Handelshögskolan
Karlstad Business School

Andreas Berdén & Hilding Larsson

Inflation risk revisited
The hedging properties of major asset classes

Inflationsrisken återbesökt
De inflationsskyddande egenskaperna hos de stora tillgångsslagen

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Supervisor:	Klaas Staal

Karlstad Business School
Karlstad University SE-651 88 Karlstad
Phone: +46 54 700 10 00
E-mail: handels@kau.se kau.se/en/hhk

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Sincerely, Andreas Berdén and Hilding Larsson

Abstract

This paper is in large parts an update to a paper by Bekaert and Wang from 2010 called *Inflation risk and the inflation risk premium*. Its purpose is to find insights into the inflation hedging properties of the major asset classes. The analysis includes stocks, bonds, treasury bills, foreign bonds, real estate, gold, and gold futures for 43 countries and covers investment horizons up to five years. For developed countries it is found that gold, gold futures and bonds are the best hedge against inflation, both in the short and long run. Treasury bills have a relatively modest performance in the short term but improve with horizons to a great hedge. For emerging countries all asset classes provide a decent hedge, with a slight favor for treasury bills and a slight disadvantage for real estate in the short and long run. All asset classes are poor hedges to unexpected inflation with an exception for real estate in longer investment horizons. The best hedge against unexpected inflation shocks is inflation-linked bonds.

Keywords: Inflation, unexpected inflation, inflation hedge, inflation-linked bonds, TIPS, treasury bills, stocks, bonds, real estate, gold

Sammanfattning

Den här uppsatsen är i stort en uppdatering av en artikel av Bekaert och Wang från 2010 kallad *Inflation risk and the inflation risk premium*. Syftet är att hitta insikter i inflationsskyddande egenskaperna för de stora tillgångsklasserna. Analysen inkluderar aktier, obligationer, statsskuldväxlar, utländska obligationer, fastigheter, guld och guldterminer för 43 länder och täcker investeringshorisonter upp till fem år. För utvecklade länder finner vi att guld, guldterminer och obligationer är bästa skyddet mot inflation, både på kort och lång sikt. Statsskuldväxlar är ett relativt dåligt inflationsskydd på kort sikt, men blir ett bra skydd över längre horisonter. För tillväxtländer ger alla tillgångsslag en skapligt skydd, med en liten fördel för statsskuldväxlar och en liten nackdel för fastigheter i kort och långt perspektiv. Alla tillgångsklasser är dåliga skydd mot oväntad inflation, med ett undantag för fastigheter i längre investeringshorisonter. Det bästa skyddet emot oväntade inflationschocker är inflationskopplade obligationer.

Nyckelord: Inflation, oväntad inflation, inflationsskydd, inflationskopplade obligationer, statsskuldväxlar, aktier, obligationer, fastigheter, guld

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1. Introduction

When the Covid-19 pandemic hit the world, many governments tried to minimize the transmission of the disease by introducing travel restrictions and lockdowns. These measures and the fear of potential consequences like unemployment had substantial negative effects on consumer spending. To limit the negative effects for consumers, central banks and governments started stimulating the economies with lower interest rates, quantitative easing, and even stimulus checks. This is likely to be the main cause of the big wave of inflation we see today. For some, this could be seen as a good thing as they manage to avoid a potential deflation spiral, but inflation comes with its own problems. Inflation erodes the purchasing power for everyone. An ideal hedge against inflation will protect the investor against unexpected inflation with low volatility and a positive real expected return.

Long-term bonds have for a long time been seen as a safe investment, but in light of recent banking failures, it is clear that investing in long-term bonds can be detrimental in the case of high unexpected inflation shocks and rising interest rates. Silicon Valley Banks' (SVB) investments in long-term bonds were one of the reasons for its recent failure. SVB bought these bonds, which were primarily U.S treasury bonds, when interest rates were at historic lows. As rates began to increase, the price of these bonds dropped quickly since the market now had the ability to buy bonds with better yields. When the bank then took losses from venture capital investments, many of which were connected to crypto currencies, it was forced to liquidate its long-term bonds at a huge loss. As news came out that SVB had taken big losses its customers began withdrawing money, making the situation for the bank even worse. This example highlights the importance of investing with the risk of inflation in mind. This begs the question what can act as a safe investment in a situation like this?

1.1 Problem statement

Due to the home bias phenomenon observed among investors, it is commonly seen that many prefer to invest in domestic stock indices, typically with the intention of funding future consumption. Achieving this goal is significantly more difficult when prices are rising. As we are currently in the midst of widespread inflation across many countries, understanding the effects of inflation on a certain asset as well as ways to hedge against inflation risk is beneficial.

1.2 Purpose

The purpose of this paper is to examine the inflation hedging properties of seven major asset classes: treasury bills, bonds, foreign bonds, stocks, real estate, gold, and gold futures.

1.3 Method

Data on consumer price index, nominal stock returns, bond yields, treasury bills, nominal gold price, gold futures, exchange rates and index for residential real estate is obtained for 43 different countries. The analysis consists of over 400 individual ordinary least square regressions with varying dependent variables, time horizons, and controlling variables accompanying inflation. We also analyze data before and after the adoption of inflation targeting.

1.4 Delimitation

We omit inflation-linked bonds, or also called treasury inflation-protected securities (TIPS) from our analysis, as data on such bonds is only limited to recent years and few countries. Furthermore, several other studies have already been done on inflation linked bonds. This type of security will however be discussed as it is one of the few ways to hedge against unexpected inflation. Also, although several studies have been discussing correlation between oil prices and either inflation or stock prices such as Schneider (2004), Balcilar et al. (2018) and Cong et al. (2008), this study will not account for oil prices.

1.5 Disposition

The reader of this paper will first be taken through relevant theory and background to the problem of inflation and inflation hedging, then the method and technical details used to approach this problem. After that, the results are presented in tables and figures, accompanied by comments on the most interesting findings. Lastly, a discussion section that compares the results with a very similar earlier paper on the topic follows. The paper ends with the conclusions that can be made from the results and suggestions for further research.

2. Theory and background

2.1 Theoretical models of inflation

The definition of inflation has always been increasing price levels of goods and services, but the understanding of inflation has evolved over time for economists and researchers. The quantity theory of money was formulated by Nicolaus Copernicus in the early 16th century, but the modern form comes from Irving Fisher. The equation is $M \cdot V = P \cdot T$, where M is the money supply, V is the velocity of money, P is the price level, and T is the real value of the aggregated transactions. If money supply increases, and velocity and transactions are unchanged, then prices must increase (Friedman & Schwartz 2008). Adam Smith (1937) had similar ideas, as did Milton Friedman (Friedman 1995). These aforementioned papers and books focused on focused on the money supply, and this was questioned by John Maynard Keynes. He pointed out that this theory assumes money demand always equals money supply. Keynes argued that this is not always the case, and instead came up with an equation for money demand. This equation is $M^d = k \cdot P \cdot Y$, where M^d is money demand, k is the proportion of the money that is stored as "cash on hand", P is price level, and Y is nominal income (Humphry 1974). Keynes equation is linked to Fishers' equation. Since number of transactions are hard to measure the T is replaced by Y. V equals $1/k$ because the latter measures the fraction of the people's income they want to keep, and the rest is spent and therefore measure the velocity. The combined equation is then $M \cdot V = P \cdot Y$.

Friedman's position can be summed up by the fact that changes in the money supply can influence inflation. If the money supply increases faster than the growth rate of goods and services in the economy, it can lead to inflation. This can happen due to factors like expansionary monetary policies, excessive government borrowing, or excessive money creation (Friedman 1995).

Keynes' contribution is that aggregate demand can exceed an economy's productive capacity, and therefore lead to inflation. The demand-pull type of inflation occurs when aggregate demand in an economy exceeds the available supply of goods and services. It is typically driven by factors such as increased consumer spending, government spending, or investment. When demand outpaces supply, businesses raise prices to capitalize on increased demand, leading to inflation. Inflation can also come from the supply side of goods and services. This is called a cost-push type of inflation and arises from an increase in production costs, such as wages, raw materials, energy prices, or supply chain disruptions. Higher costs for businesses lead to an increase in prices for final goods and services (Bjørnland, 2000). Noteworthy is that this demand-pulled and

cost-pushed inflation only can be temporary as long as money supply remains constant. This is because for example a cost-push on the supply side would only increase prices, but if money supply remains constant, the consumer affords less goods or services for the same money. This leads to less demand for goods and services and in turn leads to sinking prices again until the market reaches equilibrium again. This takes us back to Friedman's position that in the long run inflation is always caused by an increase in money supply (Friedman 1995).

Inflation impacts borrowers and lenders differently. Borrowers directly benefit from the eroding purchasing power, but one must also consider interest rates. If interest rates are higher than the inflation rate the real interest rate is positive, which would harm borrowers. A positive real interest rate provides an incentive for saving and investing rather than spending, as it allows individuals to increase their purchasing power. On the other hand, a negative real interest rate would benefit borrowers. This can therefore lead to more loans and higher consumer spending.

The balance between inflation and interest rates can be described using the "Fischer effect". The Fisher effect suggests that changes in expected inflation will be reflected in nominal interest rates. If inflation is expected to rise, lenders and investors will demand higher nominal interest rates to compensate for the erosion of purchasing power caused by inflation. Conversely, if inflation is expected to decrease, nominal interest rates may be lowered (Fischer 1930). This connection is simply explained as the following equation:

$$Nominal\ Interest\ Rate\ =\ Real\ Interest\ Rate\ +\ Expected\ Inflation\ Rate.$$

It is important to note that the Fisher effect assumes that changes in expected inflation will be fully and accurately reflected in nominal interest rates in the long run. However, in practice, various factors and market dynamics can influence the relationship between nominal interest rates and expected inflation.

2.2 Historical and recent inflation levels

Inflation existed even before the introduction of fiat money. For example, Spain exported a vast amount of gold and silver from the Americas during the 16th century, causing high inflation in their home country. Even though it is harder to inflate physical currencies like gold, it is possible. The first country to use fiat money was China at around year 1000 AD, and the first central bank in the world was the Riksbank in Sweden, or Riksens Ständers Bank, as it was named when the parliament founded it in 1668. The name was changed in 1867 and has remained since. While some currencies have been linked to gold or other physical materials at first and later transformed

into fiat money, most currencies have been fiat money from the start. Although it would sound more reasonable that inflation would be much higher after such a transition, central banks have made prices more stable due to the price control measures they have implemented in more recent history. The times before monetary policies were a lot more volatile, swinging from high inflation to significant deflation and back (Chown 1994).

In Figure 1 below a graph of the equally weighted average inflation rates for developed and emerging countries are shown for the period studied in this paper.

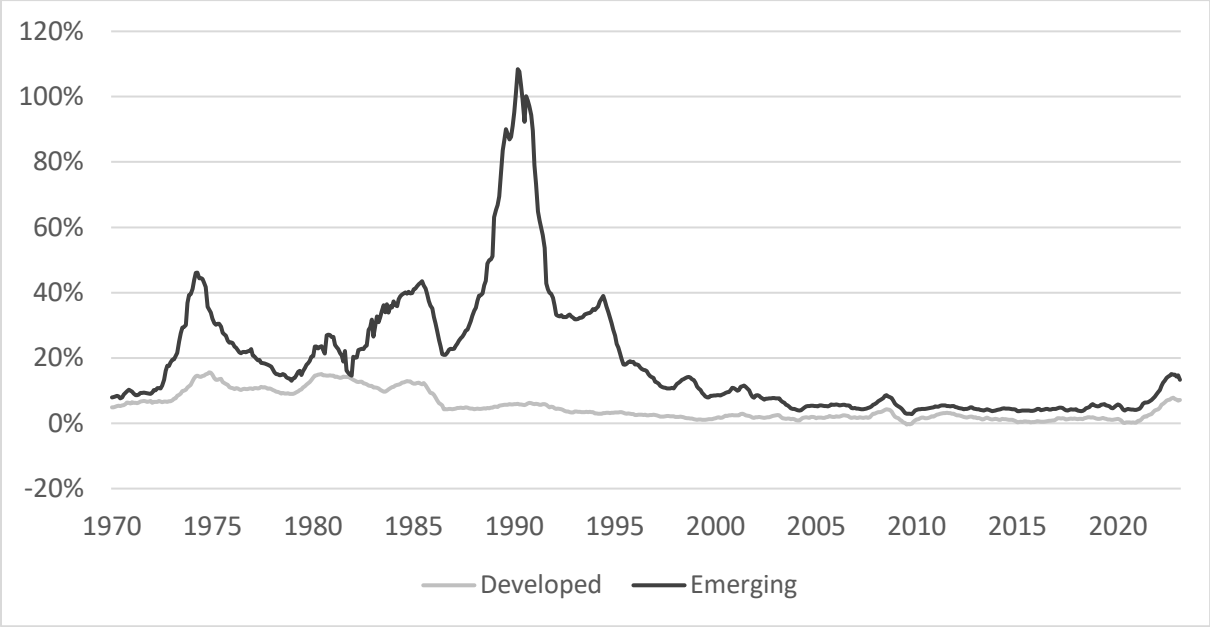

Figure 1. Historical inflation rates for developed and emerging countries. Data source: own calculations based on data from BIS.

