Which risk-return profiles do traditional bonds offer in comparison to inflation-linked bonds during periods of elevated inflation?

Robin Klein

Dissertation written under the supervision of professor Eva Schliephake

Dissertation submitted in partial fulfilment of requirements for the MSc in International Finance, at the Universidade Católica Portuguesa, 29.12.2024.

Title: Which risk-return profiles do traditional bonds offer in comparison to inflation- linked bonds during periods of elevated inflation?

Author: Robin Klein

Abstract

The preceding years have been characterised by inflationary pressure, thereby emphasizing the importance for investors to understand the dynamics of the different bonds classes within such an environment. This thesis investigates the risk-return profiles of different bonds classes (Treasury inflation protected securities, government-, and corporate bonds) within the recent elevated inflationary period. Using comprehensive bonds data from the period of 2014-2024, this study provides key insides about the impact inflation has on these bonds classes. Additionally, it provides insides about the macroeconomic environment that needs to be evaluated to understand the final impact on the bonds market.

My findings reveal that treasury inflation protected securities do not provide superior performance within inflationary periods compared to the other bonds classes. High Yield provides higher risk-rewards as credit quality is negatively correlated with risk-reward. The same is true for short duration. The less duration the less risk-reward is provided, on the Government and the Corporate side. Furthermore, it is evident that central bank actions during the recent inflation period influence the bonds market in a novel manner, as unconventional tools are employed to combat yield curve movements and supply shocks. The thesis concludes that long-duration and lower credit quality offer a more preferable risk-return profile while treasury inflation protected securities limit the downside risk.

Keywords: Bonds market, risk-return profile, monetary policy, TIPS, inflation, credit risk, duration

Resumo

Os anos anteriores foram caracterizados por uma pressão inflacionista, o que realça a importância de os investidores compreenderem a dinâmica das diferentes classes de obrigações neste contexto. Esta tese investiga os perfis de risco-rendimento de diferentes classes de obrigações no recente período de inflação elevada. Utilizando dados abrangentes sobre obrigações do período de 2014-2024, este estudo fornece informações importantes sobre o impacto da inflação nestas classes de obrigações. Além disso, fornece informações sobre o ambiente macroeconómico que tem de ser avaliado para compreender o impacto final no mercado de obrigações.

As minhas conclusões revelam que os títulos do tesouro protegidos contra a inflação não apresentam um desempenho superior em períodos inflacionistas em comparação com as outras classes de obrigações. Os títulos de elevado rendimento proporcionam maiores prémios de risco, uma vez que a qualidade do crédito está negativamente correlacionada com os prémios de risco. O mesmo se aplica à curta duração. Quanto menor for a duração, menor será o risco-recompensa, tanto do lado das obrigações do Tesouro como das obrigações de empresas. Além disso, é evidente que as acções dos bancos centrais durante o recente período de inflação influenciam o mercado de obrigações de uma forma inovadora, uma vez que são utilizados instrumentos não convencionais para combater os movimentos da curva de rendimentos e os choques na oferta. A tese conclui que a longa duração e menor qualidade de crédito oferecem um perfil de risco-retorno mais preferível, enquanto os títulos do tesouro protegidos contra a inflação limitam o lado negative.

Palavras-chave: Mercado de obrigações, perfil de risco-rendimento, política monetária, TIPS, inflação, risco de crédito, duração

Table of Contents

1. Introduction 5

2. Literature Review 7

3. Data 10

4. Methodology 12

5. Descriptive Statistics 14

6. Discussion Results 23

7. Conclusion 28

References 29

Appendix 32

Disclaimer 34

1. Introduction

The preceding years have been characterised by inflationary pressure. The financial markets exhibited a pronounced sensitivity to news and developments within that area. In order to act in an appropriate manner within such an environment, it is of importance for both institutional and individual investors to assess bonds in accordance with their risk-return profile during an inflationary period. The risk of traditional fixed-coupon bonds is elevated due to the diminished real returns. Conversely, inflation-protected securities are designed to provide protection from the effects of inflation. It is therefore essential to investigate both types of bonds in an inflationary context in order to optimise investment strategies. The aim of this study is to answer the question of which risk-return profiles traditional bonds offer in comparison to inflation-linked bonds during an inflationary period. In order to answer this question, the study will analyse the difference in returns of these bonds, the reactions of different durations and types of bonds, as well as the risks connected to inflation and inflation expectations.

This paper investigates the risk-return profiles of Treasury inflation protected securities (TIPS), High Yield- (HY), Investment Grade- (IG), and Government (Gov.) bonds within an elevated inflation period. It updates, extends and questions the evidence for studies within these bond classes. For example, it challenges the findings of Spierdijk and Umar (2015) that bonds are unable to hedge inflation, regardless of maturity, issuer and risk rating. Although empirical literature is split within that research field as other studies have focused on these specific determinants, yielding evidence for their significant influence. Fama and French (1989) find that the credit quality of bonds ultimately determines their hedging capability during inflationary periods while Fabozzi (2021) shows that duration is the determining factor. There is also evidence for the third characteristic that Spierdijk and Umar (2015) find not significant – Kang and Pflueger (2015) support the notion that the issuer plays a pivotal role in determining outcomes.

It is noteworthy that each of these determining characteristics of a bonds exhibit evidence to support both significant impact and, conversely, negligible influence, particularly during periods of elevated inflation. This is primarily attributable to the substantial disparities between the circumstances that come along with the periods chosen (e.g., the 1980s, 1990s, the Global Financial Crisis, etc.), how an elevated inflation period has been characterised (threshold inflation, CPI, inflation expectation surveys, etc.), and the comparison itself of bonds classes (e.g., yield-to-maturity, index comparison, bond price adjustments, etc.).

This is also the case for inflation-linked bond classes. In existing literature, TIPS are considered to hedge against inflation (Laatsch and Klein, 2005), and are quarterly adjusted to the US Consumer Price Index (CPI). This adjustment is supposed to make TIPS less volatile and risky during times of elevated inflation. Mkaouar et al. (2017) emphasise their profitability in relation to an inflation hedge, even during periods of non-elevated inflation. However, the effectiveness of TIPS, similarly as in the other bonds categories, has been called into question by other studies (see Huang and Zhong, 2013; Kwak and Lim, 2014).

In the context of the recent inflationary period, it is evident that there was neither a historical template for the exceptional circumstances that existed and persisted during that time, nor for the bonds markets reaction that came along with these developments. Research has emphasised the novel approaches adopted to combat inflation (Delgado and Gravelle, 2023; Haddad et al., 2021), as the recent period differed significantly from the 1980-2014 era, which forms the foundation for most existing studies. In response to these exceptional circumstances, central banks have adopted monetary tools that have influenced bond markets in a newly manner. This study also provide insights about how other factors than inflation itself impact bonds returns within the elevated inflation period.

In order to obtain a more precise depiction of the behaviour of the bonds classes and to provide a more recent perspective, the Yield-to-Maturity and the Effective Yield indices are utilised, based on the literature of Malkiel (1962). This is done in order to minimise the differences between all of the bonds classes that are examined. The behaviour of the bond classes is explicitly analysed during the period from 01.02.2021 to 31.05.2024. The period was selected based on the findings of Reis, R. (2022), who noted early signs of inflationary pressures (skewness began to rise) in inflation expectation surveys, emphasising that the inflationary force began on 01.02.2021. The period is chosen until the (realized) inflation threshold of 3% is breached. This period is of particular relevance as it is recent and has not yet been extensively studied.

The findings of this study are as follows: Firstly, TIPS have been identified as offering one of the more favourable risk-reward profiles during inflationary periods, though still with a negative risk-reward, placing them in close proximity to their peers. This suggests that TIPS do not significantly outperform as they are supposed to do. Secondly, credit quality has been found to be negatively correlated to risk-reward. HY offer a higher risk-reward and superior return distributions, which become even more interesting for investors in times of uncertainty. Thirdly, shorter duration faces higher risk while providing less return for that risk. These findings are visible on the government and the corporate side. Fourthly, special monetary and fiscal policy actions, not only in terms of actions itself but also velocity, affected bonds market not in a typical inflationary fashion within that period. As a conclusion, shorter duration and lower credit quality maximize the risk-reward. TIPS limit the maximal downside risk.

The remainder of this paper is organized as follows. Section 2 reviews the literature. Section 3 displays the data description, followed by the methodology in section. In section 5, first data observations are made within the descriptive statistics part while Section 6 dicusses results obtained out of the analysis. And Section 7 concludes.

2. Literature Review

The bonds market is a significant component of the global financial system, offering governments and corporations a crucial way for capital raising. It is customary for bonds issued by corporations and governments to pay fixed or variable interest on their notional value. The development of these bonds is significantly influenced by changes in macroeconomic factors, in particular inflation. The government issues special bonds that protect investors against inflation risk. These are known as Treasury Inflation-Protected Securities (TIPS) (Campbell and Shiller, 1996). Over the past few years, the market share of TIPS has remained relatively stable at around 7.5% of marketable debt in the United States (U.S. Department of the Treasury, 2023). These bonds adjust their interest payments and notional based on inflation references, such as the CPI. As a consequence of this adjustment, the future coupon payments of TIPS are not eroded by inflation in the same way as those of traditional bonds. This makes TIPS, in theory, less volatile and risky in periods of rising and high inflation (D'Amico et al., 2008). Fleming and Krishan (2012) demonstrate that TIPS outperform in periods of inflation due to their ability to adjust. Additionally, the low correlation to other assets, and the liquidity premium within flight-in-safety moments support TIPS price movements (Roll, 2004).

Although, TIPS can maintain their purchasing power, inflation protection comes at a cost (Campbell, Shiller and Viceira, 2009). During periods of non-elevated inflation and inflation expectations, TIPS underperform nominal bonds due to a lower initial yield and reduced liquidity (D'Amico et al., 2008). Based on that, I expect to see in the data period that inflation-linked bonds offer superior risk-adjusted returns in comparison to nominal bonds (government and corporate) during periods of high inflation (Hypothesis 1). However, as our inflationary period was accompanied by an economic expansion, Fama and French (1989) emphasise that within such periods, corporate bonds can maintain competitive returns as default risk is effectively managed, leading to stronger risk-return profiles - even outperforming TIPS.

The impact of inflation on bonds is largely determined by two key components: credit quality and duration. The ladder structure is significantly influenced by the interconnection between inflation (and its expectation) and interest rates, which ultimately determines the rate that discounts future cash flows (Campbell and Shiller, 1996). As the duration of a bond increases, the future cash flows become more distant. Consequently, the reaction of maturities to movements of interest rates differs in terms of sign and size, resulting in heteregenous performance in periods of volatile and high inflationary conditions (Malkiel: 2015). Fabozzi (2021) finds that the sensitivity of bonds tends to diminish with shorter duration due to the fact that they have less exposure to future cash flows. This trade-off between maturity and inflation risk gives rise to divergent risk-return profiles (Roll: 1971), and is especially pronounced during abrupt shifts in inflation expectations (Greenwood and Vayanos: 2014). Testing the duration components, based on these literatures, I expect to see that long-duration nominal bonds will exhibit higher volatility and lower returns in comparison to inflation-linked bonds during periods of high inflation (Hypothesis 2), and within the corporate bonds sector, that short-duration nominal bonds will offer lower returns but will be less volatile than long-duration nominal bonds during periods of high inflation (Hypothesis 3).

