostly exceed the rate of actual inflation. Real estate proved to, on average, hedge investors in all countries, except for the Czech Republic, which was also the only country where the obtained β coefficient in the regression was negative. As this period starts with the housing price change from Q1 2008-Q1 2009, most of the yields actually attain negative values, which likely originates from the then situation on the Czech real estate market, where the peak of housing prices in 2007 was followed by a contraction in 2008, reaching the bottom in 2009. A similar situation arises in the case of US real estate, where the housing bubble in 2007 escalated into a market crash in 2008. As may be seen, US real estate returns in this subperiod attained a negligible average return as compared with other assets. The negative inflation rate in Switzerland is comfortably exceeded by the average return on real estate, confirming the upward trend of Swiss housing prices since the year 2000 (graph depicted in Figure 7.3.). Stocks and REITs promise the most attractive nominal returns, which, however, are typically accompanied by higher risk and volatility. Bond yields implicate an effective 1-year yield in terms of beating inflation in all countries.

Table 7.30: Average returns Q2 2015 - Q3 2022

Average Q2 2015 - Q3 2022				
	Czech R.	Switzerland	USA	China
Inflation	3,54	0,32	2,66	1,95
1-Y Bonds	0,49	-0,65	0,78	5,78
Real Estate	11,19	3,9	8,49	2,73
S&P 500	11,16	11,16	11,16	11,16
REITs	7,02	7,02	7,02	7,02

In the second subperiod, the performance of Czech real estate improved significantly, which is likely due to the spikes in housing prices mainly between the years 2016-2018 and then 2021-2022. An interesting relationship arises between real estate returns and REITs performance; when returns on direct real estate investment increase, the performance of the indirect investment method actually decreases, despite the fact its underlying asset is a real estate portfolio. With a few exceptions, all assets exhibited, on average, larger nominal returns than the observed inflation rate.

Chapter 8

Conclusion

The aim of this thesis was to explore the inflation-hedging qualities of real estate and compare the results with alternative investments, namely bonds, stocks, and REITs. All assets were observed in the Czech Republic, Switzerland, the USA and China over the time period Q1 2009 - Q3 2022. The study was implemented by regressing annual nominal returns on the expected and unexpected rate of inflation in each country, while also including time and past nominal returns in the model to ensure more accurate results.

Among the studied investments, real estate, and bonds exhibited the most attractive capabilities in terms of inflation hedging. Though neither of the assets performed as a complete inflation hedge, their attained coefficients implied real estate shielded investors from inflation partially in Switzerland and China, where the latter even showed perfect unexpected-inflation hedging qualities. Bonds provided partial protection against the expected inflation in the Czech Republic and the USA, while the unexpected inflation rate was only incorporated positively by bonds in Switzerland. Contrary to that, bonds in the US exhibited an inverse relationship. Probably the worst performance was delivered by stock returns, which were categorized as a partial negative hedge against expected inflation in all countries except for Switzerland. At the same time, however, their relationship with the unexpected rate of inflation was positive to the extent they got the label of a perfect hedge in Switzerland and the USA. However, in none of the countries could they be considered a complete hedge. The last of the observed assets, REITs, exhibited such large standard errors in the estimations only one definitive result could have been made; this asset acts as a perverse hedge against the Chinese expected rate of inflation. Overall, numerous results were classified as inconclusive due to the substantial standard errors obtained. None of the assets can be considered a perfect hedge against inflation based on the provided estimates, however, real estate and bonds performed the best, while stocks confirmed their poor hedging qualities, as implied by previous studies.

This work broadened the previous research by adding the Czech Republic to the observed countries as well as providing a cross-border comparison with the use of the most up-to-date data. Though the results mostly comply with previous conclusions in terms of positive or negative hedging, the individual values differ greatly among all conducted studies. This likely stems from the numerous approaches taken toward the measurement of the expected rate of inflation. While some authors generate their own estimates, others, including this work, rely on official forecasts. Therefore, until a single formula for the expected inflation rate is agreed upon, the conclusion will likely differ across future studies as well.

Bibliography

John Benjamin, Stacy Sirmans, and Emily Zietz. Returns and risk on real estate and other investments: more evidence. *Journal of Real Estate Portfolio Management*, 7(3):183–214, 2001.

Michael Bond and Michael Seiler. Real estate returns and inflation: an added variable approach. *Journal of Real Estate Research*, 15(3):327–338, 1998.

Meike AS Bradbury, Thorsten Hens, and Stefan Zeisberger. How persistent are the effects of experience sampling on investor behavior? *Journal of Banking & Finance*, 98:61–79, 2019.

Nai-Fu Chen, Richard Roll, and Stephen A Ross. Economic forces and the stock market. *Journal of business*, pages 383–403, 1986.

John L Evans and Stephen H Archer. Diversification and the reduction of dispersion: An empirical analysis. *The Journal of Finance*, 23(5):761–767, 1968.

Eugene F Fama and G William Schwert. Asset returns and inflation. *Journal of financial economics*, 5(2):115–146, 1977.

Irving Fisher. The theory of interest. *New York*, 43:1–19, 1930.

Milton Friedman. *The role of monetary policy*. Springer, 1995.

Kunaey Garg. The effect of changes in the federal funds rate on stock markets: A sector-wise analysis. *Undergraduate Economic Review*, 4(1):2, 2008.

Scott E Harrington. The relationship between risk and return: Evidence for life insurance stocks. *Journal of Risk and Insurance*, pages 587–610, 1983.

David Hartzell, John S Hekman, and Mike E Miles. Real estate returns and inflation. *Real Estate Economics*, 15(1):617–637, 1987.

Roger G Ibbotson and Laurence B Siegel. Real estate returns: a comparison with other investments. *Real Estate Economics*, 12(3):219–242, 1984.

Crocker H Liu, David J Hartzell, and Martin E Hoesli. International evidence on real estate securities as an inflation hedge. *Real estate economics*, 25(2): 193–221, 1997.

Raimond Maurer and Steffen Sebastian. Inflation risk analysis of european real estate securities. *Journal of Real Estate Research*, 24(1):47–78, 2002.

Thomas McCue and John Kling. Real estate returns and the macroeconomy: some empirical evidence from real estate investment trust data, 1972-1991. *Journal of Real Estate Research*, 9(3):277–287, 1994.

John Robert Meyer and Edwin Kuh. *The investment decision: An empirical study*, volume 102. Harvard University Press Cambridge, MA, 1957.

Jeong Yun Park, Donald J Mullineaux, and It-Keong Chew. Are reits inflation hedges? *The Journal of Real Estate Finance and Economics*, 3:91–103, 1990.

Frank K Reilly, Glenn L Johnson, and Ralph E Smith. Inflation, inflation hedges, and common stocks. *Financial Analysts Journal*, 26(1):104–110, 1970.

Jack Rubens, Michael Bond, and James Webb. The inflation-hedging effectiveness of real estate. *Journal of Real Estate Research*, 4(2):45–55, 1989.

Meir Statman. How many stocks make a diversified portfolio? *Journal of financial and quantitative analysis*, 22(3):353–363, 1987.