Before the recent surge in inflation, interest rates and inflation were low for many countries. Many central banks were lowering policy rates to reach a stable level of inflation. According to the Bank of International Settlements (BIS) (2023) the global average policy rate hit an all-time low of 2,37% in October 2020. In the EU the average policy rate was 0% at the time. Since interest rates were low one might then wonder why inflation was so low. Where was this deflationary pressure coming from? Research by Ciccarelli et.al. (2017) looked at the euro area and made empirical findings suggesting the low inflation is due to cyclical factors, both global and domestic. The literature is increasingly indicating that structural changes to demographics or technological advancements, as suggested by Han (2022) and Zoakos (2002) respectively, could be aligned with a decrease in inflation.

2.3 Inflation risk premiums and the pricing of assets

Inflation risk refers to the potential adverse impact of inflation on the value of investments or the overall economy. It represents the uncertainty or vulnerability associated with rising inflation levels. Inflation risk can affect various aspects, including the purchasing power of money, interest rates, asset values, and the cost of goods and services. Inflation risk is particularly concerning for fixed-income investments like bonds, as inflation erodes the future value of the fixed interest payments. The inflation risk premiums are built into the return equation for bonds that follows: $y_t = r_t + E_t(\pi_t) + \varphi_t$, where y_t is nominal return, r_t is real return, $E_t(\pi_t)$ is expected inflation, and φ_t is inflation risk premium (Bekaert & Wang 2010).

Historical data suggests that commodities and inflation linked bonds can generate positive real returns during an inflationary period where bonds and stock market indices have negative real returns (Mendoza 2023).

Although prices in practice are determined by supply and demand, theoretically correct price of a financial asset is the present value of all future expected cash flows divided by the discount rate, which in this case would describe the risk of the cash flows. The simple general equation for valuing cash flows follows below.

$$Price = \sum_{S=1}^{\infty} \frac{Expected\ Cash\ Flow}{(1 + Discount\ Rate)^s}$$

The discount rate can also be decomposed into several risk components. The discount rate for a stock could for example be divided into one plus the real risk-free rate ($I_{t,s}$), expected inflation ($\theta_{t,s}$), uncertainty premium for future inflation ($\pi_{t,s}$), and the risk premium ($\lambda^i_{t,s}$). Below is the extended equation.

$$P^i_t = \sum_{S=1}^{\infty} \frac{Expected\ Cash\ Flow}{(1 + I_{t,s} + \theta_{t,s} + \pi_{t,s} + \lambda^i_{t,s})^s}$$

The important point here is that this can be done for all cash flow generating assets. All assets included in this study have cash flow except gold. Expected inflation and inflation uncertainty premiums are built into their prices. Expected inflation should therefore be regarded as something that is less problematic for financial asset owners. The more relevant factor that is not included in the models is therefore the unexpected change in inflation. The difference between uncertain inflation and unexpected inflation is that the first falls within an expected range, and the latter falls outside the normal variance. It is per definition not expected, so investors don't get

paid for that risk. Unfortunately, it is difficult to accurately estimate expected and unexpected inflation. Bekaert and Wang (2010) propose calculating a rough estimate by letting expected inflation twelve months into the future be today's inflation, and unexpected inflation therefore simply being the difference between expected and actual inflation. Although it is a simple model even more advanced models show less accurate results.

The capital asset pricing model (CAPM) is a widely used model for estimating the required rate of return on an investment. It is most often used for valuing stocks, but it can be applied to other assets, if certain assumptions are met. Those assumptions include efficient markets, risk-averse investors, well diversified portfolios, single-period investment horizon, homogenous expectations among all investors, and no transaction costs. CAPM calculates the market risk premium by multiplying the equity risk premium, the excess return of the market over the risk-free rate, by the asset's beta, which measures its sensitivity to market movements. The CAPM equation is: $E(R_i) = R_f + \beta_i(E(R_m) - R_f)$, where $E(R_i)$ represents the expected return on the asset, R_f is the risk-free rate, $\beta_i = \frac{Cov(R_i,R_m)}{Var(R_m)}$ equals the covariance between the assets returns and the market returns, and $E(R_m) - R_f$ is the risk premium, which reflects the excess return expected by investors for holding risky assets instead of risk-free investments. The β_i of the asset is multiplied by the risk premium to estimate the additional return required for the asset's level of systematic risk. Systematic risk is the type of risk that is inherent to the entire market or a particular segment of the market. It is also known as non-diversifiable risk or market risk. Systematic risk factors affect a wide range of assets and cannot be eliminated through diversification (Bodie et al. 2020)

2.4 Inflation hedging

Inflation hedging refers to the strategies or investments undertaken to protect against the erosion of purchasing power caused by inflation. It involves making investment choices that have the potential to preserve or increase in value in times of inflation. These investments typically have a positive correlation with inflation, meaning their value tends to rise when inflation increases. Common inflation-hedging investments include real estate, commodities (such as gold or oil), inflation-linked bonds, or Treasury Inflation-Protected Securities (TIPS) as the inflation-linked bonds are called in America, inflation swaps, and certain stocks. Companies have the potential to increase their earnings and dividends over time. As inflation rises, these companies can pass on the increased costs to consumers, which can result in higher profits and returns for investors. Similarly, real estate is an asset that tends to appreciate over time and can therefore provide a hedge against inflation. Commodities, such as gold and oil, are often considered inflation hedges

because their price tends to increase as general price levels rise. Such commodities are also often seen as a safe haven in times of economic turmoil. In the case of stagflation, commodities might therefore act as a hedge towards both inflation and recession.

As discussed by Bekaert and Wang (2010), tax is one reason why the beta value might not be equal to one. If investors are taxed on gains that are due to inflation, then the real returns might be unchanged since tax is regularly based on nominal returns. Exact values for this can be difficult to calculate since it is dependent on details of the specific tax system in each country. However, one of the most relevant factors when it comes to the beta value is perhaps whether inflation is expected or unexpected.

2.5 Inflation linked bonds and unexpected inflation

Inflation-linked bonds are a relatively new type of bonds that are inflationary protected. They have a yield of a given percent every year, plus the current inflation rate. The expected inflation is theoretically priced in for normal bonds, but they are sensitive to unexpected inflation. This has shown in 2023 where some smaller regional banks in America have gotten into trouble, as they have been investing in long term bonds when inflation was low. Now when inflation has risen and therefore interest rates too, the nominal price of these long-term bonds has rapidly declined and stresses their balance sheets. While inflation-linked bonds are a perfect hedge against inflation, or unexpected inflation, they have not become as popular as one might think. One of the reasons for that is probably because the investors don't get paid for the inflation risk and therefore have a lower expected real return than traditional bonds. Since these types of bonds are a smaller market than traditional bonds, the investors should instead demand a higher liquidity premium than for regular bonds. This, however, doesn't mean it has to be a high premium. D'Amico et al. (2018) (updated 2021) show that the liquidity risk premium has been negative for American TIPS during two periods, around 2011-2013 and 2020-2021. They also show that the liquidity risk premium has been declining over time. For Sweden, Alexandersson (2018) show the same premium has been low but stable over time, with increasing variance during turbulent times. It is natural for the American premium to decline as the market grows and therefore improve the liquidity. Fabre (2022) reports that the American TIPS market has grown by 1.5 times its size measured in USD since 2010, while the share of the total bond market has remained around 8-13% since 2005. Alexandersson (2018) find that the Swedish inflation-linked bonds have had close to zero liquidity risk premium several times, but never negative. The highest premium in Sweden has been about 0.8 percentage points, and in America about 1.8 percentage points. The tops for both countries were during the financial crisis in 2008. The variation in the

liquidity risk premium has been much higher for American TIPS than for the Swedish counterpart.

2.6 Variables analyzed in the literature

To mitigate the potential negative effects of inflation, investors often turn to various asset classes known for potential inflation hedging properties. By examining the impact of inflation on these various asset classes, a better understanding of how changes in the inflation rate affect different types of investments can be gained.

Stocks may exhibit positive correlations with inflation due to the ability of companies to adjust pricing and pass on increased costs to consumers. Bonds, on the other hand, with their fixed income streams, can potentially offer inflation protection through mechanisms such as inflation-linked bonds. Gold is often considered a store of value and safe havens during times of economic uncertainty, and its' limited supply contributes to the perceived inflation hedging potential. Real estate, encompassing various property types, has historically demonstrated the ability to rise in value alongside inflation, driven by factors such as construction costs and rental income adjustments (Bekaert & Wang 2010).

Several studies have also looked at oil and its correlation with inflation. This study refrains from having oil as an asset class. There are several reasons for this. Oil is not a common investment and is not one of the major asset classes. Furthermore, oil has a complex relationship with inflation. While it is true that oil prices tend to increase during periods of high inflation, the relationship between the two variables is not always straight forward. Oil prices are highly volatile and influenced by a variety of factors such as global politics, supply and demand imbalance, and natural disasters. The inclusion of oil prices may therefore lead to spurious or misleading results. Furthermore, oil prices may not accurately reflect the underlying inflationary pressure in the broader economy. Results by Baumeister and Kilian (2016) suggest increased oil prices lead to higher inflation in advanced economies but not in developing economies. There are, however, compelling arguments for why one should account for oil prices when running regressions on other assets. This study includes industrial production, indirectly accounting for the relevant effects of changing oil prices while also aiming to account for economic growth. Fama (1981) argues that there is a compelling negative relationship between stock returns and inflation. This is due to stock returns anticipating future economic activity and inflation acting as a proxy for expected real activity. Similar relationships may be found for other asset classes, and it is therefore important to account for economic growth when running regressions. As previously

mentioned, expected and unexpected inflation are important to include and control for. They are commonly analyzed in literature, for example in Stultz (1986) and Lajeri and Dermine (1999). Expected inflation is included in the asset prices but the unexpected inflation reflects the inflation risk that is not included in the prices.

2.7 Stability of inflation betas and effects of adopting inflation targeting

When analyzing the inflation beta, it is important to consider the influence of additional factors, such as economic activity, which might make it challenging to interpret the relationship between variables. Another significant factor that can contribute to instability is the monetary policy regime.

The primary objective of inflation targeting is to keep inflation within a desired range, promoting price stability and providing a predictable environment for economic decision-making. Inflation targeting offers several potential benefits. It provides a clear and transparent framework for central banks to communicate their policy intentions to the public and financial markets. This enhances credibility and fosters public trust in the central bank's ability to maintain price stability. Moreover, by focusing on a specific inflation target, central banks can avoid excessive fluctuations in prices, which can have adverse effects on economic stability, investment, and consumer purchasing power. This commitment helps anchor inflation expectations and influences the behavior of households and businesses. As a result, inflation expectations become more aligned with the target, and this alignment influences actual inflation outcomes (Agénor & da Silva 2019).

Inflation expectations could be explained in theory using the New Keynesian Philips Curve (NKPC). The NKPC is dynamic alteration of the Philips curve and relates inflation to various factors, including expected inflation, output gap, and degree of price stickiness. The NKPC can be represented as follows:

$$\pi_t = E_t(\pi_{t+1}) + \lambda(Y_t - Y^*) + \varepsilon_t.$$

In this equation π_t represents current inflation, $E_t(\pi_{t+1})$ represents expected inflation in the next period, λ represents the parameter capturing the responsiveness of inflation to the output gap represented by $Y_t - Y^*$, Y_t is the difference between current output, and natural level of output is Y^*. Various other effect is captured in the error term, denoted as ε_t. To incorporate effects of inflation targeting, the NKPC can be extended to include additional terms that reflect the central bank's inflation target and its credibility. This equation follows below:

$$\pi_t = (1-\alpha)\pi^*_t + \alpha\pi T_t + E_t(\pi_{t+1}) + \lambda(Y_t - Y^*) + \varepsilon_t.$$

In this modified NKPC, π^*_t represents the natural rate of inflation, πT_t is the central bank's announced inflation target, and the α represents the credibility parameter, reflecting the degree to which agents believe the central bank will achieve the target. The credibility parameter, α, may differ significantly between countries (Hornstein 2008).