In terms of credit quality, Bai, Bali and Wen (2019) demonstrate a positive correlation between returns and volatility in the cross-section of US corporate bonds. This implies that the elevated default risk associated with High-Yield (HY) bonds tends to result in superior performance compared to Investment-Grade (IG) bonds. However, higher default risk is amplified in worse credit condition environments (Brennan and Xia, 2002), as issuers tend to be more leveraged and therefore suffer more from increased borrowing costs. This results in underperformance of

HY within elevated inflation periods (Fama and French, 1989). Given the literature, I test the Hypothesis that HY bonds are subject to heightened volatility and diminished returns during periods of high inflation (Hypothesis 4).

De Santis and Bekaert (2020) examine these two key components, comparing the riskiest HY credit category with the safest IG category and the longest residual maturity bonds with the 1-3 year bonds. Significant discrepancies in risk and return are evident. The distinction in credit quality is also discernible between government and corporate bonds. As demonstrated by Kang and Pflueger (2015), corporate spreads (=yield differential between corporate and government bonds) exhibit a pronounced widening during inflationary periods, reflecting a heightened risk premium.

However, due to the special circumstances before and within the inflationary data period I look at, we need to look specifically what happened within this inflationary period compared to others. Delgado and Gravelle (2023) demonstrate that the use of unconventional monetary policy tools were employed, with a significant proportion of purchases concentrated in government bonds. A significant proportion of government debt issuance during the 2020–21 period was absorbed by central banks. That means from a technical perspective, the purchase of central bank assets modified the duration and credit risk profile of the private sector, as it exchanged lower duration assets (central bank reserves) for private holdings of higher duration assets (government bonds) (Hammermann et al., 2019). This resulted in a decline in credit risk premia (=tighter credit spreads). The Federal Reserve also took action within the corporate sector, announcing on 23 March 2020 IG bonds purchasing, which impacted the most shorter maturities and lower credit risk as these were the primary targets. The effects on non-targeted HY debt were minimal (Haddad et al., 2021). Shortly after, on the 9th of april announced the US government to also include non-targeted HY. Support that was never seen before (Haddad et al., 2021). These circumstances are especially important to know before going into the inflationary period to better evaluate the upcoming reactions in the market. The strong economic rebound led to a fast termination of the asset purchasing program, followed by the start of the war in Ukraine, starting in Feb. 2022. As a consequence, food and energy prices soared, pressuring central banks into a tightening policy cycle. The implementation of Quantitative Tightening (QT) had as a consequence that central banks reduced their balance sheets by selling bonds or allowing them to mature (Ramsden, 2023). A reduction in liquidity in the bond market was observed, with a notable impact on longer-duration assets that had previously been purchased by central banks during the course of Quantitative Easing (Mangwiro, 2023). QT increases the supply of longer-term securities in the market, in theory, exerting downward pressure on their prices, supporting Hypothesis 3. However, the rise in overnight funding spreads and decline in the “convenience yield” of government bonds did not significantly affect pricing, nor the liquidity of government debt securities. The demand of domestic non-banks equalized the reduced bonds holdings of central banks, so that effects of QT are insignificant on average (Du et al., 2024).

Eventually, studies find when market sentiment shifted in 2023 and 2024, and market anticipated to see potential interest rate cuts, Longer-term bonds demonstrated a stronger recovery than other bond types. Although TIPS yields increased during the period, the impact on prices was somewhat mitigated due to investors' consideration of the inflation protection component. The Federal Reserve's aggressive tightening in 2022-2024 contributed to a reduction in inflation from its previous highs, accompanied by a decline in inflation expectations. The convergence of inflation compensation embedded in TIPS and overall yield adjustment in nominal bonds resulted in a relative similarity in performance over the longer term (Andreasen, Christensen, and Riddell, 2021; Campbell, J. Y., Shiller, R. J., & Viceira, L. M., 2009).

3. Data

To conduct a comprehensive analysis of bond performance within an elevated inflationary period, the paper employs a non-inflationary period from 01.10.2014 until 31.01.2021 and an inflationary period from 01.02.2021 until 30.05.2024 as a point of comparison. The data were obtained in conjunction with Bloomberg, the Federal Reserve Economic Data, the World Bank database, and the IMF database. The analysis is exclusively focused on geographical data pertaining to the United States. The dataset comprises 2,497 daily observations per asset.

The analysis focuses on the index level and examines the daily returns of the effective yield, as represented by the indices of BofA and Bloomberg. At the level of individual bonds, the following data were employed: 24 high-yield bonds with an average maturity of 10.63 years, predominantly rated BB or single B, with two CCC-rated bonds. The sectoral distribution was as follows: Consumer (1), Non-cyclical (3), Basic Materials (2), Cyclical (6), Communications (5), Industrial (2), Energy (3), Utilities (1) and Financials (2).

The portfolio comprises 57 single IG bonds with an average maturity of 14.71 years. The majority of these bonds are rated as either BBB or single A, with one AAA-rated bond also included. The sector classification is as follows: The sectors in question are as follows: Energy (8), Communications (4), Technology (4), Industrial (8), Consumer, Non-cyclical (9), Financials (12), Consumer, Cyclical (5), Utilities (5), and Basic Materials (2).

In general, the data on single bonds were more extensive for IG than for HY bonds. However, both categories lacked somewhat in extensivity, and thus were only used to support or question results obtained on the index level. As the single bonds have different maturities, coupon payments, and idiosyncratic risk, the yield to maturity was calculated in order to minimise the discrepancies between the bonds and thereby facilitate a more comparable analysis. This approach was informed by the recommendations put forth by Malkiel (1962). Furthermore, in order to ensure consistency in the analysis, the 10-year and 30-year government yield and the effective yield indices were used.

In the context of TIPS, it was not possible to identify an index that is exclusively focused on the US. Consequently, I devised one myself. To gain a comprehensive overview, five distinct single TIPS with varying maturities and coupons were chosen. This approach ensures that the resulting data accurately reflects the entire TIPS market. The distribution of the single TIPS in comparison to the index is illustrated in Appendix 3.

In conducting the regression analysis, I employed the World Energy index, which comprises 10 oil and gas integrators (BP, Chevron, Exxon, Repsol, etc.), excluding nationalised oil producers such as Saudi Aramco. In accordance with Ready (2018), the initial nearest maturity NYMEX crude-oil WTI futures contract is employed as a proxy for the price of crude oil. The VIX index is employed as a means of capturing shocks related to changes in market sentiment and attitudes towards risk. The inflation indicator employed to ascertain realised inflation is the CPIAUCSL, as it incorporates inflation expectations to a greater degree than other available options – visible in Appendix 2. Other CPI figures were sourced in order to ascertain whether they could be of significant value. Given the high correlation of over 0.9 with the CPI YOY

Index and the CPI-U, as well as the similar ranges of minima, maxima and standard deviations, there is limited added value in using additional CPI numbers. Furthermore, inflation expectations were considered as a variable to gain a more comprehensive understanding. The inflation expectation median 1Y of Bloomberg, which measures the views of 1,200 US consumers, offers a more comprehensive insight than other similar sources. In terms of macroeconomic factors, data on gross domestic product (GDP) and unemployment reflect the economic health of a country and provide information about the outlook going forward. Central banks closely monitor these two factors because they deliver information about potential monetary tools that central banks need to use to maintain economic stability. Ultimately, central banks aim to adjust interest rates (such as the Federal Funds rate) in response to developments in the macroeconomic landscape.

4. Methodology

I employ not only the conventional statistical parameters such as mean, standard deviation, or median but also those that will help to assess the distribution of the returns to evaluate the risk from a risk-averse investors perspective. The downside becomes here special focus with measures like minima, value-at-risk (VaR) and conditional-value-at-risk (CVaR). The VaR represents the potential risk of loss that can be excluded with a certainty of 95% (Duffie and Pan, 1997). In the event of a 5% probability occurrence, the conditional value-at-risk is employed to ascertain the average loss sustained by the investor (Rockafellar and Uryasev, 2002). The conclusion regarding the distribution is typically elucidated through the utilisation of skewness and kurtosis (Mardia, 1970). The normal distribution is typically eroded in return distributions, which do not reflect kurtoses of 3 and skewness of 0. However, the distribution remains a crucial element in testing for differences of means and variances. Testing for the differences will help to especially see how the other bonds classes perform in comparison to TIPS, taking central tendency and volatility into consideration. As the risk-return profiles are tested, the variance heterogeneity is also assessed using the Brown-Forsythe test, which is considered to yield more robust results (see Box, 1953) than the Levene test (Olejnik and Algina, 1987). Brown and Forsythe (1974) concentrate on the discrepancy between the group medians, thereby rendering the test applicable even in the absence of a normal distribution. The p-value can be calculated using analysis of variance (ANOVA) to assess the hypotheses of the variance comparison (Gelman, 2005). The Brown-Forsythe null hypothesis is employed to test for heteroscedasticity (equality of variances) at the 5% significance level.

In light of the aforementioned results, it is evident that either the t-test or the Welch test should be employed to ascertain whether there is heteroscedasticity (inequality) of means. In instances where heteroscedasticity in variances is present (Behrens Fischer problem), the Welch test is the preferred option. As proposed by Welch (1947), the calculation of the means and the line of freedom used to determine the critical t-statistics should be modified accordingly. In theory, both tests assume a normal distribution. However, various studies have demonstrated that a normal distribution is not a prerequisite for unpaired t-tests, particularly when utilising a large sample size that has been equalised by the central limit theorem (Kubinger et al., 2009; Rasch & Guiard, 2004; Wilcox, 2012).

Eventually, after having a deeper understanding of the data, the correlation between the bonds classes are calculated to see how they react to each other within the inflation period. That not only tells similarities, but also complements the overall picture for investors which risk-return profiles are delivered, and can be used to hedge others.

With the following regression is the correlation of each bonds class to inflation measured to understand the reactions of Bonds to Inflation movements:

$$Return_t = \alpha + \beta_{inflation} * Inflation\ Rate_t + \epsilon_t$$

The coefficient $\beta_{inflation}$ shows the sensitivity of each bonds to inflation. The higher positive beta the more aligned with inflation movements. As the inflation rate is only infrequently changed and subject to noise due to the exclusive focus of unexpected inflation (change in inflation rate) on the short term - unable to distinguish between temporary and permanent components-, the assessment from that is rather limited, but helps to get a first impression of risks attached to changes in the rate.

Besides the factor inflation, there are these factors already discussed earlier that might influence Bonds returns. I tested - try-by-error - regressions with different factors to find a regression that explains best the performances, by shrinking β_0. These factors consisted out of Oil Price (Crude Oil Future), GDP, Fed Funds rate, CPI, MSCI World Energy, VIX, and Unemployment.

In order to finally assess the risk-return profiles, risk-adjusted return measures are employed, not only the classic Sharpe Ratio (Sharpe, 1966) but also the Sortino Ratio (Sortino and Price,

1994) and the Calmar Ratio (Magdon and Atiya, 2004). It should be noted that all calculations assume a consistent risk-free rate of 0%. Having said that, the risk-free rate has moved quite strongly over such a long time horizon, but as the analysis compares measures between the bonds returns in that period rather than period with period, all data is similar affected.

Sharpe Ratio: $\frac{Average\ Return - Risk\ Free\ Rate}{Standard\ Deviation}$

To calculate how much return you earn for every unit of total risk (assumes normal distribution).

Sortino Ratio: $\frac{Average\ Return - Risk\ Free\ Rate}{Downside\ Deviation}$

To Improve the Sharpe Ratio by focusing solely on downside risk - how much return you earn for every unit of downside risk, which is more helpful for loss-averse strategies. The challenge here is that the ratio is subject to time period bias, therefore needing long data series to get a profound assessment.

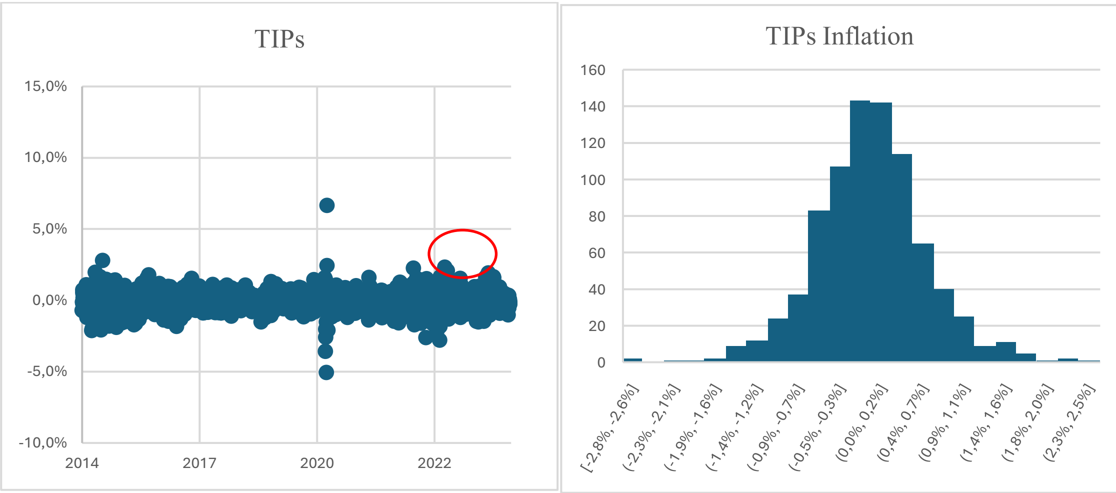
Calmar Ratio: $\frac{Average\ Return * 250}{|Maximum\ Drawdown|}$

To have a resilient measure also during times of market stress, especially important for the inflationary period between 2021-24. Although that ratio ignores general volatility and is time-frame sensitive.

Even though all 3 risk-reward ratios have their limits, an assessment of all these 3 should yield a profound result.

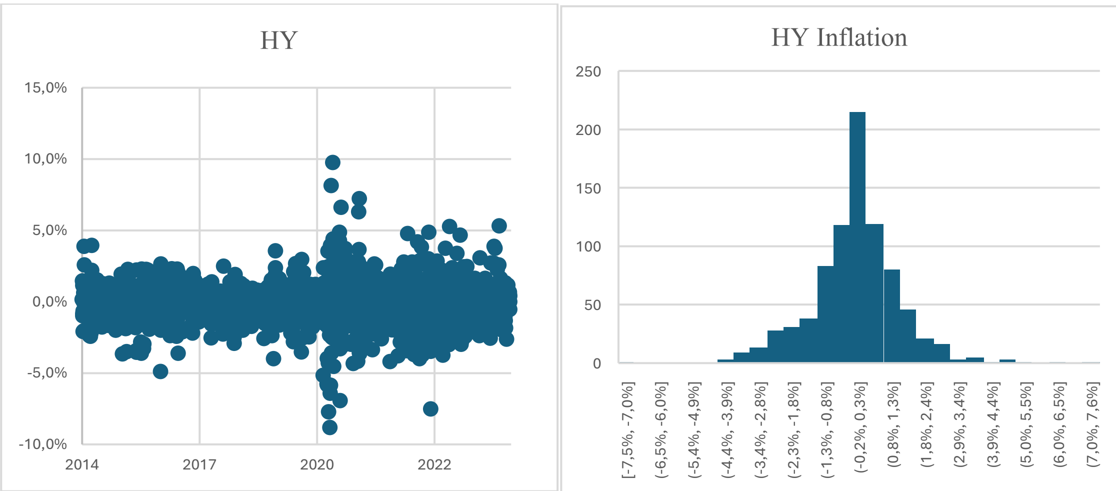
5. Descriptive Statistics

Starting this section, I have results visualized to get an first impression of the distributions over time, and within the inflationary period. The visualization helps to understand how bonds classes performances changes due to inflation, and which profile investors can expect in general from these specific bonds. The visualization part is followed by first statistical measures.



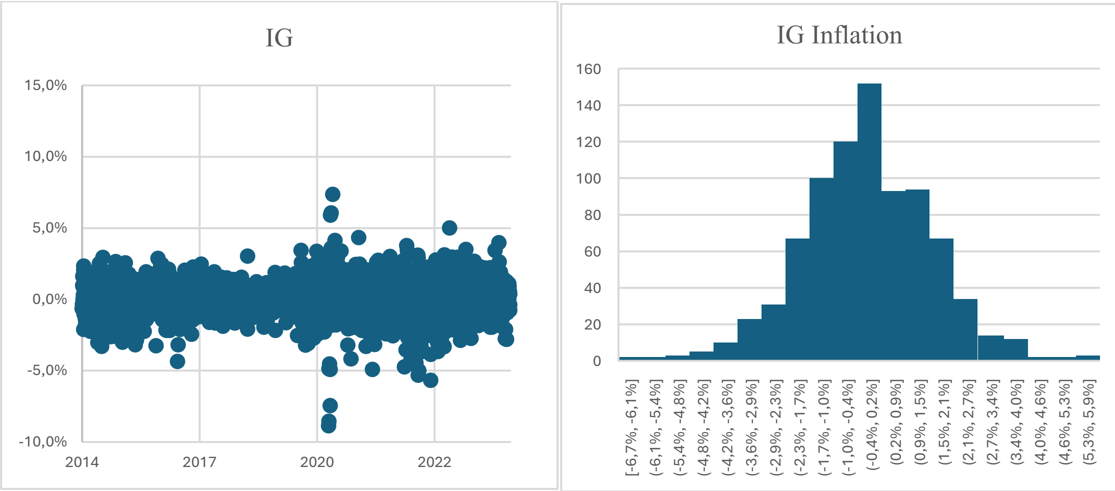
Visualization 1: TIPs return distribution over time, and within the high inflationary period

In the first visualization, we can see that TIPs do not show high volatility. The distribution gets wider within the COVID period 2020, and within the period in which the Ukrainian war started in 2022. The strongest movements during COVID did not surpass -5,1% and +6.7%. A striking observation is that there are positive outlier returns in 2022, emphasizing a potential protection against inflation spikes. However, the distribution does not appear to be strongly right skewed.



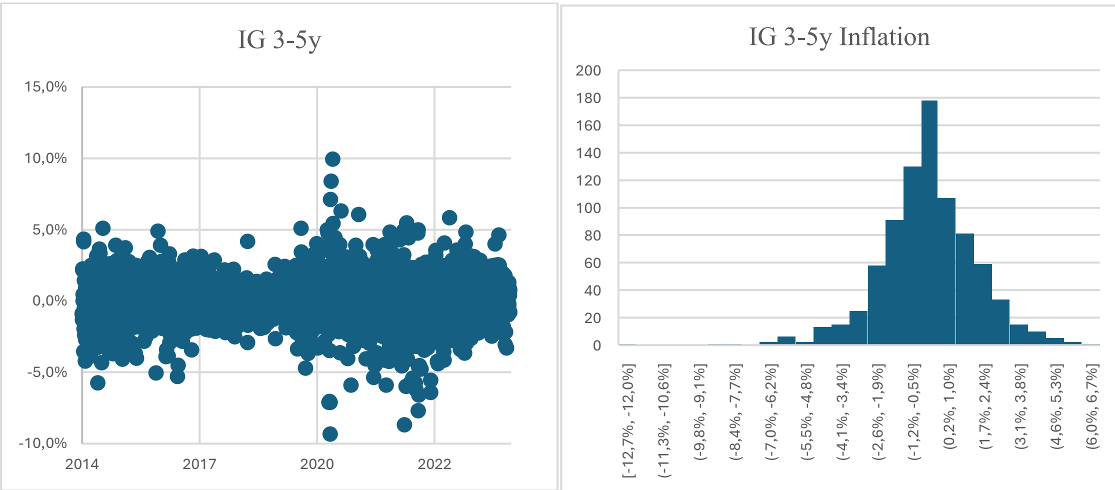
Visualization 2: HY return distribution over time, and within the high inflationary period

Visualization 2 shows clearly a higher volatility for HY than for TIPs. In distressed markets times, the volatile moves amplify. However, the right graph looks almost as if the HY distribution within the high inflationary period is to a normal distribution. The outliers are in a same range and a similar frequency on both sides. This observation may appear counterintuitive, given the expectation that HY is more susceptible to inflation. Consequently, the impact of an interest rate hike on a deteriorating credit rating is expected to be more significant.



Visualization 3: IG return distribution over time, and within the high inflationary period

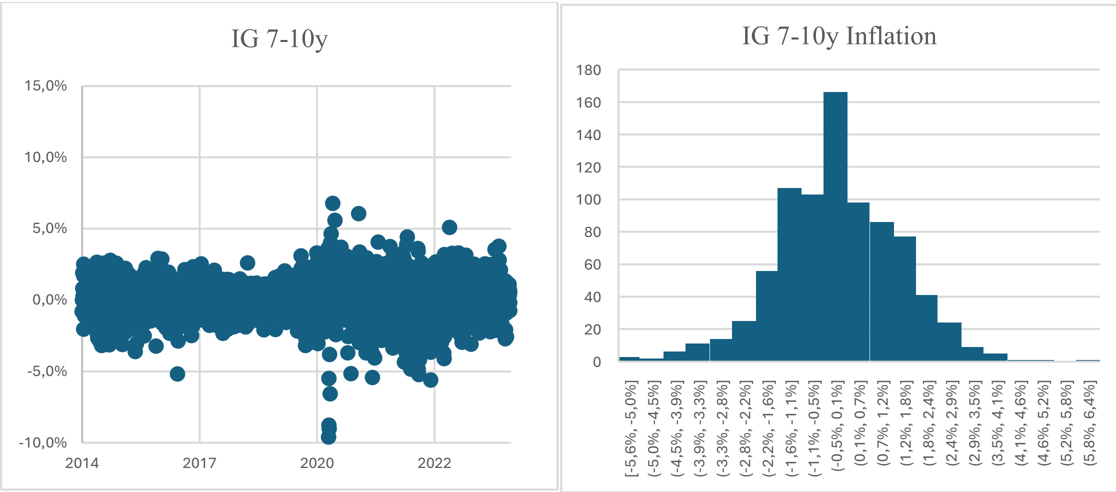
IG provides a comparable illustration to HY during the period of elevated inflation, yet a distinct one within the inflationary phase, visible in visualization 3. Notably, in the histogram, the left-skewness of IG is evidently visible. The downside is larger than the upside (-6.7% vs. 5.9%) while the higher frequnce is not only displayed by the higher bars to the left but also by the highest middle bar (-0.4% to 0.2%). The frequency and extent of downward movements indicate distinct responses of credit quality within an elevated inflationary period, and also a more pronounced downward movement with a higher rating.