Critics of the idea of inflation targeting argue that these targets may have limitations. They point out that focusing solely on inflation can neglect other important objectives, such as employment and economic growth. Having a strict inflation target assumes that central banks have precise control over inflation, which may not always be the case, as external factors and shocks can influence price levels. As is more common, and as Agénor and da Silva (2019) suggest instead, a more integrated approach to inflation targeting is preferred. Meaning that focus does not solely lie on inflation, and inflation targeting regimes can allow for external effects to determine inflation for shorter periods. Many countries have adopted a more integrated inflation target and have a certain tolerance band in which they wish inflation should lie. It is worth mentioning that countries without a particular tolerance band may still utilize an integrated approach. Also worth mentioning is that even with a so-called integrated approach, many countries either fail to reach their inflation target or overuse monetary policy to control inflation with negative effects to the overall economy.

2.8 Results of earlier research

One of the earliest studies on inflation hedges discussing both expected and unexpected inflation was written by Fama and Schwert (1977). Their findings suggests that U.S. government bonds is a successful hedge against the expected inflation and that private residential real estate was a successful hedge against both expected and unexpected inflation. Their results also suggest that common stock returns are shown to be negatively correlated with expected inflation. Similar results are also produced by Fama (1981) as well as Boudoukh and Richardson (1993). Boudoukh and Richardson do however mention that over longer time horizons common stock tends to produce positive real returns. The takeaway here is that high inflation can be unfavorable to the investor in the short run, but over longer periods of time, stock returns are inclined to give a premium accounted for inflation. Fama (1981) finds that stock returns are positively related to real economic activity and negatively correlated with inflation. Stock returns correlation with economic activity is something that Bekaert and Wang (2010) adjust for when estimating inflation betas.

Bekaert and Wang (2010) found that government bonds and a broad stock index are poor inflation hedges. Other assets such as gold and foreign bonds are found to be a viable way to hedge against inflation. Treasury bills also show a positive relation with inflation, but results suggest that they fail to hedge unexpected inflation. Tracking inflation with major assets classes and securities is found to be difficult, something that may have led to the growing popularity of TIPS or indexed linked bonds. In 2010, the liquidity for these types of securities was low and the cost of issuance high. Even though TIPS would limit risk in volatile markets most investors would instead gravitate towards more liquid securities such as treasury bills and bonds. Bekaert and Wang expect a more liquid and credible market to benefit these types of securities, enabling the market for these types of securities to grow.

The investment horizon is a well-known factor for expected return of an investment in a market portfolio. In the short run the return is determined by market volatility, but in the long run the fundamental development of the underlying assets matters the most. In other words, the short run the expected return is stochastic, but for longer horizons it narrows to the expected long-term return for the market (Chou et al. 2000).

3. Methodology

3.1 Data description

The monthly collected data contain the consumer price index (CPI), stock index for mid and large cap companies, gold price, gold futures, residential real estate index, industrial production, bonds, and treasury bills with varying maturity times, all for 43 different countries. Data for certain variables are missing for some countries. The full specification is presented in Appendix C and Appendix F. Note also that the length of each time series varies, but for many countries they date back to 1970. We refrain from using data earlier than 1970 following Bekaert and Wang (2010). All variables are monthly except for real estate, which is quarterly. Index over residential real estate prices, exchange rates, gold prices, and data for the CPI is collected from Bank of International Settlements (BIS). Since all regressions include inflation, the countries with available CPI data will determine which countries are included in this study.

For stocks the Morgan Stanley Capital International (MSCI) Mid & Large Cap total return index is used. In general, there are more data points for stocks than for bonds as well as for developed than emerging countries. In this paper yields are used instead of prices for bonds and treasury bills. The average time to maturity for the bond yields is about 5 years. For T-bills it varies a lot. For most countries the 12-month time to maturity is used, but for countries with better availability of data averages of everything from 1 to 12 months to maturity is used. The source for bonds and T-bills data is Macrobond or the respective central bank for the country.

Industrial production for each country is collected from the International Monetary Fund (IMF). The data is seasonally adjusted, and for most countries the data covers industrial production across all industries. For a small number of countries industrial production for the manufacturing sector was used instead. These countries were Indonesia, Peru, Philippines, Singapore, and South Africa.

The data for gold futures prices is taken from the commodity exchange (COMEX) and the future has a 6-month delivery date.

3.2 Analytical approach

In this paper the relationship between inflation and the returns of the asset classes is analyzed through ordinary least square regression models. This approach allows us to analyze the unique effect of inflation on each asset class separately and tests the strength and significance of the relationship between the variables. For pooled regressions unbalanced panels are used. This

means countries have differing weights in those regressions. This method is used for being able to include all available data in time series with differing lengths to still gain insights in countries where the length of the time series is shorter. A minimum of 24 observations are used as a requirement to include a country.

This study as far as possible uses the same variables as Bekaert and Wang (2010), with the intention of achieving comparability. That means examining the relationship between inflation, expected inflation, unexpected inflation, industry production and several major asset classes including stocks, bonds, treasury bills, foreign bonds, real estate, gold, and gold futures. Gold futures is included since it is a forward-looking asset and gives insight into the market expectations. It is also a far more liquid investment compared to gold and often involves leverage, allowing bigger speculative investments to a wide range of market participants.

This study uses monthly data, and annual natural logarithmic returns are calculated. Since all the time series are computed into logarithmic returns, the interpretation of the beta values is therefore very straight forward. For every percentage point increase in the independent variables, the dependent variable increases by the beta value in percentage points. A beta of one is therefore interpreted as if for example inflation increases by one percentage point, the asset class return also increases by one percentage point. The null hypothesis for the initial regressions for individual countries is that the beta equals one.

There is a general problem with economic data, and it is that they all tend to correlate. Since money supply tends to increase, almost all economic data increases over time as well. In this paper industrial production is used in some regressions to adjust for the general growth in the economy. When the horizon regressions are made, a problem with serial correlation occurs since returns are summed together. For example, a one-year horizon regression sums the last twelve inflation numbers together at time t. That is twelve annual inflation rates, measured monthly. At time $t + 1$, eleven of the twelve numbers are the same as the previous horizon data point. This according to Bekaert & Wang (2010) results in positive serial correlation in the residuals. It means there is a bias in the standard errors, and they handle the problem by using the Hansen and Hodrick (1980) method to recalculate them. In this paper the standard errors are not corrected.

In pooled regressions, countries are divided into groups depending on geographical location or state of development. The groups are Developed, Emerging, North America, Latin America, Asia, Oceania, EU, and Non-EU Europe. The IMF (2023) definition of developed and emerging is used for grouping countries depending on development.

The foreign bond portfolio is a bond portfolio with equally weighted government bonds from Japan, United Kingdom, Germany, and United States. For each of these four countries, their respective foreign bond portfolio consists of bonds for the other three countries. Returns on the foreign bonds portfolio are transformed into returns in USD using exchange rates that are taken from BIS. From this general portfolio in USD returns, exchange rates are used to translate this into local currency returns for the portfolio.

Like Bekaert and Wang (2010) this study uses a simple approach to inflation hedging using the ordinary least square regression below:

$$Nominal\ return = \alpha + \beta\ Inflation + \varepsilon. \quad (1)$$

The β indicates the inflation hedging properties for the particular asset being the dependent variable in the regression and ε represents the part of the return that cannot be explained by inflation. To qualify as an inflation hedging asset class, its returns must be positively correlated with inflation at the very least. To be considered a strong inflation hedge, it should ideally have an inflation beta of one or above. One should note that higher returning assets will most likely have done well with this kind of measurement but may not be reliable protection against inflation in the short term (Bekaert & Wang 2010). As will be discussed and analyzed in later parts of the paper, certain aspects such as economic activity might have a relevant effect on returns for certain variables and should therefore not be omitted from the regression. Therefore, industrial production growth acts as a proxy for economic activity and will be included in certain regressions.

For each country the year-on-year logarithmic returns for stocks, bonds, treasury bills, foreign bonds, gold, gold futures, and industry production growth are calculated monthly. In similar fashion the year-on-year inflation in month t is calculated as follows: $\pi_{i,t} = \ln(CPI_{i,t}) - \ln(CPI_{i,t-12})$, where π is inflation and CPI is the consumer price index, for country i. There is an exception for bonds, foreign bonds, and treasury bills as the collected data were yields. For bonds and treasury bills the logarithmic return is calculated in the following way: $R_i = \ln(100 + yield_i) - \ln(100)$.

For returns accumulated over horizons the logarithmic return is added for the previous year, three years, or five years. This method is used for the dependent variable as well as for the independent variables when running regressions over time horizons. Mathematically it is: $r_{i,t+h,h} = r_{i,t+h} + r_{i,t+h-1} + \cdots + r_{i,t+1}$.

Expected inflation at time t is defined as the actual inflation at time $t - 12$. Expected inflation for a k year horizon is calculated as follows: $E(\pi_{i,t}) = \pi_{i,t-12} \cdot k \cdot 12$.
Unexpected inflation is defined as the difference between the actual inflation at time t and the expected inflation at time t. For a one-year horizon this means that unexpected inflation would be $UE(\pi_{i,t}) = \pi_{i,t-11} + \pi_{i,t-10} + \pi_{i,t-9} + \ldots + \pi_{i,t} - (\pi_{i,t-12} \cdot 12)$.

Gold and gold price returns in local currency are calculated from the gold price in USD and the exchange rates between the local currency and USD. The monthly year-on-year return is therefore the combined effect of the gold price return in USD and the currency price return in USD to catch the total spot yield. The equation used is below.

$$Gold\ price\ retun_i = \ln\left(\frac{\text{Gold price in USD}_t}{Gold\ price\ in\ USD_{t-12}} \cdot \frac{Exchange\ rate_{i,t}}{Exchange\ rate_{i,t-12}}\right)$$

The same procedure is applied to gold futures. The foreign bond portfolio is calculated in a similar fashion to gold, with exchange rates, but with the calculation from bonds instead of gold.

4. Results and analysis

Inflation betas for stocks and bonds are estimated for all individual countries the sample. Results from regressions using equation (1) follows below. Figure 2 shows the inflation betas for bonds yields.

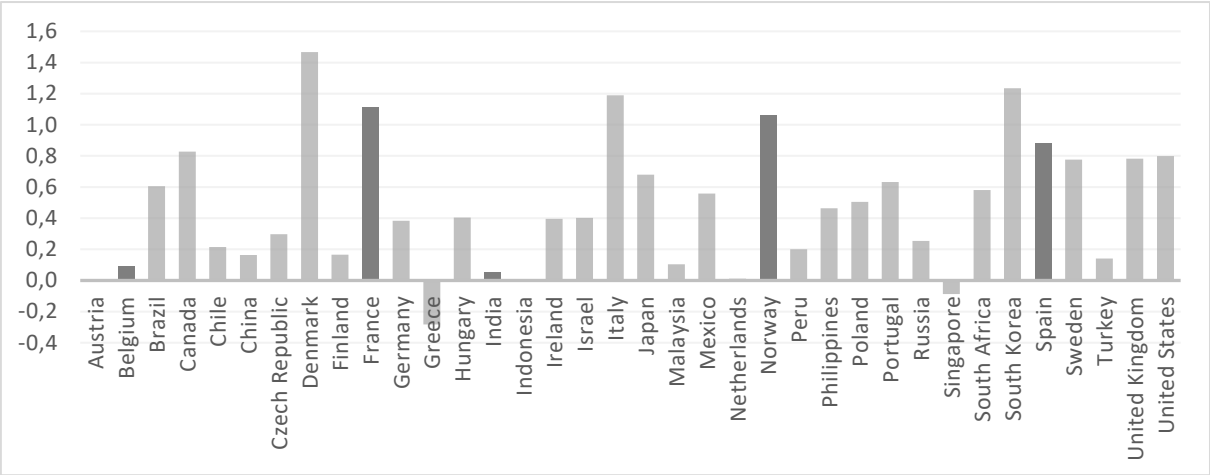

Figure 2. Inflation betas for bonds. Light grey colored bars indicate betas statistically significantly different from 1 at 10% significance level. Further specifications presented in Appendix A. Source: own calculations based on data from BIS and Macrobond.