Visualization 4: IG 3-5y return distribution over time, and within the high inflationary period

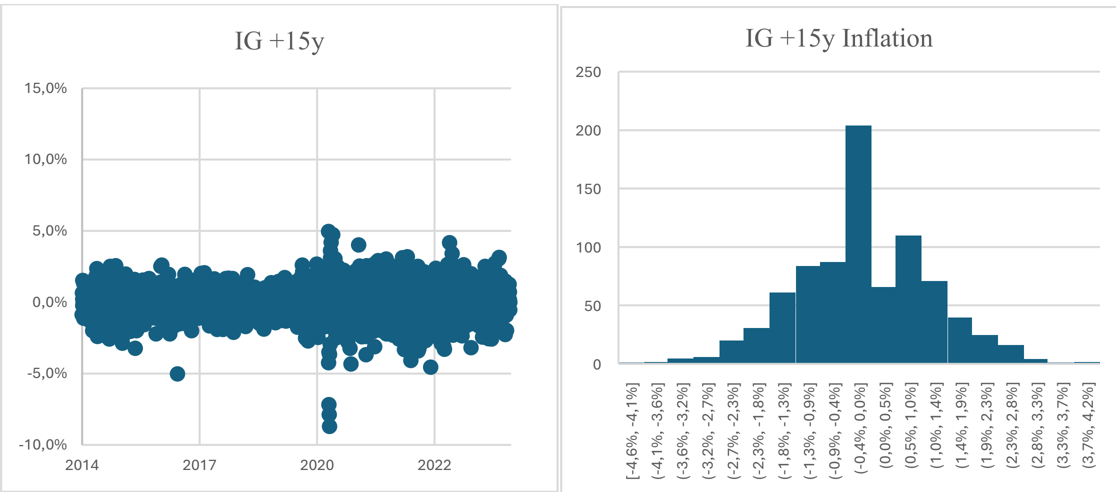
In visualization 4, with regard to duration, short-duration (3-5 years) demonstrate higher levels of volatility in comparison to the IG Index, particularly in the context of negative outliers (-

5.0% to -10.0%). In addition to these outliers, short-duration appear to exhibit significantly higher volatility compared to even HY.



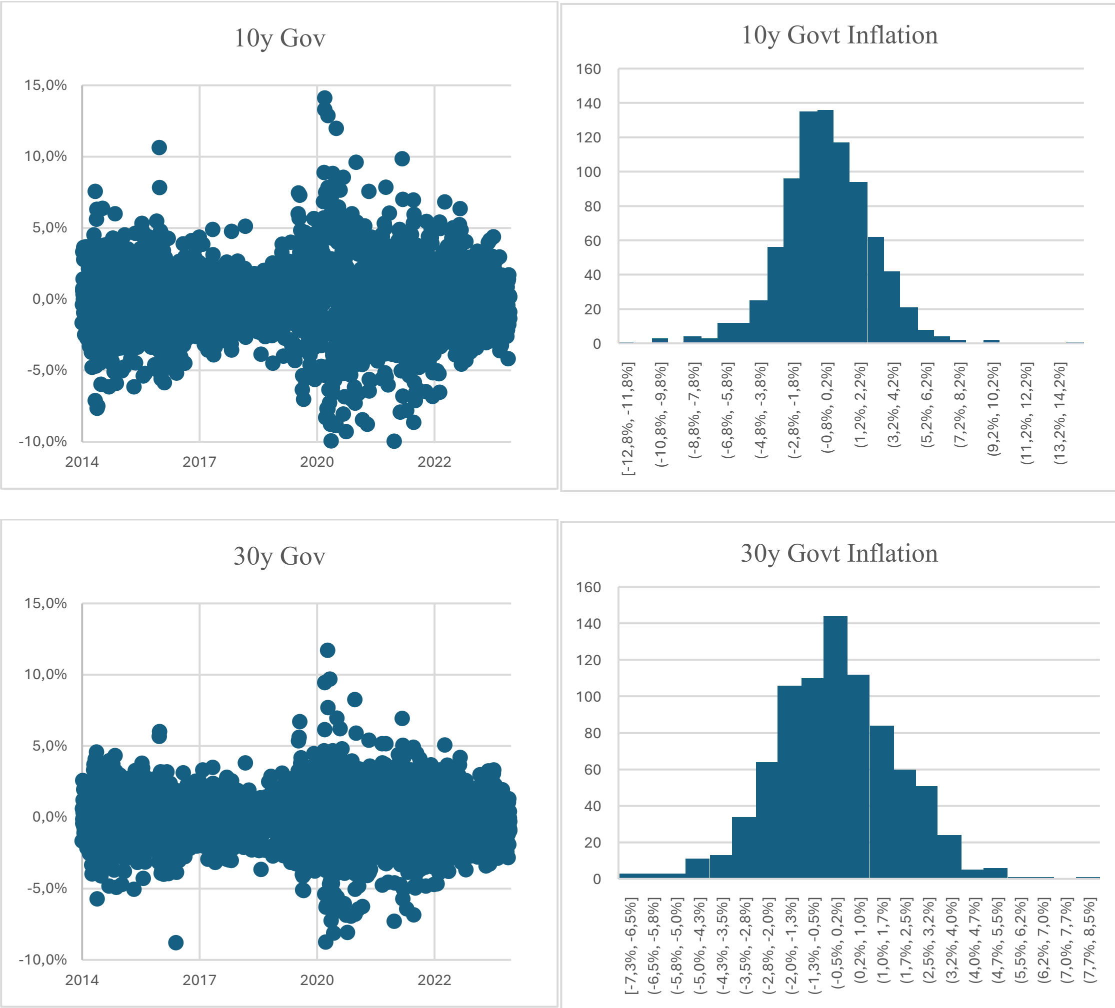
Visualization 5: IG 7-10y return distribution over time, and within the high inflationary period

When we look at visualization 5, we can see that the long-duration (7-10 year) exhibits a greater degree of similarity to the IG index, characterised by a slight left-skewness and a reduced number of outliers. The volatility appears to decrease with an increase in duration. This phenomenon is further supported when considering ultra-long durations (+15 years).



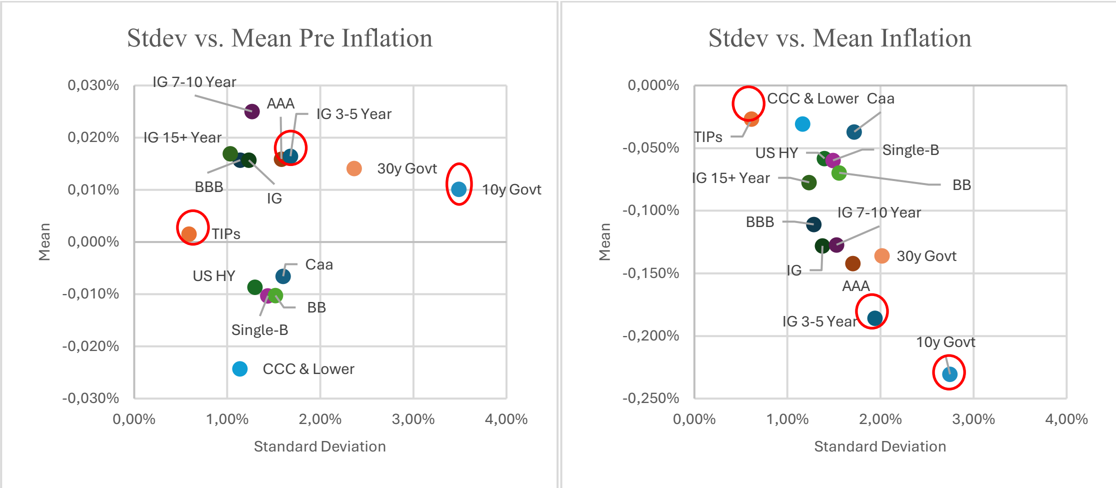
Visualization 6: IG +15y return distribution over time, and within the high inflationary period

The findings in visualization 7 on the government side indicate that duration results are aligned both on corporate and government side. A notable disparity in volatility is observed between the long-end (Gov. 10y)and ultra-long-end (Gov 30y) segments. Surprisingly, the 10-year government bond demonstrates the highest volatility among the all the bonds classes under consideration. Not only in the high inflationary period, but also before.



Visualization 7: Gov. 10y and 30y return distribution over time, and within the high inflationary period

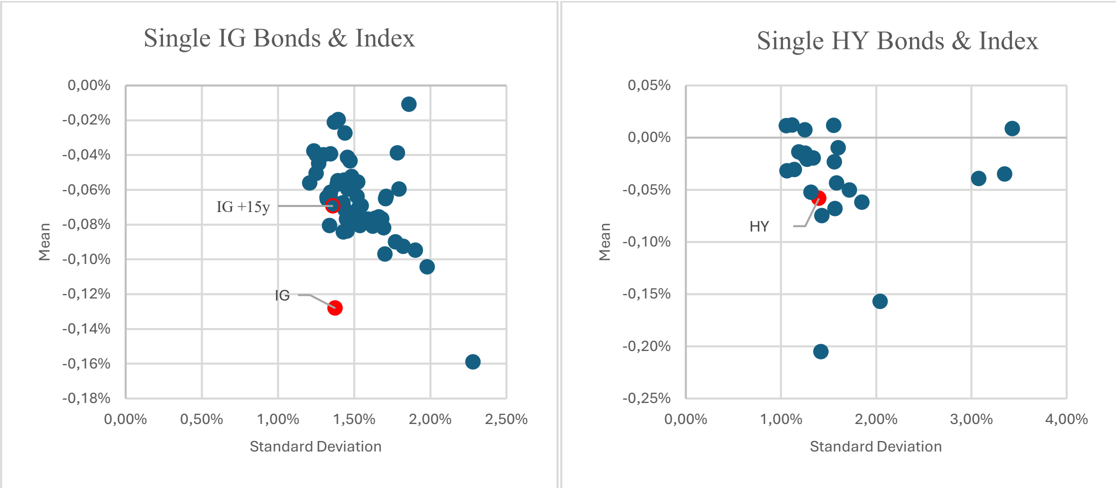
As the distribution profiles, and therefore risk-return tendencies were to some extent visible, I compare all the bonds pre- and within the inflation period to get an initial overview of all the changes that had occured in the bonds classes due to inflation, as well as to gain a brief insight into the profiles of the bond classes in comparison to each other. The risk-return profiles will already show the statistical measures standard deviation and mean, the other descriptive statistics will follow in visualization 10.



Visualization 8: Risk-return profiles within the high inflationary period

In visualization 8, it is noteworthy that inflation did, in fact, exert the anticipated influence. The mean performance of nominal bonds indices appears to be worse during periods of inflation. It is evident that the global pandemic had an impact on the results, however the tendencies seem to be aligned (see Appendix 1) through which the pre-inflation period as a whole can be used to conclude results for non-elevated inflationary periods. The only interesting observation is that HY was stronger negatively affected than IG in the Covid period (2020).

In visualization 8, there is a clear shift of the two measures visible. All bonds classes react distinctively to the elevated inflationary period. The majority display diminished performance. Even though they remain within the 1.0% to 2.0% standard deviation range, the vertical axes of both graphs demonstrate the shift towards more negative returns. Also, TIPS exhibit a slight decline in performance, despite the product's inherent design to thrive during such periods. The most pronounced negative movements is visible in 10y Gov and IG 3-5y bonds, indicating a heightened vulnerability in shorter-duration, emphasizing the results already seen in the visualized distributions. Noteworthy, the evolution that HY is having, particularly in the lowest rating categories CCC & Lower and Caa. HY changes position with the IG bulk (pre-inflation -> inflation).



Visualization 9: Single HY & IG bonds risk-return profiles within the high inflationary period

Looking at visualization 9, upon examination of the index in comparison to the individual bonds during the inflationary period, it becomes evident that the index of HY offers a relatively reliable representation of the market. The majority of IG bonds exhibit average returns within the range of -0.02% to -0.10%, with a standard deviation of 1.25% to 1.75%. Meanwhile, the index of IG performs at the lower bound of the risk, but also on the lower side of the return side in the peer group. That reflect again the observation we have already seen in terms of duration. With an average of 14.71y of the single bonds, the bulk of longer maturing bonds perform more similar to the IG +15y index while the IG broader Index reflects a more medium duration performance.

Comparing both graphs, HY and IG, it is evident that single HY bonds differentiate more substantially from its peers than the single IG peer group. Especially the risk range, seen in the standard deviation, is much wider for HY single bonds than for IG single bonds. That may be due to the nature of those two classes, the difference in duration (Average 10.63y vs. 14.71y) since the peer group is only limited in size, or simple a combination of both. Although, the big bulk of single HY´s is in the same risk range as single IG´s, HY`s are performing better than IG´s in regards to returns. That HY is wider spreaded is somehow expected, given that HY single bonds are typically less liquid, more sensitive during periods of distress, and investors higher selective and adjusting their risk within turbulent times. That the risk-reward, the Sharpe Ratio respectively, for (single) HY bonds is higher than for (single) IG bonds can here already be seen.

Inflation	TIPs	HY	Caa	CCC & Lower	Single-B	BB	BBB	AAA	IG	IG 3-5Y	IG 7-10Y	IG +15Y	10Y Govt	30Y Govt
Stdev	0,006	0,014	0,017	0,012	0,015	0,016	0,013	0,017	0,014	0,019	0,015	0,012	0,027	0,020
Mean	-0,00027	-0,00058	-0,00037	-0,00031	-0,00060	-0,00070	-0,00111	-0,00142	-0,00128	-0,00186	-0,00127	-0,00077	-0,00231	-0,00136
Median	-0,00037	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	-0,00098	0,00000
Max	0,023	0,072	0,124	0,065	0,080	0,077	0,049	0,059	0,050	0,061	0,060	0,042	0,152	0,083
Min	-0,028	-0,075	-0,068	-0,094	-0,074	-0,089	-0,055	-0,067	-0,057	-0,127	-0,056	-0,046	-0,128	-0,073
VaR	-0,010	-0,025	-0,030	-0,021	-0,027	-0,028	-0,022	-0,030	-0,023	-0,034	-0,026	-0,022	-0,045	-0,033
Beta	-0,017	-0,076	-0,079	-0,082	-0,073	-0,077	-0,071	-0,053	-0,070	-0,118	-0,065	-0,038	-0,043	-0,033
Drawdown	-0,393	-0,644	-0,694	-0,637	-0,676	-0,739	-0,718	-0,795	-0,747	-0,878	-0,756	-0,612	-0,983	-0,910
Downside Deviation	0,004	0,010	0,012	0,009	0,010	0,011	0,008	0,011	0,009	0,014	0,010	0,008	0,018	0,013
CVaR	-0,013	-0,031	-0,041	-0,029	-0,033	-0,035	-0,029	-0,039	-0,032	-0,047	-0,034	-0,027	-0,063	-0,044
Sharpe Ratio	-0,044	-0,042	-0,022	-0,026	-0,040	-0,045	-0,086	-0,083	-0,093	-0,096	-0,083	-0,063	-0,084	-0,067
Sortino Ratio	-0,068	-0,060	-0,030	-0,032	-0,058	-0,065	-0,133	-0,130	-0,143	-0,133	-0,131	-0,101	-0,127	-0,108
Calmar Ratio	-0,171	-0,226	-0,133	-0,120	-0,221	-0,236	-0,386	-0,447	-0,429	-0,529	-0,421	-0,316	-0,587	-0,373
MAD	0,003	0,007	0,009	0,006	0,008	0,008	0,008	0,011	0,009	0,011	0,010	0,008	0,017	0,013
Kurtosis	1,571	2,839	4,818	7,543	2,795	3,184	0,962	0,990	1,047	2,982	0,791	0,412	2,349	0,723
Skewness	0,031	0,052	0,133	-0,679	0,050	0,032	-0,209	-0,169	-0,205	-0,564	-0,108	-0,087	-0,079	-0,036
Jarque Bera	72,947	1,316	120,462	801,861	1,859	1,349	154,397	148,120	141,999	45,354	175,640	239,976	16,002	185,119
p-value JB	0,000	0,518	0,000	0,000	0,395	0,509	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Visualization 10: Descriptive statistics within the high inflationary period

The descriptive statistics for the bonds returns are presented in Visualization 10. As it can be seen, 9/14 of the distributions exhibit negative skewness, indicating a left-tailed distribution during periods of high inflation. Government and IG Bonds are all left-skewed while that is only the case for CCC & Lower Index in the HY sector. TIPS, HY Index, Caa, Single-B and BB are all right-skewed. A similar picture can be drawn with the Kurtosis. TIPS, Caa, CCC & Lower, and BB are leptokurtic while the rest is platykurtic. The Jarque-Bera (1980) test shows that, besides the HY index and Single-B and BB, all the samples are not normally distributed at a 5% confidence level.

It is noteworthy that Gov 10y exhibit the highest risk (2.7% standard deviation vs. the average 1.6%) and the most negative mean returns (-0.23%) when compared to other bonds classes. The only index with a less favourable risk-reward ratio is the short-duration IG index (3-5 years), which has a Sharpe ratio of -0.096. This serves to reinforce the observations that have already been presented graphically above. Furthermore, when considering downside risk, which is of particular importance for risk-averse investors, IG 3-5y and Gov 10y exhibit the poorest risk-reward ratio (Sortino and Calmar ratios). TIPS exhibit the lowest standard deviation, although this is not reflected in its performance per se. It is noteworthy that the Caa and CCC & Lower indices exhibit the most favourable risk-reward profile within the peer group, as evidenced by all three risk-reward ratios. It appears that not only is there a negative correlation between risk-reward and duration, but also between credit quality and risk-reward. In that context, the results have to be careful considered, especially for single bonds interpretation within the credit rating categories as the survivorship bias[1] is higher for lower credit quality, mainly in the lower bound Caa and CCC & Lower. However, on an index level are these findings profound as investors

[1] Survivorship bias = defaulted companies tend to be excluded from performance studies, thereby skewing results higher (Rohleder et al., 2011)

are able to invest in it, and benefit from the risk-reward, and the distribution. This finding supports the results of a higher tendency for more positive returns in the lower credit quality segment in comparison to those of IG and government bonds. The most unfavourable combination appears to be a high credit rating with short duration. The 3-5y IG category exhibits the most pronounced negative skewness, suggesting that investors may experience more negative returns. These negative returns result in a 5% probability of daily negative returns of 3.4% or more. Only 10y Gov bonds have a higher daily negative return potential, with 4.5% or more. Once more, the lowest risk is observed in TIPS, with a daily negative return potential of 1.0%.

Another noteworthy observation is that there is almost no correlation to inflation (visible beta to inflation) across all bond categories. Even TIPS do not react as a consequence of a change in inflation. Again, subject to the infrequent changes of CPI. The highest beta can be seen at IG 3-5y with -0.118, which is considered to be non-correlating (Mankiw and Shapiro, 1984).

Inflation	TIPs	US HY	Caa	CCC & Lowe	B	BB	BBB	AAA	IG	IG 3-5Y	IG 7-10Y	IG 15+Y	10Y Govt	30Y Govt
TIPs														
US HY	0,039													
Caa	-0,019	-0,031												
CCC & Lower	0,019	0,870	-0,001											
B	0,032	0,979	-0,041	0,821										
BB	0,041	0,983	-0,028	0,811	0,950									
BBB	0,051	0,462	-0,038	0,360	0,412	0,494								
AAA	0,042	0,365	-0,032	0,254	0,314	0,402	0,954							
IG	0,048	0,437	-0,033	0,326	0,389	0,471	0,986	0,965						
IG 3-5Y	0,703	0,023	-0,011	0,001	0,017	0,023	0,012	0,006	0,011					
IG 7-10Y	0,730	0,038	-0,009	0,019	0,028	0,037	0,005	-0,003	0,001	0,927				
IG 15+Y	0,054	0,406	-0,019	0,301	0,366	0,435	0,926	0,876	0,931	0,000	-0,010			
10Y Govt	0,037	0,433	-0,039	0,321	0,384	0,468	0,969	0,959	0,971	0,004	0,000	0,896		
30Y Govt	0,019	0,414	-0,029	0,317	0,367	0,445	0,904	0,923	0,905	0,001	-0,001	0,747	0,932	

Visualization 11: Correlation matrix for the high inflationary period

When we look at visualization 11 at the correlations between the bonds classes, we can see how TIPS behave within the inflationary period. There is almost no correlation to any of the classes, besides the IG 3-5Y and 7-10Y. That shows that TIPS are rather reactive like the short- to medium-duration bonds. Another striking observation is the strong relation between IG (broad index, AAA- & BBB index) bonds and the Gov bonds. Movements in the Gov. bonds are almost 1:1 translated in the IG Bonds. A clear distinction can here be drawn again between the short and long duration. We can see that the IG broad index react rather like the ultra long-duration (probably due to the structure of the index) while the short (3-5y) and (7-10y) completely behave differently. Unsurprisingly, in terms of credit quality, HY and IG sector show only low correlations. The Caa index is the only one in the group that shows no correlation to any bonds class.