The results show that 29 countries out of the 36 countries that data was available for have a significant inflation beta below 1. In total we find three countries where 1 fall within a 95% confidence interval in which all three are significant at a 1% significance level. These were France, Norway, and Spain all marked in a darker shade in Figure 2 above. All other countries marked in the darker shade had insignificant p-values. The null hypothesis that the inflation beta equals one is therefore not rejected. The average inflation beta for bonds across all countries was 0.47 suggesting that bonds are not as good of an inflation hedge.

The result for stocks is shown in Figure 3. One thing to note is that the data for stocks is more extensive than for bonds. In 22 out of the total 43 countries we find inflation betas that are significantly below 1. Notable here is that most countries with positive beta-values above one is emerging countries. This also goes for the countries that had significant betas.

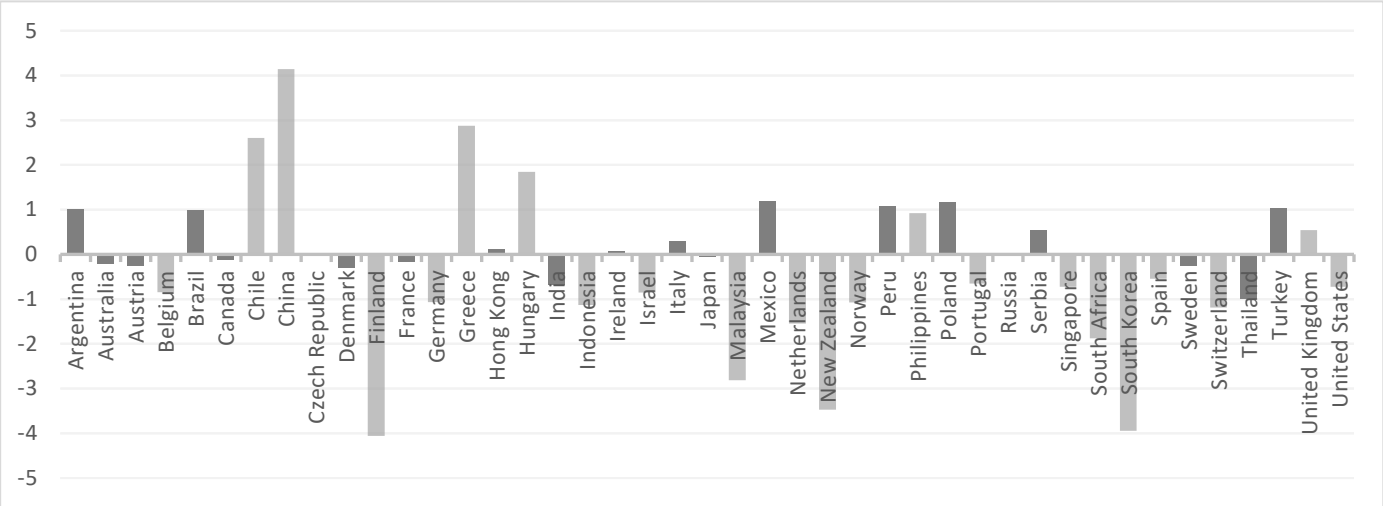

Figure 3. Inflation betas for stocks. Light grey colored bars indicate betas statistically differently from 1 at 10% significance level. Further specifications on these regressions are presented in Appendix B. Sources: Own calculations based on data from BIS and MSCI.

Table 1 presents pooled regressions where countries are pooled in groups depending on geographical location, EU membership or development status. The regression is run twice. First with only inflation as independent variable and then a multivariate regression with inflation and unexpected inflation.

Table 1. Inflation betas and inflation betas accommodating unexpected inflation.

Country groups	Inflation beta		Accommodating unexpected inflation	
	Bonds	Stocks	Bonds	Stocks
Developed countries	0.71 (0.01)	-0.27 (0.05)	0.98 (0.01)	0.02 (0.06)
Emerging countries	0.39 (0.01)	1.00 (0.02)	0.57 (0.01)	1.03 (0.02)
North America	0.83 (0.03)	0.92 (0.09)	1.04 (0.03)	0.90 (0.09)
Latin America	0.63 (0.03)	1.00 (0.01)	1.00 (0.04)	1.01 (0.01)
Asia	0.78 (0.02)	0.18 (0.14)	0.87 (0.02)	0.68 (0.15)
Oceania	-0.10 (0.02)	-0.48 (0.10)	-0.15 (0.02)	0.08 (0.12)
EU	0.50 (0.02)	0.32 (0.07)	0.92 (0.02)	0.50 (0.07)
Non-EU Europe	0.36 (0.01)	0.77 (0.13)	0.62 (0.02)	0.92 (0.13)

Notes: Standard errors are presented in parentheses. In column 3 and 4 the inflation beta accommodating the unexpected inflation beta is reported. All regressions are statistically significant at the 1% significance level. Sources: Column 1 and 3 based on data from BIS and Macrobond, Column 2 and 4 based on data from BIS and MSCI. Own calculations were used for all columns. Number of observations presented in Appendix F.

When looking at the different regions the most notable outlier is Oceania. Here we can see negative inflation betas for both bonds and stocks only reaching positive values for stocks when accommodating unexpected inflation. Figure 3 shows that no countries in Oceania have positive

inflation betas and New Zealand and Malaysia have very low inflation betas for stocks compared to the average that is -0.21 for stocks.

Looking over different horizons allows us to account for potential lagged effects. It is not unreasonable to assume that inflation would reach stocks or bonds later than consumer goods that determine the CPI. Table 2 presents pooled regressions over a one-year, three-year and five-year periods.

Table 2. Inflation betas over horizons

Country groups	Bonds			Stocks		
	1-y horizon	3-y horizon	5-y horizon	1-y horizon	3-y horizon	5-y horizon
Developed countries	0.90 (0.01)	1.27 (0.02)	1.46 (0.02)	0.06 (0.05)	0.26 (0.03)	0.47 (0.03)
Emerging countries	0.49 (0.01)	0.66 (0.02)	0.72 (0.02)	1.02 (0.01)	1.06 (0.01)	1.05 (0.01)
North America	0.92 (0.03)	1.53 (0.06)	1.33 (0.03)	0.98 (0.08)	0.99 (0.06)	0.86 (0.05)
EU	0.68 (0.02)	1.05 (0.03)	1.20 (0.03)	0.33 (0.06)	0.35 (0.05)	0.45 (0.04)

Notes: Standard errors are presented in parentheses. All regressions are statistically significant at the 1% significance level. Sources: Column 1-3 based on data from BIS and Macrobond, Column 4-6 based on data from BIS and MSCI. Own calculations were used for all columns. Number of observations presented in Appendix F.

For bonds the beta value increases across all groups between the one-year and three-year horizons. This would suggest a lagged effect of inflation over one year for bonds. Stocks seem to have a similar change in beta for developed countries but not for the other groups.

It is also important to look at the unexpected inflation over longer horizons. Table 3 provides the unexpected inflation betas over longer horizons for four different country groups for both stocks and bonds. A negative unexpected inflation beta implies that asset returns tend to decline when inflation unexpectedly increases.

Table 3. Unexpected inflation betas over longer horizons

Country groups	Bonds			Stocks		
	1-y horizon	3-y horizon	5-y horizon	1-y horizon	3-y horizon	5-y horizon
Developed countries	-0.11 (0.00)	-0.16 (0.01)	-0.24 (0.01)	-0.12 (0.01)	-0.17 (0.02)	-0.47 (0.02)
Emerging countries	-0.06 (0.00)	-0.09 (0.01)	-0.10 (0.01)	-0.02 (0.00)	-0.01 (0.00)	-0.03 (0.00)
North America	-0.14 (0.01)	-0.22 (0.01)	-0.30 (0.02)	-0.14 (0.01)	-0.28 (0.02)	-0.31 (0.02)
EU	-0.14 (0.00)	-0.22 (0.01)	-0.35 (0.01)	-0.11 (0.02)	-0.33 (0.03)	-0.55 (0.03)

Notes: Standard errors are presented in parentheses. All regressions are statistically significant at the 1% significance level. Sources: Column 1-3 based on data from BIS and Macrobond, Column 4-6 based on data from BIS and MSCI. Own calculations were used for all columns. Number of observations presented in Appendix F.

Among all country groups, the unexpected inflation beta is consistently negative for both stocks and bonds. Among emerging countries, the unexpected inflation betas for both bonds and stocks are generally less negative than for developed countries, but still negative across all horizons. Note also that the unexpected inflation beta generally becomes more negative as the time horizon increases.

As mentioned, stocks and bonds are heavily impacted by economic growth. Industrial production growth is used as a proxy for economic growth, mainly due to data availability. Table 4 presents inflation betas with and without controlling for industrial production growth.

Table 4. Inflation betas with and without controlling for industry production growth.

Country groups	Inflation beta		Accommodating industrial production	
	Bonds	Stocks	Bonds	Stocks
Developed countries	0.75 (0.01)	-0.27 (0.07	0.74 (0.01)	-0.32 (0.06)
Emerging countries	0.40 (0.01)	1.10 (0.02)	0.40 (0.01)	1.10 (0.02)
North America	0.88 (0.03)	0.94 (0.09)	0.88 (0.03)	0.85 (0.08)
Latin America	0.84 (0.04)	1.10 (0.02)	0.85 (0.04)	1.09 (0.01)
Asia	0.81 (0.02)	-0.44 (0.17)	0.80 (0.02)	-0.71 (0.16)
Oceania	-0.12 (0.02)	-0.32 (0.19)	-0.13 (0.02)	-0.29 (0.18)
EU	0.46 (0.02)	0.06 (0.08)	0.46 (0.02)	-0.10 (0.08)
Non-EU Europe	0.42 (0.01)	0.95 (0.05)	0.41 (0.01)	0.92 (0.04)

Notes: Standard errors are presented in parentheses. Only the inflation beta accommodating industrial production growth beta is reported in third and fourth column. All regressions are statistically significant at the 1% significance level. Sources: Column 1 and 3 based on data from BIS and Macrobond, Column 2 and 4 based on data from BIS and MSCI. Own calculations were used for all columns. Number of observations presented in Appendix F.

Controlling for industrial production growth allows for a more refined analysis of the relationship between inflation and asset returns by isolating the specific effects of inflation from the broader effects of industrial production. By doing so, the change in the inflation beta values when adjusting for industrial production may reflect how changes in industrial production can either reinforce or attenuate the relationship between inflation and asset returns. In general, the betas experienced a marginal reduction. This implies that the economic growth variable has a marginally positive effect on stocks and bonds.

Table 5 presents inflation betas for five common asset classes besides bonds or stocks. The regressions are run twice to adjust for unexpected inflation.