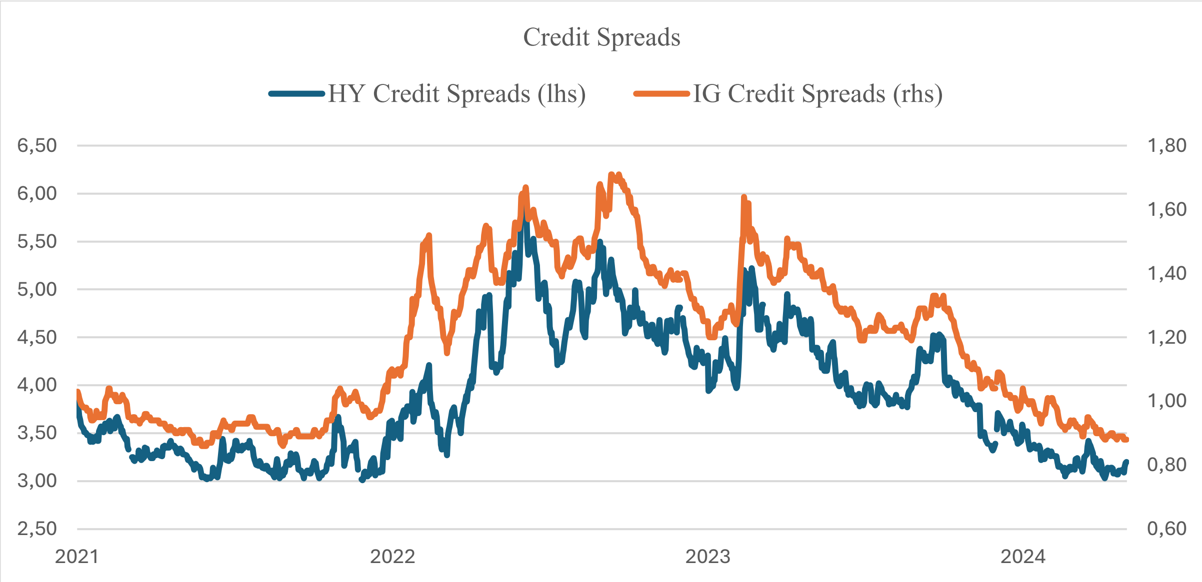
Pre-Inflation	TIPs	HY	Caa	CCC & Lower	Single-B	BB	BBB	AAA	IG	IG 3-5Y	IG 7-10Y	IG +15Y	10Y Govt	30Y Govt
Stdev	0,006	0,013	0,016	0,011	0,014	0,015	0,011	0,016	0,012	0,017	0,013	0,010	0,035	0,024
Mean	0,00002	-0,00009	-0,00007	-0,00024	-0,00010	-0,00010	0,00016	0,00016	0,00016	0,00016	0,00025	0,00017	0,00010	0,00014
Median	0,00022	0,00000	0,00102	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00000	0,00032
Min	-0,067	-0,098	-0,085	-0,079	-0,100	-0,119	-0,075	-0,095	-0,074	-0,099	-0,068	-0,050	-0,291	-0,227
Max	0,050	0,144	0,133	0,094	0,160	0,172	0,129	0,147	0,142	0,160	0,151	0,122	0,502	0,311
VaR	-0,009	-0,017	-0,026	-0,017	-0,019	-0,020	-0,015	-0,022	-0,017	-0,023	-0,017	0,000	-0,044	-0,031
Beta	-0,016	0,049	-0,022	0,083	0,055	0,041	-0,012	-0,040	-0,023	-0,036	-0,029	-0,008	-0,110	-0,061
Drawdown	-0,228	-0,593	-0,774	-0,607	-0,636	-0,649	-0,560	-0,543	-0,552	-0,704	-0,539	-0,405	-0,813	-0,620
Downside Deviation	0,004	0,013	0,014	0,011	0,014	0,015	0,011	0,014	0,012	0,015	0,012	0,009	0,032	0,020
CVaR	-0,013	-0,034	-0,042	-0,031	-0,037	-0,039	-0,027	-0,038	-0,029	-0,041	-0,030	-0,025	-0,077	-0,051
Sharpe Ratio	0,003	0,007	0,004	0,021	0,007	0,007	-0,014	-0,010	-0,013	-0,010	-0,020	-0,016	-0,003	-0,006
Sortino Ratio	0,004	0,010	0,007	0,032	0,011	0,010	-0,023	-0,015	-0,021	-0,016	-0,035	-0,028	0,003	0,007
Calmar Ratio	0,017	-0,036	-0,021	-0,100	-0,041	-0,039	0,070	0,073	0,071	0,058	0,116	0,104	0,031	0,057
MAD	0,003	0,005	0,008	0,005	0,005	0,005	0,005	0,007	0,006	0,008	0,006	0,005	0,013	0,010
Kurtosis	15,060	23,050	7,757	12,916	22,086	25,076	31,565	13,945	23,720	16,079	25,403	20,519	60,548	44,517
Skewness	0,241	-1,836	-0,939	-1,082	-1,627	-1,838	-2,744	-0,932	-2,209	-1,601	-2,450	-1,999	-2,717	-1,211
Jarque Bera	9504,628	27111,397	1706,911	6721,699	24460,522	32679,725	55207,521	8042,980	29286,450	11829,746	34315,246	21068,760	218017,966	112852,328
p-value JB	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Visualization 12: Descriptive statistics within the pre-inflationary period

As might have been anticipated, the downside risk for TIPS was constrained within the inflationary period, as it was within the pre-inflationary period. Interestingly, TIPS provide pre-inflation the only positive skewness. In contrast, the opposite is true for Gov 10y bonds. Once again, the highest risk was observed, both in terms of volatility and potential for negative returns (maximum drawdown: 84.3%). This was evident both before and after the inflationary period, with the highest sensitivity to inflation. Looking at the risk-reward pre-inflation, HY tend to offer a higher risk-reward than IG. That changes when the downside is taken into account (Calmar Ratio). However, the risk of HY and IG is not substantially different.

6. Discussion Results

The data analysis reveals that there is no statistically significant difference in volatility or mean between HY and TIPS. It is somewhat surprising when considering the higher credit risk associated with the HY bonds compared to TIPS that are issued by the government and are considered to have no credit risk. Therefore, the reason for this cannot be attributed to the nature of the product itself, but rather to the circumstances surrounding it. Although, the principal of TIPS adjusts in line with inflation, these time-lagged infrequent adjustments do not prevent the impact of inflation expectation and interest rate shifts. Following the increase in interest rates by the Federal Reserve within the inflationary period, both HY and TIPS demonstrated an adjustment in response to evolving inflation expectations, driven by factors such as elevated credit spreads and interest rate pressure. During periods of inflation, investors seek higher yields to compensate for the erosion of purchasing power, finding that in TIPS as they are designed to provide a more direct hedge while HY is by nature higher rewarding due to the risk attached (Roll, 2004). When this inflation is connected to an economic boom (after COVID) especially HY thrives. On average, as they are more leveraged, debt payments stay relatively similar while higher demand and income growth accelerates (De Santis and Bekaert, 2020). Even though we can see in visualization 13 that credit spreads several times widened throughout the inflationary period due to economic uncertainty (ukrainain war, gasoline price spikes, recession fears), overall there is a clear trend of tighter credit spreads visible as a effect of the aforementioned mechanicals. IG spreads show a similar pattern as HY, although in the extent of movement they are strongly differing.



Visualization 13: Credit Spreads in the last 5y

TIPS on the other side, they maintain real returns during periods of declining inflation, but may underperform when interest rate rise, even when inflation is high (d'Amico, Kim, and Wei, 2018). Both happened within the elevated inflationary period I look at. Eventually, Sharpe Ratio and Sortino Ratio of TIPS exhibit negative results. Since inflation expectation and interest rates are observable much more frequent than CPI, TIPS perform rather like a bonds, insufficiently offseting the rising yields. This resulted in significant price fluctuations, even in the event of temporary high inflation. D'Amico, Kim and Wei (2018) emphasize how TIPS demonstrate delayed responsiveness to abrupt inflation spikes due to the lag in CPI adjustments.

Still, the risk-reward ratios of TIPS are among the better performing ones, therefore providing value to some extent to investors. It is perhaps unsurprising that HY bonds, and especially the lowest quality HY bonds, provide the best risk-reward ratio, given the actions taken by central banks. The implementation of quantitative easing by central banks, and eventually the buying activity of the FED within the non-target HY bonds segment supported these bonds, which have the highest risk-premium, but ultimately reduced their default risk through the support provided by fiscal and monetary policy (Du et al., 2024).

Already visible in the descriptive statistics part, the differences in volatility between IG and IG shorter duration are subsequently validated at a statistically significant level. Comparing that to TIPS, only the 3-5y IG is significantly different from TIPS in terms of volatility. This cannot be proven for the other IG categories, neither at the broader nor at the specific credit rating level. The ladder result can be expected as the credit risk of IG (safe heaven asset) is rather close to the non-existing credit risk of governments bonds. However, the return side, all IG mean´s behave significantly different to TIPS, except for the long end IG +15Y. In comparison to TIPs and HY, IG does not provide a robust cushion against sudden inflationary pressures, given that credit spreads are already considerably tighter, thereby offering diminished returns. With regard to the impact of duration, the shorter end (IG 3-5y) exhibits a significant divergence from the +15y IG.

In the further sections it is of importance to see why these effects are visible. Certainly the interest rates movement short- vs. long-term rates mainly influenced the differences. It started in 2021 with a yield-curve steepening, where long-term rates rates have risen stronger than short-term rates reflecting economic growth and inflation in the future. Increases of longer rates are accompanied with reactions of longer duration bonds as it only affects cashflows in the longer-end (Malkiel, 2015). In 2022, with persistent inflation, central banks reacted and implemented rate hikes. In response to these actions, we saw a flattening yield curve (defined as a decrease in the difference between short- and long-term rates), in which the short-end of the curve is significantly rising while the long-end remains stable, shorter duration bonds consequently face higher volatility and downside risk. The market is pricing in higher short-term potential market risks, and investors shift their money within the short-end more frequent while longer duration remain relatively stabile, or provide a "safe heaven" for investors, attracting a shift from the short- to the long-end (Neville, 2021). The flattening move of the yield curve eventually occured to such an extent that the yield curve inverted, offering higher short-term- rates than long-term rates. This even more emphasized the short-term risk as in history there was never a time in which the US economy moved out of an inverted yield curve without a recession (Hughes, 2024). The effect of new bonds issuance with similar (short-term) maturities but higher coupons due to the interest rate environment additionally support the price adjustments on the shorter end (Malkiel, 2015). Longer-duration Bonds benefited from stable long-term rates. The risk appetite became stronger in 2023 where inflation seemed to have peaked, making HY more appealing. Inflation expectation stabilized, with both short- and long-term adjusting. HY bonds outperformed IG with higher yields and imporved credit outlooks. In 2024, the yield curve began to steepend slightly as a consequence of falling short-term rates. This move came along with inflation (expectation) cooling off (Du et al., 2024). That means the interest rate movements between 2022 and 2023 along with the elevated inflation took mainly place in the short-end, and emphasizing the argument pro long-duration to avoid high volatility/risk.

The immediate effects of central bank actions in the battle against the developments mentioned above are visible in Gov. bonds, namely the 10y gov. bonds, which is primarily influenced by changes in nominal interest rates, including both real interest rates and expected inflation (Spierdiyk and Umar, 2015). In particular, inflation expectations fluctuated significantly by the Federal Reserve's shift in stance from considering inflation "transitory" to implementing aggressive rate hikes, leading up to “no landing”. These shifts frequently gave rise to reallocations between TIPS and nominal treasuries. TIPS are generally characterised by lower liquidity compared to nominal treasuries. During periods of market stress, when interest rates rise rapidly, this lower liquidity can exacerbate price movements, contributing to greater downside volatility (Roll, 2004). However, in my analysis the TIPS` downside is comparably limited, and the Gov. bonds volatility is significantly higher than the TIPS due to all the expectation vs. reality shifts.

But how about the influencing factors within the periods we look at to see whether inflation is the predominant factor, and/ or what else impacted bonds returns. When we have a first look on the whole period, there is a clear tendency visible that Energy has an significant impact on HY, emphazised by the BB single Index as well. As one of the main impacting factors of inflation is it supporting the fact that inflation (expectation) pushes HY. It is crucial to distinguish between the causes of these phenomena, as the effects of demand and supply shocks vary considerably. Significant fluctuations resulting from supply-side factors, as evidenced by the energy crises of the 1970s and the influence of geopolitical tensions, can give rise to alterations in inflation expectations and, consequently, bond yields (Demirer et al., 2020). Fluctuations related to demand contain greater sentiment information and thus affect sovereign bonds in a heterogeneous manner, both in terms of size and sign. The period that I look into is rather concentrated to a supply shock, with mainly the geopolitical tensions in middle east and

Ukraine. Kang et al. (2014) present a compelling argument in their study that oil price shocks account for approximately 30% of the long-run variation observed in the broad US bonds index. A more detailed examination of the evidence reveals that HY bonds exhibit volatility and return spillovers from oil markets (Gormus et al., 2014)). Nguyen et al. (2018) confirms that and even find that oil fluctuations, oil price declines respectively, hurt riskier assets like HY while it benefits safer assets like Govies or IG. In the period of 2021-24, the oil price stayed on elevated levels above the long-term oil average price, inflicting the opposite effect. In the IG space does the VIX, and the Fed Funds rate play a significant role, apart from β_0. Not surprising as IG tend to have robust balance sheets, so that they are rather reactive to distress sentiment moments than short-term oil price fluctuations. Fed Funds rate are also significantly influencing the 30y Govt. bonds.