Table 5. Inflation betas for other assets

Country groups	T-Bills	Foreign bonds	Real estate	Gold	Gold futures
Developed countries	0.73 (0.01)	0.46 (0.03)	0.80 (0.03)	1.05 (0.02)	0.97 (0.02)
Emerging countries	0.99 (0.01)	0.97 (0.00)	1.03 (0.05)	0.96 (0.01)	0.93 (0.01)
North America	0.99 (0.04)	0.84 (0.02)	0.67 (0.10)	1.01 (0.04)	1.02 (0.01)
Latin America	0.32 (0.02)	0.96 (0.01)	0.41 (0.17)	0.95 (0.01)	0.92 (0.01)
Asia	0.54 (0.02)	0.73 (0.03)	0.96 (0.07)	1.03 (0.02)	0.99 (0.02)
Oceania	0.55 (0.04)	1.28 (0.05)	0.83 (0.03)	1.18 (0.06)	0.97 (0.06)
EU	0.86 (0.01)	0.63 (0.03)	0.83 (0.03)	0.86 (0.03)	0.67 (0.04)
Non-EU Europe	1.15 (0.01)	1.20 (0.02)	1.19 (0.07)	1.08 (0.02)	1.09 (0.02)
Country groups	Accommodating unexpected inflation				
	T-Bills	Foreign bonds	Real estate	Gold	Gold futures
Developed countries	0.90 (0.01)	0.53 (0.03)	0.79 (0.03)	0.97 (0.02)	0.90 (0.02)
Emerging countries	0.98 (0.01)	0.95 (0.00)	1.04 (0.05)	0.93 (0.01)	0.91 (0.01)
North America	1.34 (0.05)	0.84 (0.02)	0.57 (0.10)	0.83 (0.04)	0.85 (0.04)
Latin America	0.24 (0.02)	0.94 (0.01)	0.62 (0.20)	0.92 (0.01)	0.90 (0.01)
Asia	0.61 (0.02)	0.83 (0.04)	0.98 (0.07)	0.95 (0.02)	0.93 (0.02)
Oceania	0.79 (0.04)	1.08 (0.06)	0.62 (0.07)	0.95 (0.07)	0.68 (0.07)
EU	1.03 (0.01)	0.76 (0.03)	0.81 (0.04)	0.97 (0.04)	0.79 (0.04)
Non-EU Europe	1.20 (0,01)	1.18 (0.02)	1.12 (0.09)	1.05 (0.02)	1.06 (0.02)

Notes: Standard errors are presented in parentheses. Only the inflation beta accommodating unexpected inflation beta is reported in the bottom section of the table. All regressions are statistically significant at the 1% significance level. Sources: CPI from BIS, T-bills from Macrobond, Foreign bonds from Macrobond and BIS, Real estate from BIS, Gold from BIS, Gold futures from COMEX. Own calculations were used for all columns. Number of observations presented in Appendix F.

Compared to stocks and bonds, the assets presented in Table 5 show less variation between country groups. In contrast to Table 4 there are also no negative inflation betas for any assets in Table 5. Although one might assume this means that the risks in these assets are significantly lower, that is not always the case. The average inflation beta across country groups is lowest for T-bills at 0.77 and the highest for gold at 1.01. Adjusting for unexpected inflation real estate instead becomes the lowest average across country groups at 0.82. Gold remains the highest average at 0.95. The lowest observed beta is found in treasury bills in Latin America. It is however important to mention that the number of observations in this group is fewer than other country groups. As mentioned, the data availability is scarce for many emerging countries. For Latin America we have 814 observations with data not going further back than 1995 for Brazil.

In general, differences between country groups were larger between developed and emerging as well as Latin America and Oceania having certain outliers in their group. In Oceania the inflation

betas of Malaysia and New Zealand heavily impact the overall country group. It is noteworthy that stock returns were above inflation during the measured period by margins of roughly 4%, but the covariance between inflation and stock returns were low. In Latin America, T-bills and bonds show relatively low inflation betas, compared to other country groups. This is more than likely the cause of high inflation and continually changing interest rates in this region.

Table 6 and 7 are presented on separate sheets on the following two pages. Table 6 represents the inflation betas for the same asset classes as in table 5 but over longer horizons. As in the case of bonds and stocks in Table 2, the inflation betas increase slightly over horizons in most cases. Some exceptions to this are real estate in emerging countries, that decreases over horizons, and gold futures for emerging countries where an initial decrease is followed by a significant increase at a five-year horizon resulting in the highest inflation beta in the table. Another notable remark is that for foreign bonds, we see higher betas in emerging countries compared to developed countries. Overall, there is a positive relationship between inflation and all five asset classes over longer periods.

The unexpected inflation betas in Table 7 show very different results compared to the regular inflation betas. For most of the assets, the beta values are significantly lower across all horizons for each country group. The exception to this is real estate where the unexpected inflation betas are low at a one-year horizon but reach similar values to the regular inflation beta at a three and five-year horizon. Treasury bills show a negative relationship with unexpected inflation. Results for treasury bills also differ in that the beta is getting lower over horizons across all country groups, whereas for the regular inflation beta show consistent increase over horizons across all groups. For foreign bonds, the unexpected inflation beta is generally close to zero. This implies that foreign bonds returns are less sensitive to unexpected inflation. For the other three asset classes, the results suggest a positive relationship with unexpected inflation. Table 7 should also be analyzed in comparison to Table 3, where unexpected inflation betas for stocks and bonds are presented. In general, the unexpected inflation betas for stocks and bonds are lower than for asset classes in Table 7. Treasury bills are the only asset that compares to stocks and bonds.

Table 6. Inflation betas over longer horizons for other asset classes

Country groups		T-bills	
	1-y horizon	3-y horizon	5-y horizon
Developed countries	0.85 (0.01)	1.03 (0.02)	1.08 (0.02)
Emerging countries	1.18 (0.01)	1.26 (0.01)	1.28 (0.00)
North America	1.17 (0.05)	1.74 (0.05)	1.76 (0.05)
EU	1.01 (0.02)	1.22 (0.02)	1.26 (0.02)
		Foreign Bonds	
	1-y horizon	3-y horizon	5-y horizon
Developed countries	0.62 (0.03)	0.68 (0.02)	0.78 (0.02)
Emerging countries	0.97 (0.00)	0.97 (0.00)	0.97 (0.00)
North America	0.94 (0.02)	0.90 (0.01)	0.91 (0.01)
EU	0.85 (0.02)	0.82 (0.01)	1.01 (0.01)
		Real estate	
	1-y horizon	3-y horizon	5-y horizon
Developed countries	0.83 (0.03)	0.88 (0.02)	0.90 (0.02)
Emerging countries	0.97 (0.05)	0.82 (0.05)	0.78 (0.05)
North America	0.71 (0.09)	0.74 (0.08)	0.72 (0.07)
EU	0.86 (0.03)	0.89 (0.03)	0.90 (0.03)
		Gold	
	1-y horizon	3-y horizon	5-y horizon
Developed countries	1.05 (0.02)	1.06 (0.01)	1.05 (0.01)
Emerging countries	0.94 (0.00)	0.93 (0.00)	0.92 (0.00)
North America	0.98 (0.03)	0.90 (0.02)	0.90 (0.02)
EU	0.88 (0.02)	0.95 (0.02)	1.03 (0.02)
		Gold futures	
	1-y horizon	3-y horizon	5-y horizon
Developed countries	0.99 (0.02)	1.01 (0.01)	1.14 (0.05)
Emerging countries	0.92 (0.00)	0.91 (0.00)	2.39 (0.06)
North America	0.99 (0.03)	0.91 (0.02)	1.66 (0.17)
EU	0.80 (0.02)	0.85 (0.02)	1.50 (0.07)

Notes: Standard errors are presented in parentheses. All regressions are statistically significant at the 1% significance level. Sources: CPI from BIS, T-bills from Macrobond, Foreign bonds from Macrobond and BIS, Real estate from BIS, Gold from BIS, Gold futures from COMEX. Own calculations were used for all data points in the table. Number of observations presented in Appendix F.

Table 7. Unexpected inflation betas over longer horizons for other asset classes

Country groups		T-Bills	
	1-y horizon	3-y horizon	5-y horizon
Developed countries	-0.10*** (0.00)	-0.16*** (0.01)	-0.24*** (0.01)
Emerging countries	0.00*** (0.00)	-0.02*** (0.00)	-0.04*** (0.00)
North America	-0.15*** (0.01)	-0.18*** (0.03)	-0.31*** (0.02)
EU	-0.13*** (0.00)	-0.23*** (0.01)	-0.30*** (0.01)
		Foreign bonds	
	1-y horizon	3-y horizon	5-y horizon
Developed countries	0.01*** (0.00)	-0.03*** (0.01)	-0.08*** (0.01)
Emerging countries	0.01*** (0.00)	0.01*** (0.00)	0.00* (0.00)
North America	0.03* (0.00)	0.07*** (0.01)	0.09*** (0.01)
EU	0.01*** (0.00)	-0.02*** (0.01)	-0.03*** (0.01)
		Real estate	
	1-year horizon	3-year horizon	5-year horizon
Developed countries	0.17*** (0.01)	0.76*** (0.05)	1.25*** (0.06)
Emerging countries	0.00 (0.06)	0.53*** (0.12)	0.98*** (0.16)
North America	0.46*** (0.10)	1.31** (0.15)	1.61*** (0.20)
EU	0.25*** (0.05)	0.92*** (0.08)	1.49*** (0.10)
		Gold	
	1-year horizon	3-year horizon	5-year horizon
Developed countries	0.09*** (0.01)	0.16*** (0.01)	0.16*** (0.01)
Emerging countries	0.02*** (0.00)	0.02*** (0.00)	0.02*** (0.00)
North America	0.16***(0.01)	0.22*** (0.01)	0.23*** (0.01)
EU	0.09*** (0.01)	0.22*** (0.01)	0.27*** (0.01)
		Gold futures	
	1-year horizon	3-year horizon	5-year horizon
Developed	0.07*** (0.01)	0.08*** (0.01)	0.14*** (0.01)
Emerging	0.02*** (0.00)	0.01*** (0.00)	0.02*** (0.00)
North America	0.14*** (0.01)	0.13*** (0.01)	0.22*** (0.01)
EU	0.07*** (0.01)	0.13*** (0.01)	0.24*** (0.01)

Notes: Standard errors are presented in parentheses. The asterisk indicates significance at the 10% (*), 5% (**) or 1% (***) level. Sources: CPI from BIS, T-bills from Macrobond, Foreign bonds from Macrobond and BIS, Real estate from BIS, Gold from BIS, Gold futures from COMEX. Own calculations were used for all data points in the table. Number of observations presented in Appendix F.

Table 8 presents inflation betas for stocks and bonds pre, and post inflation targeting was adopted for 20 countries. The data for bonds are in some cases not available, or in many cases, have too few data points to capture the pre target.

Table 8. Inflation betas for stocks and bonds pre and post inflation targeting.

Country	Stocks		Bonds	
	Pre target	Post target	Pre target	Post target
Australia	-0.88*** (0.33)	0.55 (0.77)	N/A	N/A
Brazil	0.98*** (0.02)	-2.05** (0.79)	N/A	N/A
Canada	-1.41*** (0.39)	2.12*** (0.75)	0.48 (0.50)	-0.28 (0.51)
Czech Republic	1.33 (4.58)	-1.46 (4.60)	N/A	N/A
Finland	-9.03*** (1.43)	6.83*** (1.81)	0.92*** (0.28)	-0.65*** (0.29)
Hungary	5.58*** (0.76)	-6.90*** (0.91)	N/A	N/A
Indonesia	-1.46*** (0.23)	1.52** (0.77)	0.00 (0.01)	0.00 (0.01)
Israel	-9.03*** (1.96)	8.22*** (2.03)	N/A	N/A
Mexico	0.46** (0.24)	-3.25*** (1.16)	N/A	N/A
New Zealand	5.24* (3.08)	-9.35*** (3.11)	N/A	N/A
Peru	3.06*** (0.40)	-9.68*** (1.01)	N/A	N/A
Philippines	3.16*** (0.60)	-5.09*** (1.07)	N/A	N/A
Poland	1.72** (0.89)	-2.84*** (1.08)	N/A	N/A
South Africa	-1.75** (0.84)	-0.46 (0.94)	0.08*** (0.03)	0.18*** (0.05)
South Korea	-1.70 (1.52)	-4.65** (1.81)	0.64*** (0.30)	0.20 (0.31)
Sweden	-0.76 (0.55)	-3.67*** (0.89)	0.28*** (0.10)	-0.20* (0.12)
Thailand	-8.23*** (1.17)	11.10*** (1.45)	N/A	N/A
Turkey	0.71*** (0.17)	0.46 (0.32)	N/A	N/A
United Kingdom	-0.19 (0.21)	1.51** (0.63)	0.44*** (0.03)	-0.54*** (0.06)
United States	-0.61** (0.25)	-0.43 (0.71)	0.73*** (0.04)	-0.53*** (0.09)

Notes: Standard errors are presented in parentheses. The asterisk indicates significance at the 10% (*), 5% (**) or 1% (***) level. Sources: Data for stocks from MSCI, data for Bonds from Macrobond, CPI from BIS, and date of adopting inflation target from BIS (further specifications provided in Appendix D). Own calculations were used for all data points in the table.