The Pre-Inflation period displays a similar picture. As in the whole period, there is no significant factor that is influencing TIPS. Within the corporate sector are the results aligned. For the Govt. sector is also no significant factor found. That picture changes when we look only at the inflation period. CPI is significantly influencing the performance of TIPS, emphasizing the product´s nature. For the other categories is only β_0 significant. As these results pointing in the direction of a too long horizon with too many influencing factors, a deeper look on each year beginning with 2021 seems necessary. In 2021, TIPS are influenced by Energy, again showing the connection to inflation (expectation). Also, Unemployment shows a significant level for TIPS as it was one of the main factors market looked at to see where inflation will move. In the IG and HY sector, there are similar results as in the pre inflation period - Energy, and Fed Funds rate. In 2022, the direct relation to CPI is visible as at multi-decade highs CPI influenced TIPS unsurprisingly. Gov. Bonds were influenced by CPI as well. During the time of uncertainty in 2022, market sentiment also influenced Gov. Bonds. Noteworthy, QT announcements on 01.06.2022 and 01.09.2022 had significant effects on bonds returns, additionally emphasizing the uncertainty in markets. In 2023 changed the situation. GDP determined all corporate segments. As the inflationary pressure stabilized and rates peaked, the focus shifted to economic growth. The only dominating question was at that time if the tightening policy would lead to a recession, which then strongly would effect credit spreads. In 2024, central banks watched closely the unemployment rate to see the real economic strength. TIPS and Gov. Bonds, therefore where significantly influenced by Unemployment. Apart from that did Energy again influence TIPS as the main headline inflation expectation driver. Again Fed Funds rates for IG came back to the normal times.

Although there are significance level of β_0 in some of the regressions visible, β_0 is often times vanished by adding variables iniatially. As that is not the main focus of the paper, it can certainly be used as template for further studies.

7. Conclusion

It is no surprise that the different bonds classes behave differently as they supposed to do out of the historical context given the circumstances seen in the period 2021-2024. The COVID aftermath, Ukrainian war, and the energy/ commodity volatility pressured markets, and fiscal and monetary actions as a (re)action to it strongly affected bonds markets. The combination of inflation, inflation expectation and interest rate volatility lead also to a similar performance of TIPS and other bonds classes as a consequence of infrequent CPI adjustments (Papathanasiou et al. (2023)). However, TIPS provide one of the best risk-rewards also given the limited downside. Risk-averse investors can therefore use TIPS to limit downside risks within elevated inflationary periods, but can not use it as a hedge as it possess a relatively high correlation to IG short- and medium duration assets, and rather react like a traditional bonds than a protection. Surprisingly, one of the lowest credit-rating (Caa) shows the best risk-reward, outperforming the peer group. That only applies to an index level, and cannot be applied to a single bonds level as the survivorship bias is potentially in this category the highest. Also, the correlation to other bonds classes is the lowest, providing investors a hedge opportunity. When we look on the broader level within the inflationary period, HY provide (risk averse) investors higher risk-rewards and tendencies of positive returns in comparison to IG bonds. The risk (standard deviation) of both classes does not differ substantially from each other, but the downside is steeper for IG than for HY. That difference is mainly visible in the risk-adjusted risk-reward ratio. That means for risk-averse investors that there is a clear tendency for lower credit quality within elevated inflationary periods. On the duration side, longer duration should be preferred, not only on the corporate side but in general terms. The shorter-duration (IG 3-5y) has the second highest risk attached with the second lowest risk-reward. The combination of lower duration plus higher credit quality provides risk-averse one of the least desired outcomes, besides the 10y Govt. bonds. The 10y Gov. emphasizes the duration observation when comparing it with the 30y Govt. bonds. However, it is no surprise that the 10y Govt. Bonds has the strongest risk attached in the inflationary period. As Govt. Bonds reflect a expected real interest rate, an expected rate of inflation, and a risk premium, an unexpected surge in inflation inflict an increase in the embedded yield, letting bond price fall (Neville et al. (2021)). As a conclusion, longer duration with lower credit quality are the bonds that provide risk-averse investors a more desired outcome within elevated inflationary period that are accompanied with these recent macroeconomic variables in place.

References

ANDREASEN, M. M., CHRISTENSEN, J. H., & RIDDELL, S. (2021). *The TIPS liquidity premium.* Review of Finance, 25(6), 1639-1675.

BAI, J., BALI, T. G., & WEN, Q. (2016). *Common risk factors in the cross-section of corporate bond returns.* In Journal of Financial Economics, Forthcoming, HKUST Finance Symposium.

BRENNAN, M. J., & XIA, Y. (2002). *Dynamic asset allocation under inflation.* The journal of finance, 57(3), 1201-1238.

CAMPBELL, J. Y., & SHILLER, R. J. (1996). *A scorecard for indexed government debt.* NBER macroeconomics annual, 11, 155-197.

CAMPBELL, J. Y., SHILLER, R. J., & VICEIRA, L. M. (2009). *Understanding Inflation-Indexed Bond Markets.* Brookings Papers on Economic Activity, 2009(1), 79-120.

D'AMICO, S., KIM, D. H., & WEI, M. (2018). *Tips from TIPS: the informational content of Treasury Inflation-Protected Security prices.* Journal of Financial and Quantitative Analysis, 53(1), 395-436.

DEMIRER, R., FERRER, R., & SHAHZAD, S. J. H. (2020). *Oil price shocks, global financial markets and their connectedness.* Energy Economics, 88, 104771.

DE SANTIS, R. A., & BEKAERT, G. (2020). *Risk and Return in International Corporate Bond Markets.*

DELGADO, M., & GRAVELLE, T. (2023). CGFS Papers.

DU, W., FORBES, K., & LUZZETTI, M. N. (2024). *Quantitative Tightening Around the Globe: What Have We Learned?.* National Bureau of Economic Research, No. w32321.

HAMMERMANN, F., LEONARD, K., NARDELLI, S. & VON LANDESBERGER, J. (2019). *Taking Stock of the Eurosystem´s asset purchase programme after the end of the net asset purchases.* ECB. https://www.ecb.europa.eu/press/economic-bulletin/articles/2019/html/ecb.ebart201902_01~3049319b8d.en.html

FABOZZI, F. J., & FABOZZI, F. A. (2021). *Bond markets, analysis, and strategies.* MIT Press.

FAMA, E. F., & FRENCH, K. R. (1989). *Business Conditions and Expected Returns on Stocks and Bonds.* Journal of Financial Economics, 25(1), 23-49.

FLEMING, M. J., & KRISHNAN, N. (2012). *The Microstructure of the TIPS Market.*Journal of Financial Markets, 15(2), 214-239.

GREENWOOD, R., & VAYANOS, D. (2014). *Bond supply and excess bond returns.* The Review of Financial Studies, 27(3), 663-713.

KANG, J., & PFLUEGER, C. E. (2015). *Inflation risk in corporate bonds.* The journal of finance, 70(1), 115-162.

GORMUS, N. A., SOYTAS, U., & DILTZ, J. D. (2014). *Volatility transmission between energy-related asset classes.* Global Finance Journal, 25(3), 246-259.

HUANG, J., AND Z. ZHONG. (2013). *Time variation in diversification benefits of commodity, REITS, and TIPS.* The Journal of Real Estate Finance and Economics 46: 152–192.

HUGHES, J. (2024, September 21). *What is the yield curve really telling us about the odds of recession?*. https://www.ft.com/content/e73831d9-1fdc-407d-ba34-fe46f4db2564.

KANG, W., RATTI, R.A. AND YOON, K.H. (2014). *The Effect of Oil Price Shocks on U.S. Bond Market Returns.* Energy Economics, 44, 248–258.

KWAK, M., AND B.H. LIM. 2014. *Optimal portfolio selection with life insurance under inflation risk.* Journal of Banking & Finance 46: 51-71.

LAATSCH, F.E., AND D.P. KLEIN. (2005). *The nominal duration of TIPS bonds.* Review of Financial Economics 14: 47–60.

MAGDON-ISMAIL, M., & ATIYA, A. F. (2004). *Maximum drawdown*. Risk Magazine, 17(10), 99-102.

MALKIEL, B. G. (1962). *Expectations, bond prices, and the term structure of interest rates.* The Quarterly Journal of Economics, 76(2), 197-218.

MALKIEL, B. G. (2015). *Term structure of interest rates: expectations and behavior patterns.* Princeton University Press.

MANGWIRO, B. (2023, October 27). *How QT is impacting the government bond market.* Financial Times. https://www.ftadviser.com/opinion/2023/10/27/how-qt-is-impacting-the-government-bond-market/.

MANKIW, N. G., & SHAPIRO, M. D. (1984). *Risk and return: Consumption versus market beta*. National Bureau of Economic Research.

MKAOUAR, F., J.L. PRIGENT, AND I. ABID. (2017). *Long-term investment with stochastic interest and inflation rates: The need for inflation-indexed bonds*. Economic Modelling 67: 228–247.

NEVILLE, H., DRAAISMA, T., FUNNELL, B., HARVEY, C. R., & VAN HEMERT, O. (2021). *The best strategies for inflationary times. Available at SSRN 3813202.*

NGUYEN, H., NGUYEN, H. AND PHAM, A. (2018). *Oil price declines could hurt financial markets and a possible explanation. Working Paper*.

PAPATHANASIOU, S., KENOURGIOS, D., KOUTSOKOSTAS, D., & PERGERIS, G. (2023). *Can treasury inflation-protected securities safeguard investors from outward risk spillovers? A portfolio hedging strategy through the prism of COVID-19.* Journal of Asset Management, 24(3), 198.

RAMSDEN, D. (2023). *Quantitative tightening: the story so far.* Bank of England. https://www.bankofengland.co.uk/speech/2023/july/dave-ramsden-speech-on-quantitative-tightening-chaired-by-money-macro-and-finance-society

READY, R.C. (2018). *Oil prices and the stock market.* Review of Finance, 22(1), 155-176.

ROHLEDER, M., SCHOLZ, H., & WILKENS, M. (2011). *Survivorship bias and mutual fund performance: Relevance, significance, and methodical differences*. Review of Finance, 15(2), 441-474.

ROLL, R. (1971). *Investment diversification and bond maturity.* The Journal of Finance, 26(1), 51-66.

ROLL, R. (2004). *Empirical tips.* Financial Analysts Journal, 60(1), 31-53.

REIS, R. (2022). *The burst of high inflation in 2021-22: How and why did we get here?*. Bank for International Settlements, Monetary and Economic Department.