From examining the betas for stocks, one can notice that there is prominent variation between countries, both in the magnitude of the beta and the direction of change pre and post target. In most countries that show significant results on at least a 10% significant level, there is a notable shift in the beta. In most cases, from positive to negative. Although this would indicate that the relationship between stocks and inflation may have been influenced by the adoption of an inflation target, it is important to consider other macroeconomic changes as many countries adopt an inflation target in a similar time frame. This makes these results hard to interpret.

Table 9 below presents pooled regressions for bond and stock betas over horizons pre and post inflation targeting. Like in Table 8, there is limited data availability for bonds, especially when looking at a five-year horizon. For emerging countries, the sample size of the pooled regression for bonds is too small and therefore not shown in this case.

Table 9. Pooled regressions pre and post inflation targeting.

Country groups	Bonds pre-targeting			Bonds post-targeting		
	1-y horizon	3-y horizon	5-y horizon	1-y horizon	3-y horizon	5-y horizon
Developed countries	0.70 (0.03)	0.81 (0.03)	N/A	0.21 (0.04)	0.10 (0.07)	N/A
Emerging countries	N/A	N/A	N/A	N/A	N/A	N/A
	Unexpected inflation betas					
	1-y horizon	3-y horizon	5-y horizon	1-y horizon	3-y horizon	5-y horizon
Developed countries	0.04 (0.01)	0.03 (0.01)	N/A	0.00 (0.01)	-0.07 (0.02)	N/A
Emerging countries	N/A	N/A	N/A	N/A	N/A	N/A
	Stocks pre-targeting			Stocks post-targeting		
	1-y horizon	3-y horizon	5-y horizon	1-y horizon	3-y horizon	5-y horizon
Developed countries	-0.64 (0.12)	-0.28 (0.09)	-0.06 (0.07)	-0.91 (0.27)	-0.34 (0.23)	-0.21 (0.22)
Emerging countries	1.06 (0.02)	1.12 (0.01)	1.12 (0.01)	0.88 (0.05)	0.25 (0.09)	0.48 (0.09)
	Unexpected inflation betas					
	1-y horizon	3-y horizon	5-y horizon	1-y horizon	3-y horizon	5-y horizon
Developed countries	-0.26 (0.03)	-0.43 (0.03)	-0.70 (0.04)	-0.26 (0.04)	-0.20 (0.06)	-0.27 (0.08)
Emerging countries	0.12 (0.01)	0.15 (0.01)	0.11 (0.01)	0.09 (0.02)	0.02 (0.03)	-0.09 (0.05)

Notes: Standard errors are presented in parentheses. All regressions are statistically significant at the 1% significance level. Sources: Data for stocks from MSCI, data for Bonds from Macrobond, CPI from BIS, and date of adopting inflation target from BIS (further specifications provided in Appendix D). Own calculations were used for all data points in the table. Number of observations presented in Appendix F.

The implementation of inflation targets has a negative impact on both stocks and bonds for inflation betas. For both bonds and stocks, the unexpected inflation betas show mixed results across different time horizons and country groups.

5. Discussion

The regressions for individual countries as well as the pooled regressions show that emerging countries have a higher beta for stocks compared to developed countries. Figure 3 show that Chile, Greece, and China are among those countries where stocks show high inflation betas. Other emerging countries such as Malaysia and South Africa however do not show positive inflation betas for stocks. The fact that China has the highest beta should not be a surprise. In recent years, China have had large economic growth because they are a major competitor in the global technology market. The Chinese government has also implemented a range of policies aimed at stimulating economic growth. China has also become increasingly attractive to foreign investors. Policies as well as increasing foreign investments increase the impact on the global economy and has led to China taking market shares in many foreign markets.

Emerging countries from our subsample and in general are and have been exposed to higher inflation. As explained by the Fischer effect, negative real interest rates benefit borrowers. In many emerging countries, we also see tendencies of negative real interest rates. There is an argument for why this will have a beneficial effect on companies. A company's assets value appreciates, and the debt will be reduced. There are also advantages to companies exporting goods to countries with lower inflation, as they will get a competitive advantage due to the devaluation of the currency. Negative real interest rates are therefore more advantageous to businesses rather than consumers. Negative real interest rates also increase consumer spending because of the benefits of taking dept. In most emerging countries we do see a prominent negative real interest rate as their central bank's measures are in most cases not enough to limit inflation. This is probably one of the causes of the results we get, as we see high inflation betas for stocks in the emerging countries. This may not be the case if central banks in these countries adjust the policy rate to keep the real interest rates close to zero or positive.

Over longer horizons, results suggest that stocks become a more pronounced hedge against inflation. The inflation betas generally exhibit an increasing trend as the time horizon expands. This would suggest that long-term investors are less sensitive to inflation compared to short-term investors. However, this phenomenon did not hold true in the context of unexpected inflation, where the betas exhibited a progressively negative trend as the time horizon is lengthened. The tendencies for higher inflation betas over longer horizons are likely due to the fact that in the long run all assets should at least have a beta equal to one, assuming all other factors are the same as is suggested by Freidman (1995). Reasons for inflation betas over one in a longer time horizon should be because of positive real returns due to being a yielding asset. This is, however, not true

for gold and yet it is shown to be a good hedge over longer horizons. This is simply due to demand being higher than the growing supply. Since gold is non yielding asset that is priced depending on supply and demand rather than any potential cash flow, there are arguments for why more risk would be involved simply due to it being a more speculative asset but historically it has been a safe haven, and demand is seemingly growing faster than supply according to our results. Returns on gold futures have been even better, but it also entails more risk. Investors demand a risk premium to compensate for the potential downward risk associated with the future price of gold being lower than the current price. This could also be a part of the explanation for why gold futures have higher betas than gold. Bekaert and Wang (2010) got comparable results for gold to this study. There is a larger discrepancy in the inflation betas for real estate between the studies. This is partly due to difference in the length of the data sample as Bekaert and Wangs data sample end close to the financial crisis in 2008 when real estate prices were low in many countries. They also use real estate stocks whereas this study uses residential real estate index.

Treasury bills also show betas over one for all country groups at a three- and five-year horizon. In general treasury bills are the safest investment out of the assets included in this study. The yield is therefore also very low and has at certain times been negative in some countries, primarily in the euro zone. Although buying a treasury bill with a negative yield may seem counterintuitive, there are certain reasons for why banks might want to do so. Banks are often subject to regulatory requirements regarding capital and liquidity. Holding government securities, including T-bills, can help fulfil some of these requirements. In certain cases, regulatory bodies may accept negative-yielding securities as eligible assets, enabling banks to maintain compliance. Financial institutions may also purchase negative-yielding T-bills based on speculation or market expectations or to fund collateral for borrowing funds in other markets. This allows them to profit from the interest rate differential or engage in arbitrage strategies. In such cases, even though the T-bills themselves have negative yields, the overall transaction may be profitable.

When testing the stability of betas by dividing the time frame in two before and after the adoption of inflation targeting, the results are somewhat spurious. The initial hypothesis was that emerging countries would have lower faith in the central bank's ability to reach these goals and we would therefore see a bigger effect of adopting an inflation target for developed countries. Results do however not suggest this. The pooled regressions show a clear decrease for inflation betas. One should however be careful using these results to draw conclusions about the implementation of inflation targets. This is because it is a comparison between older versus

newer data. The world is constantly developing and changing so these results might have happened without the specific targeting. An inflation target also does not necessarily mean central banks take them seriously, and the opposite for countries with no inflation targets. United States implemented their two percent target as late as 2012 but Federal Reserve have had high credibility for a long time. During the oil crisis in the 1970s and 1980s, the chairman of the Federal Reserve, Paul Volker, dramatically increased the interest rate to battle the high inflation. On the opposite side and a present example is Turkey. They have an inflation target of five percent, but their central bank doesn't raise the rent as much as necessary to take control of their spiraling inflation. As mentioned earlier, the credibility in the central bank may alter inflation and the outcome of adopting an inflation target. We hypothesize the credibility parameter (α) in the NKPC-equation is lower for emerging countries because the central banks in these countries have less solid reputation.

There is also an argument to be made for the growth potential in emerging countries. Like China we believe many other emerging countries have higher potential for economic growth compared to developed countries. This might be due to factors such as potential for rapid urbanization, abundance of natural resources, or simply just the fact that there is a less diluted market with high potential for growth. This could be a reason for stocks performing better in emerging countries than in developed countries in relation to inflation.

5.1 Comparing to Bekaert and Wang

The study conducted by Bekaert and Wang primarily focus on overlapping countries. Their study encompasses 45 countries, while this paper includes 43 countries. The only additional country included in this study, which is not covered in the original paper, is Serbia. The missing countries from this study compared to Bekaert and Wang (2010) is Colombia, Pakistan, and Egypt. These countries are excluded due to lack of data availability for consumer price index.

One of the interesting differences between the results in this study and the 2010 paper is the inflation betas for bonds. Table 1 and 2 suggests that the inflation beta for bonds is higher for developed countries in this study and the inflation beta for emerging countries is instead lower in this study. This is likely due to methodological differences between these studies as we use bond yields in our regressions and Bekaert and Wang used bond prices. Bond and stock inflation betas for Asia are also notably higher in our study.

Figure 2 illustrates a remarkable shift in inflation betas across various countries. In contrast to the year 2010, where 13 emerging countries exhibited substantial negative inflation betas, nearly all

countries now demonstrate positive inflation betas. This substantial improvement prompts us to explore potential explanations, including variations in starting dates and our utilization of bond yields instead of bond prices. An important consideration is the availability of historical data for emerging countries, potentially leading to later starting points in our analysis.

Comparing our results to Bekaert and Wang's findings, Table 3 underscores notably lower beta values for bonds and stocks in emerging countries across both short and long horizons. This suggests that emerging countries may have become less effective in hedging unexpected inflation using these assets. Notably, emerging economies, characterized by rapid development, offer an intriguing context for analysis. We hypothesize that this shift could be attributed to heightened efforts by central banks to control inflation. To explore this hypothesis, we conducted a parameter stability test, as outlined in Tables 8 and 9. Interpreting these results presents challenges due to inconclusive outcomes when compared to Figure 2 and Bekaert and Wang's earlier study. A possible explanation could be an overall improvement in central banks' anti-inflationary measures, regardless of their adoption of inflation targets. However, this stands in contrast to the significant negative difference revealed by the parameter stability tests between pre- and post-target regimes in the pooled regressions.

Table 4 demonstrates that industrial production has limited to no impact on inflation betas, as evidenced by our results. This differs from Bekaert and Wang's findings, particularly for emerging countries, where controlling for industrial production leads to a significant negative shift. However, the reliability of this finding is tempered by the relatively small number of data points available for emerging economies.

Table 5 presents significant disparities in real estate. Methodological discrepancies, temporal factors, and variations in the studied period likely contribute to these differences. Notably, the 2008 crisis had a pronounced effect on real estate, particularly evident in Bekaert and Wang's study, which focused on real estate companies listed on stock exchanges. Our analysis, in contrast, incorporates residential real estate prices and reveals a nuanced perspective on the impact of the crisis on this asset class. By critically examining these disparities and methodological nuances, we contribute to a more comprehensive understanding of the evolving dynamics of inflation betas across diverse asset classes and economies.

In Table 6, our findings reveal elevated inflation betas associated with T-bills across our chosen timeframe, spanning one-to-five-year periods. Unlike Bekaert and Wang's study, which lacks inflation betas exceeding one for T-bills. Our research demonstrates that almost all inflation betas

surpass one, except for the one-year horizon within developed countries. Notably distinct inflation beta patterns emerge for foreign bonds within developed countries. Our results indicate that most country clusters exhibit betas slightly below one, except for developed countries that exhibit a beta of approximately 0.7, displaying minimal variation across horizons. This contrasts with Bekaert and Wang's findings, where betas consistently escalate over horizons, notably peaking between 1.65 and 2.3 for developed countries. For real estate, our analysis identifies positive betas that experience a gradual increase as the horizon extends across all regions. This diverges from Bekaert and Wang's observations, wherein negative betas were evident for developed countries and the EU. The North American market stood out with extreme betas, surging from approximately 2 to 8 as the horizons lengthened.

Turning to gold, our outcomes are consistently close to one. However, Bekaert and Wang's research uncovered significantly higher betas for developed countries and North America. Our examination of gold futures reveals increasing betas over time, with all groups exhibiting betas above one at the five-year horizon. In contrast, Bekaert and Wang's study reported stable or declining betas over horizons, even presenting a negative beta for North America's five-year horizon.

The investigation of unexpected inflation, as presented in Table 7, stands in stark contrast to the findings of Bekaert and Wang. Our analysis reveals betas that align closely with zero across all asset classes and time horizons, except for real estate, where North America exceeds one on the three-year horizon, and all groups register betas close to one or above in the five-year horizon. While Bekaert and Wang's study unveiled predominantly positive albeit low betas for T-bills, our research identifies primarily low negative betas, representing a notable divergence. Furthermore, Bekaert and Wang determined foreign bonds to be a robust safeguard against unexpected inflation for most groups and time horizons, excepting North America, which displayed negative betas for the one- and three-year periods, but demonstrated a beta of 0.78 over the five-year horizon. Our study reflects a departure from this pattern with betas close to zero, as previously mentioned.

Their results for real estate were negative for developed countries and extremely negative for EU, and extremely high for North America, with betas stating at 2.19 and increases to 8.73 over the horizons. Their betas for gold and gold futures were all between one and 2.5. That’s a sharp contrast to our results.

Examining the stability of betas before and after inflation targeting in Table 9, the most notable difference is the magnitude of the inflation betas. For stocks, both expected and unexpected inflation show betas considerably exceeding one for Bekaert and Wang, whereas this study indicates betas exceeding one exclusively for emerging countries pre-targeting. Similar results between the studies are found in that betas for stocks are for the most part negative for developed countries and positive betas characterize emerging ones.

While the available bond data remained limited, it is noteworthy to highlight that the inclusion of data from the past decade enhances the robustness of our findings. This is of particular significance given that, as of 2010, many countries had yet to implement inflation targeting for an extended duration. Our analysis demonstrates a consistent reduction in inflation betas subsequent to the adoption of an inflation target. This trend remains consistent across the majority of regression analyses, with the sole exception being the betas associated with unexpected inflation for stocks. Similar patterns can be discerned in the research conducted by Bekaert and Wang.

Standard errors in this paper are in general considerably lower compared to Bekaert and Wang's paper. This difference in standard error values could potentially stem from dissimilarities in the lengths of the respective time series utilized, or possibly attributed to the use of Hansen and Hodrick corrected standard errors in Bekaert and Wang's paper.

6. Conclusions

The availability of viable hedges against inflation varies based on regions, investment horizon, and occurrences of inflation surprises. A general conclusion is that most assets analyzed in this paper, except for bonds and real estate, are decent hedges in emerging countries. Real estate starts off as a good hedge for immediate inflation but the beta declines for longer investment horizons. For bonds it is the opposite, their betas increase over time but never reaches the threshold for a good hedge. Treasury bills provide the best inflation hedge for both developed and emerging countries. For developed countries, the findings suggest that after treasury bills, gold and gold futures are the best hedges, and foreign bonds provide the lowest protection. Interestingly an opposite relation between stocks and bonds is found between developed and emerging countries. For developed countries, stocks inherit a poor hedge, but bonds prove better, and the opposite holds true for emerging countries. To complete the picture, we show a significant general improvement for bond inflation betas for individual countries compared to Bekaert and Wang's paper.

When adjusting for industrial production no noteworthy changes are found for stocks, and neither or slight negative effects are found for bonds. When adjusting for unexpected inflation for stocks and bonds, improvement in betas is shown for most country groups. The unexpected inflation betas are found to be slightly negative for stocks and bonds, and near zero or negative for other asset classes, with real estate, which has positive and increasing betas over time, being the exception. This suggests real estate is the best hedge against inflation surprises. Adopting inflation targets show very mixed results on an individual country level. On a group level over time horizons, results show a negative effect with decreasing inflation betas both for stocks and bonds for developed countries. For emerging countries data is missing for bonds, but available for stocks. A negative effect was found for stocks. For unexpected inflation betas, the adoption of inflation targeting had almost no effect and the betas were stable close to zero.

In the short-term, hedging inflation with positive real returns is challenging, particularly in developed countries. Inflation linked bonds are one of the few ways to hedge against inflation in the short term. This would also account for unexpected inflation that no other asset class seems to hedge against in the short term. In emerging countries, where inflation is generally higher, certain assets such as stocks, gold and real estate adapt to fast prices changes and can act as hedges against inflation.

The biggest lesson is that, almost unanimously, all asset classes improve with an extended investment horizon. Time has always been said to be on the diversified investor's side. The findings in this paper support this statement. Results may however differ substantially between countries and time periods. Stocks were seen as a better inflation hedge in the short run for emerging countries. In developed countries short run hedges were harder to determine. In theory and as is implied by Bekaert and Wang (2010), TIPS, or inflation-linked bonds, are the safest and best way to hedge inflation in the short term. In developed countries where monetary policy regimes are better at controlling inflation to a stable positive rate, inflation-linked bonds are one of the few ways to hedge sudden inflation shocks with a positive real return.

This paper extends the current body of knowledge by extending the research done by Bekaert and Wang for more than a decade. By analysing the latest decade our results manage to reflect the latest surge in inflation. We also argue that we obtain a more reliable measure of real estate as an asset class by not relying on real estate equities. Several new insights are brought to the surface as the results differs. Our results show that unexpected inflation is inherently more difficult to hedge against then what is suggested in earlier research, with real estate being an exception when it comes to longer time horizons.

6.1 Further research

It would be interesting to dig further into the improvement in the bond inflation betas for mainly emerging countries to get more insights to this significant improvement.

Further research could also dive deeper into why certain developed countries have seemingly low inflation betas for stocks even though stock markets have yielded significant positive real returns. This holds true for a handful of countries within our sample and investigating similarities in these countries might lead to interesting findings.

Due to positive serial correlation in the data in our method we suggest correcting the standard errors using Hansen and Hodrick's method in future research. We also suggest using bond prices instead of bond yields to get easier interpretable results.

References

Agénor, P. R., & da Silva, L. A. P. (2019). Integrated inflation targeting-Another perspective from the developing world.

Alexandersson, L. (2018). Liquidity premiums in the Swedish inflation-indexed government bond market. *Sveriges Riksbank Economic Review (Sweden)*, (2), 82-93.

Balcilar, M., Uwilingiye, J., & Gupta, R. (2018). Dynamic relationship between oil price and inflation in South Africa. *The Journal of Developing Areas*, 52(2), 73-93.

Bank of International Settlements (2023). *Central bank policy rates.* https://www.bis.org/statistics/cbpol.htm [2023-05-20].

Baumeister, C., & Kilian, L. (2016). Forty years of oil price fluctuations: Why the price of oil may still surprise us. *Journal of Economic Perspectives*, *30*(1), 139-160.

Bekaert, G., & Engstrom, E. (2010). Inflation and the stock market: Understanding the "Fed Model". *Journal of Monetary Economics*, *57*(3), 278-294.

Bekaert, G., & Wang, X. (2010). Inflation risk and the inflation risk premium. *Economic Policy*, *25*(64), 755-806.

Bodie, Z., Kane, A., & Marcus, A. J. (2020). *Investments*. McGraw Hill Education.

Boudoukh, J., & Richardson, M. (1993). Stock returns and inflation: A long-horizon perspective. *The American economic review*, *83*(5), 1346-1355.

Bjørnland, H. C. (2000). The dynamic effects of aggregate demand, supply and oil price shocks—a comparative study. *The Manchester School*, *68*(5), 578-607.

Chou, P. H., Hsu, Y. L., & Zhou, G. (2000). Investment Horizon and the Cross Section of Expected Returns: Evidence from the Tokyo Stock Exchange. *Annals of Economics and Finance*, 1(1), 79-100.

Chown, J. F. (1994). *A History of Money: from AD 800*. Psychology Press.

Cong, R. G., Wei, Y. M., Jiao, J. L., & Fan, Y. (2008). Relationships between oil price shocks and stock market: An empirical analysis from China. *Energy Policy*, 36(9), 3544-3553.

Ciccarelli, Matteo (Ed.); Osbat, Chiara (Ed.) (2017). Low inflation in the euro area: Causes and consequences, ECB Occasional Paper, No. 181, ISBN 978-92-899-2843-4, European Central Bank (ECB).

European Union. (n.d.). Principles, countries, history - Country profiles. Available at: https://european-union.europa.eu/principles-countries-history/country-profiles_sv?page=1 [2023-08-05].

Fabre, J. (2022). The Missing Link: The Real Bond Return Parity. *Available at SSRN*.

Fama, E. F. (1981). Stock returns, real activity, inflation, and money. The American economic review, 71(4), 545-565.

Fama, E. F., & Schwert, G. W. (1977). Asset returns and inflation. Journal of financial economics, 5(2), 115-146.

Fisher, I. (1930). The theory of interest. *New York*.

Friedman, M. (1995). *The role of monetary policy*. Macmillan Education UK.

Friedman, M., & Schwartz, A. J. (2008). *A monetary history of the United States, 1867-1960* (Vol. 14). Princeton University Press.

Han, G. (2022). Demographic Changes and Inflation Dynamics. *Available at SSRN 4217306*.

Hornstein, A. (2008). Introduction to the New Keynesian Phillips Curve. FRB Richmond Economic Quarterly, 94(4), 301-309.

Humphrey, T. M. (1974). The quantity theory of money: its historical evolution and role in policy debates. *FRB Richmond Economic Review*, *60*, 2-19.

International Monetary Fund (2023). *World Economic Outlook Projections*. https://www.imf.org/en/Publications/WEO/Issues/2023/04/11/world-economic-outlook-april-2023?cid=ca-com-compd-pubs_belt [2023-05-20].

Kilian, L., & Park, C. (2009). The impact of oil price shocks on the US stock market. *International economic review*, *50*(4), 1267-1287.

Lajeri, F., & Dermine, J. (1999). Unexpected inflation and bank stock returns: The case of France 1977–1991. *Journal of Banking & Finance*, *23*(6), 939-953.

Mendoza, A. F. (2023). "The effectiveness of different asset types as a hedge against inflation". Economic Bulletin - Banco de España, 2023/Q1, 03.

Schneider, M. (2004). The impact of oil price changes on growth and inflation. *Monetary Policy & the Economy*, 2, 27-36.

Smith, A. (1937). *The wealth of nations [1776]* (Vol. 11937).

Stulz, R. M. (1986). Asset pricing and expected inflation. *The Journal of Finance*, 41(1), 209-223.

Zoakos, C. M. (2002). Good and bad deflation. *The International Economy*, *16*(2), 10-15.

Appendix A. Data from regressions for bonds

Country	β	Std. Error	p-value	Lower CI	Upper CI	n
Austria	0.00	0.06	0.94	-0.13	0.12	313
Belgium	0.09	0.07	0.18	-0.04	0.23	366
Brazil	0.60	0.06	0.00	0.48	0.73	191
Canada	0.83	0.08	0.00	0.67	0.99	444
Chile	0.22	0.03	0.00	0.16	0.27	223
China	0.16	0.02	0.00	0.13	0.19	252
Czech Republic	0.30	0.03	0.00	0.23	0.37	286
Denmark	1.47	0.09	0.00	1.30	1.64	474
Finland	0.16	0.08	0.05	0.00	0.33	362
France	1.11	0.11	0.00	0.90	1.33	409
Germany	0.38	0.08	0.00	0.23	0.54	443
Greece	-0.28	0.12	0.02	-0.53	-0.04	281
Hungary	0.40	0.04	0.00	0.32	0.49	253
India	0.06	0.05	0.25	-0.04	0.15	318
Indonesia	0.01	0.00	0.00	0.00	0.01	222
Ireland	0.40	0.06	0.00	0.27	0.52	410
Israel	0.40	0.05	0.00	0.31	0.49	134
Italy	1.19	0.07	0.00	1.05	1.32	384
Japan	0.68	0.03	0.00	0.62	0.74	580
Malaysia	0.10	0.01	0.00	0.08	0.13	256
Mexico	0.56	0.06	0.00	0.43	0.68	257
Netherlands	0.01	0.07	0.87	-0.13	0.16	442
Norway	1.06	0.07	0.00	0.92	1.20	445
Peru	0.20	0.05	0.00	0.11	0.29	218
Philippines	0.46	0.04	0.00	0.39	0.54	191
Poland	0.50	0.05	0.00	0.41	0.60	276
Portugal	0.63	0.08	0.00	0.47	0.80	339
Russia	0.25	0.03	0.00	0.20	0.31	205
Singapore	-0.09	0.02	0.00	-0.13	-0.04	294
South Africa	0.58	0.06	0.00	0.47	0.70	350
South Korea	1.24	0.08	0.00	1.07	1.40	334
Spain	0.88	0.07	0.00	0.75	1.02	381
Sweden	0.78	0.06	0.00	0.67	0.89	433
Turkey	0.14	0.02	0.00	0.10	0.18	127
United Kingdom	0.78	0.04	0.00	0.70	0.86	528
United States	0.80	0.04	0.00	0.72	0.88	561

Sources: Own calculations based on data from BIS and Macrobond.