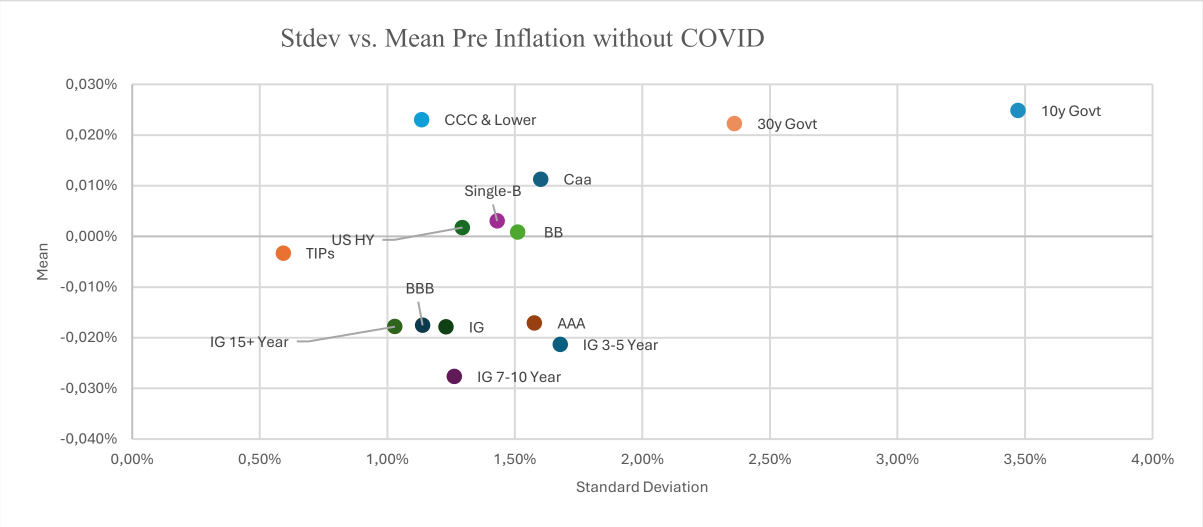
SHARPE, W. F. (1966). *Mutual fund performance*. The Journal of business, 39(1), 119-138.

SORTINO, F. A., & PRICE, L. N. (1994). *Performance measurement in a downside risk framework.* The Journal of Investing, 3(3), 59-64.

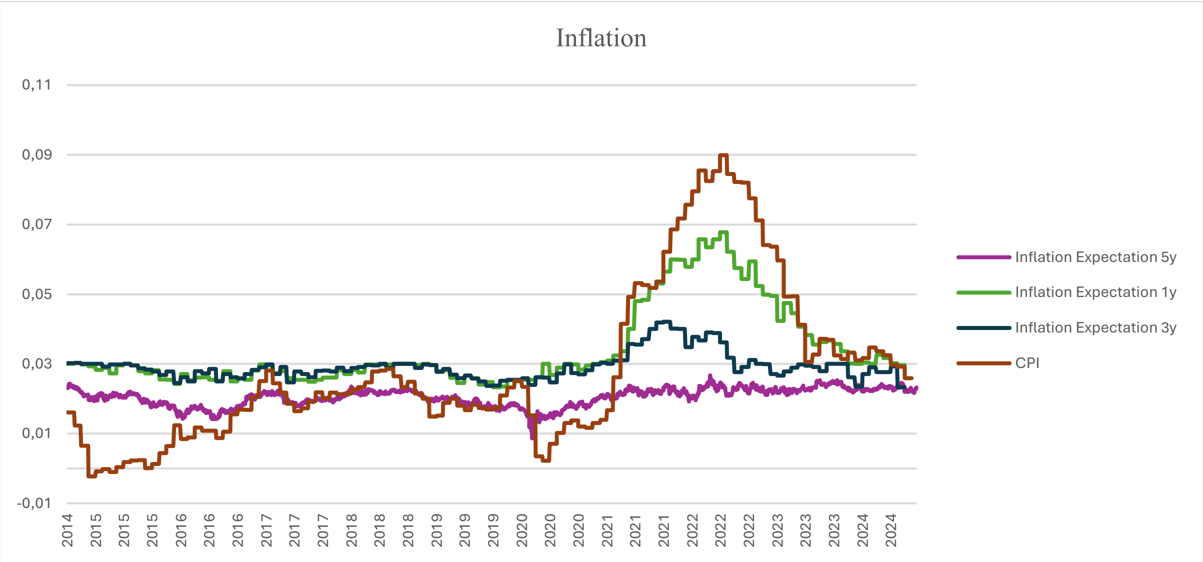
SPIERDIJK, L., AND Z. UMAR. 2015. *Stocks, bonds, T-bills and inflation hedging: From great moderation to great recession.* Journal of Economics and Business 79: 1–37. https://doi.org/10.1016/j.jeconbus.2014.12.002.

U.S.DEPARTMENT OF THE TREASURY. 2023. *TIPS Issuance, Demand, and Level of Supply.* https://home.treasury.gov/system/files/221/TBACCharge2Q22023.pdf.

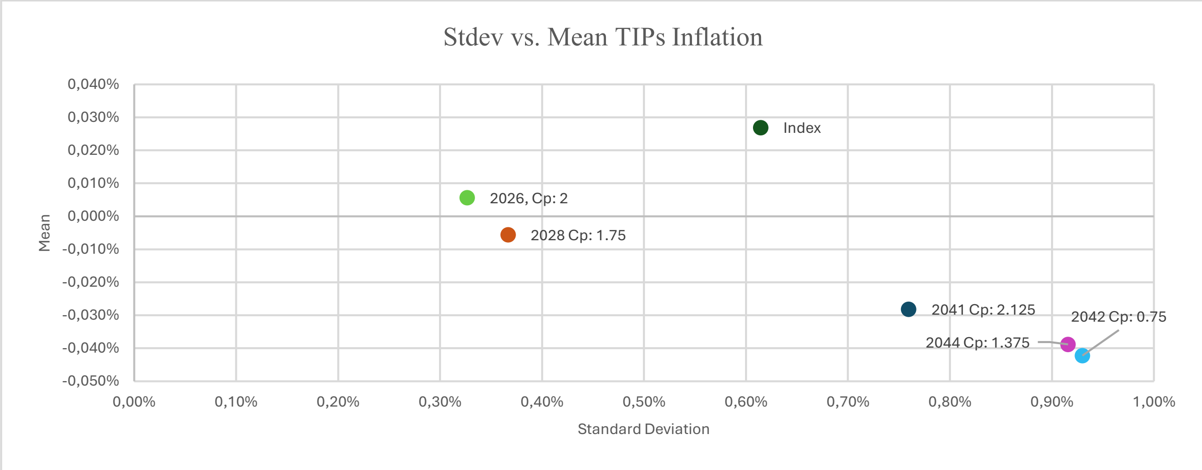
Appendix



Appendix 1: Risk-return profiles within pre-inflation period without COVID (2020)



Appendix 2: Inflation and inflation expectation evolvement over time



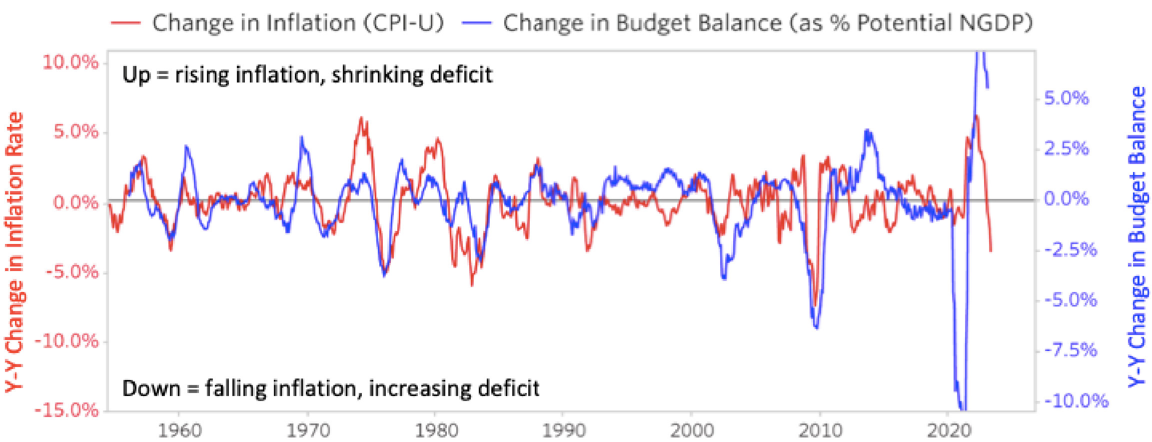
Appendix 3: Risk-return profiles single TIPS & Index within high inflationary period

Short Duration	HY	Caa	CCC & Lower	Single-B	BB	BBB	AAA	IG	10Y Govt	30Y Govt	IG 3-5Y	IG 7-10Y	IG 15+Y
2026	-0,010	0,004	-0,021	-0,005	-0,013	0,009	-0,001	0,007	0,345	0,265	0,022	-0,005	-0,024
2028	0,004	0,002	-0,014	0,007	0,003	0,022	0,012	0,020	0,556	0,465	0,030	0,007	-0,013
Long Duration													
2042	0,050	-0,020	0,027	0,042	0,054	0,056	0,048	0,054	0,717	0,773	0,058	0,043	0,025
2044	0,047	-0,021	0,027	0,037	0,050	0,054	0,046	0,051	0,711	0,769	0,055	0,041	0,025
2041	0,039	-0,030	0,026	0,028	0,042	0,055	0,049	0,053	0,690	0,738	0,056	0,044	0,030

Appendix 4: Single TIPS correlation to other bonds classes within high inflationary period

Inflation	TIPs	US HY	Caa	CCC & Lowe	B	BB	BBB	AAA	IG	IG 3-5Y	IG 7-10Y	IG 15+Y	10Y Govt	30Y Govt
TIPs														
US HY	0,039													
Caa	-0,019	-0,031												
CCC & Lower	0,019	0,870	-0,001											
B	0,032	0,979	-0,041	0,821										
BB	0,041	0,983	-0,028	0,811	0,950									
BBB	0,051	0,462	-0,038	0,360	0,412	0,494								
AAA	0,042	0,365	-0,032	0,254	0,314	0,402	0,954							
IG	0,048	0,437	-0,033	0,326	0,389	0,471	0,986	0,965						
IG 3-5Y	0,703	0,023	-0,011	0,001	0,017	0,023	0,012	0,006	0,011					
IG 7-10Y	0,730	0,038	-0,009	0,019	0,028	0,037	0,005	-0,003	0,001	0,927				
IG 15+Y	0,054	0,406	-0,019	0,301	0,366	0,435	0,926	0,876	0,931	0,000	-0,010			
10Y Govt	0,037	0,433	-0,039	0,321	0,384	0,468	0,969	0,959	0,971	0,004	0,000	0,896		
30Y Govt	0,019	0,414	-0,029	0,317	0,367	0,445	0,904	0,923	0,905	0,001	-0,001	0,747	0,932	

Appendix 5: Correlation matrix of bonds classes within high inflationary period



Appendix 6: Fiscal and monetary influence over time (Source: U.S. Department of the Treasury, 2023)

Disclaimer

The Chat GPT4 language model from OpenAI and Deepl Write was used in the creation of that thesis. Its use was limited exclusively to the improvement and revision of formulations in order to improve the clarity and precision of the text. No content or conceptual parts of the work were generated by these models.