Appendix B. Data from regressions for stocks

Country	β	Std. Error	p-value	Lower CI	Upper CI	n
Argentina	1.02	0.03	0.00	0.95	1.08	410
Australia	-0.21	0.20	0.29	-0.61	0.18	625
Austria	-0.25	0.49	0.61	-1.20	0.71	627
Belgium	-0.85	0.31	0.01	-1.45	-0.24	627
Brazil	1.00	0.02	0.00	0.97	1.03	410
Canada	-0.13	0.23	0.56	-0.57	0.31	626
Chile	2.60	0.19	0.00	2.23	2.98	411
China	4.14	0.80	0.00	2.57	5.71	325
Czech Republic	0.03	0.37	0.95	-0.71	0.76	327
Denmark	-0.31	0.26	0.23	-0.82	0.20	624
Finland	-4.06	0.88	0.00	-5.78	-2.34	411
France	-0.17	0.23	0.47	-0.62	0.29	627
Germany	-1.07	0.43	0.01	-1.90	-0.23	625
Greece	2.88	0.38	0.00	2.12	3.63	410
Hong Kong	0.12	0.27	0.66	-0.41	0.65	626
Hungary	1.84	0.33	0.00	1.19	2.50	327
India	-0.67	0.61	0.27	-1.87	0.52	349
Indonesia	-1.13	0.21	0.00	-1.54	-0.72	411
Ireland	0.08	0.59	0.90	-1.08	1.23	410
Israel	-0.85	0.33	0.01	-1.49	-0.21	348
Italy	0.30	0.19	0.12	-0.08	0.68	627
Japan	-0.06	0.22	0.79	-0.49	0.37	626
Malaysia	-2.81	0.77	0.00	-4.33	-1.29	410
Mexico	1.19	0.15	0.00	0.89	1.48	411
Netherlands	-1.55	0.30	0.00	-2.14	-0.96	627
New Zealand	-3.47	0.43	0.00	-4.33	-2.62	409
Norway	-1.07	0.33	0.00	-1.73	-0.42	627
Peru	1.08	0.35	0.00	0.40	1.76	351
Philippines	0.92	0.38	0.02	0.17	1.67	411
Poland	1.17	0.28	0.00	0.61	1.73	349
Portugal	-0.66	0.34	0.05	-1.32	0.00	411
Russia	0.00	0.57	0.48	-1.54	0.72	242
Serbia	0.55	0.51	0.28	-0.46	1.55	166
Singapore	-0.72	0.26	0.01	-1.23	-0.21	625
South Africa	-1.88	0.36	0.00	-2.58	-1.17	350
South Korea	-3.94	0.61	0.00	-5.13	-2.75	411
Spain	-0.54	0.17	0.00	-0.88	-0.21	627
Sweden	-0.26	0.27	0.33	-0.78	0.27	627
Switzerland	-1.19	0.28	0.00	-1.73	-0.65	627
Thailand	-1.00	0.63	0.11	-2.24	0.23	411
Turkey	1.03	0.10	0.00	0.83	1.22	411
United Kingdom	0.54	0.16	0.00	0.22	0.87	626
United States	-0.73	0.23	0.00	-1.17	-0.28	627

Sources: Own calculations based on data from BIS and MSCI.

Appendix C. Start and ending dates for country specific data.

Country	Stocks		Bonds		Real estate		Industry production	
	Start	End	Start	End	Start	End	Start	End
Argentina	1987–12	2023–03	N/A	N/A	N/A	N/A	N/A	N/A
Australia	1969–12	2023–03	N/A	N/A	1970–01	2022–10	2000–01	2021–01
Austria	1969–12	2023–03	1997–01	2023–03	2000–01	2022–10	1996–01	2022–11
Belgium	1969–12	2023–03	1992–09	2023–03	1970–01	2022–07	1969–12	2022–11
Brazil	1987–12	2023–03	2007–04	2023–03	2001–01	2022–10	1991–01	2020–08
Canada	1969–12	2023–03	1986–02	2023–03	1970–01	2022–10	1969–12	2022–02
Chile	1987–12	2023–03	2004–08	2023–02	2002–01	2022–04	1997–01	2019–09
China	1992–12	2023–03	2002–02	2023–03	2005–04	2022–10	2010–01	2022–03
Czech Republic	1994–12	2023–03	1999–04	2023–03	2008–01	2022–07	1993–01	2022–11
Denmark	1969–12	2023–03	1983–07	2023–03	1970–01	2022–07	2000–01	2022–11
Finland	1987–12	2023–03	1993–02	2023–03	1970–01	2022–07	1969–12	2022–11
France	1969–12	2023–03	1989–03	2023–03	1970–01	2022–07	1969–12	2022–11
Germany	1969–12	2023–03	1986–03	2023–03	1970–01	2022–07	1969–12	2022–11
Greece	1987–12	2023–03	1999–09	2023–03	2006–01	2022–07	2000–01	2022–11
Hong Kong	1969–12	2023–03	N/A	N/A	1979–10	2022–10	N/A	N/A
Hungary	1994–12	2023–03	2002–02	2023–03	2007–01	2022–07	1985–01	2022–10
India	1992–12	2023–03	1996–05	2022–10	2009–01	2022–07	1971–01	2022–11
Indonesia	1987–12	2023–03	2004–10	2023–03	2002–01	2022–10	1998–01	2019–04
Ireland	1987–12	2023–03	1988–02	2023–03	1970–01	2022–10	1975–07	2022–11
Israel	1992–12	2023–03	2011–10	2023–03	1994–01	2022–07	1969–12	2021–06
Italy	1969–12	2023–03	1991–02	2023–03	1970–01	2022–10	1969–12	2022–11
Japan	1969–12	2023–03	1974–10	2023–03	1970–01	2022–07	1969–12	2022–11
Malaysia	1987–12	2023–03	2001–10	2023–03	1988–01	2022–10	1971–01	2019–03
Mexico	1987–12	2023–03	2001–10	2023–03	2005–01	2022–07	1980–01	2021–10
Netherlands	1969–12	2023–03	1986–05	2023–03	1970–01	2022–07	1969–12	2022–10
New Zealand	1987–12	2023–03	N/A	N/A	1970–01	2022–07	N/A	N/A
Norway	1969–12	2023–03	1986–02	2023–03	1970–01	2022–10	1969–12	2022–10
Peru	1992–12	2023–03	2005–01	2023–02	1998–01	2022–10	1993–01	2018–04
Philippines	1987–12	2023–03	2007–04	2023–03	2008–01	2022–07	1993–01	2022–10
Poland	1992–12	2023–03	2000–01	2023–03	2010–01	2022–07	1997–01	2022–11
Portugal	1987–12	2023–03	1994–12	2023–03	2008–01	2022–07	1995–01	2022–11
Russia	1995–03	2022–03	2006–01	2023–03	2001–01	2022–10	2000–01	2022–01
Serbia	2008–05	2023–03	N/A	N/A	N/A	N/A	2000–01	2022–11
Singapore	1969–12	2023–03	1998–07	2023–03	1998–01	2022–10	1997–01	2022–11
South Africa	1992–12	2023–03	1985–01	2023–02	1970–01	2022–10	1990–01	2022–10
South Korea	1987–12	2023–03	1995–05	2023–03	1975–01	2022–10	1969–12	2022–11
Spain	1969–12	2023–03	1991–06	2023–03	1971–01	2022–07	1970–01	2022–10
Sweden	1969–12	2023–03	1987–02	2023–03	1970–01	2022–07	1997–01	2022–10
Switzerland	1969–12	2023–03	N/A	N/A	1970–01	2022–10	N/A	N/A
Thailand	1987–12	2023–03	N/A	N/A	1991–01	2022–10	N/A	N/A
Turkey	1987–12	2023–03	2012–08	2023–03	2010–01	2022–10	1986–01	2022–10
UK	1969–12	2023–03	1979–02	2023–03	1970–01	2022–10	1969–12	2022–10
United States	1969–12	2023–03	1976–06	2023–03	1970–01	2022–10	1969–12	2022–08

Sources: Stocks from MSCI, Bonds from Macrobond, Real estate from BIS, Industry production index from IMF.

Appendix D. Adoption of inflation targets

Country	Date adopted	Initial target	Current target	Current tolerance band
Australia	1993–06	2.5%	2.5%	0.5%
Brazil	1999–06	4.0%	3.3%	1.5%
Canada	1991–02	2.0%	2.0%	3.0%
Czech Republic	1997–12	2.0%	2.0%	1.0%
Finland	1998–09	2.5%	2.5%	1.5%
Hungary	2001–06	3.0%	3.0%	1.0%
Indonesia	2005–08	3.5%	3.0%	1.0%
Israel	1997–06	2.0%	2.0%	1.0%
Mexico	2001–01	3.0%	3.0%	1.0%
New Zealand	1989–12	1.0%	2.0%	1.0%
Peru	2002–02	2.0%	2.0%	1.0%
Philippines	2002–03	4.0%	3.0%	1.0%
Poland	1998–01	2.5%	2.5%	1.0%
South Africa	2000–02	4.5%	4.5%	1.5%
South Korea	1998–03	2.0%	2.0%	1.0%
Sweden	1993–11	2.0%	2.0%	0.0%
Thailand	2000–05	Not specified	2.0%	1.0%
Turkey	2006–01	25.0%	5.0%	0.0%
United Kingdom	1997–05	2.5%	2.0%	1.0%
United States	2012–01	2.0%	2.0%	0.0%

Sources: Data from BIS.

Appendix E. Country groups

Developed	Emerging	North America	Latin America	Asia	Oceania	EU	Non-EU Europe
Australia	Argentina	Canada	Brazil	China	Australia	Austria	Norway
Austria	Brazil	Mexico	Chile	India	Indonesia	Belgium	Russia
Belgium	Chile	United States	Mexico	Israel	Malaysia	Czech Republic	Serbia
Canada	China		Peru	Japan	New Zealand	Denmark	Switzerland
Denmark	Czech Republic			South Korea	Philippines	Finland	Turkey
Finland	Greece			Thailand	Singapore	France	United Kingdom
France	Hungary					Germany	
Germany	India					Greece	
Hong Kong	Indonesia					Hungary	
Ireland	Malaysia					Ireland	
Israel	Mexico					Italy	
Italy	Peru					Netherlands	
Japan	Philippines					Poland	
Netherlands	Poland					Portugal	
New Zealand	Russia					Spain	
Norway	Serbia					Sweden	
Portugal	South Africa						
Singapore	Thailand						
South Korea	Turkey						
Spain							
Sweden							
Switzerland							
United Kingdom							
United States							

Sources: Data for development status from IMF, current EU membership status from EU.

Appendix F. Number of observations in regressions

Country groups	Stocks	Bonds	T-bills	Foreign bonds	Real estate	Gold	Gold Futures
Developed	13 673	8 375	7 054	10 661	4 437	15 029	12 565
Emerging	6 867	3 727	4 221	7 696	1 398	9 421	8 933
North America	1 664	1 262	1 162	1 334	483	1 880	1 697
Latin America	1 571	889	814	2 177	325	2 652	3 678
Asia	2 673	1 618	2 199	2 976	917	3 983	3 678
Oceania	2 891	963	1 249	2 663	782	3 634	3 329
EU	8 283	5 865	4 093	7 188	2 435	9 228	8 435
Non-EU Europe	2 698	1 305	1 490	2 346	544	3 074	2 830

Notes: In regressions where industrial production is controlled for, the number of observations can be lower. Observations are lowered by 12, 36, 60 times the number of countries in the country groups for the 1, 3- and 5-year horizon respectively. If a country's time series falls below 24 observations, it is excluded from the country group. Sources: BIS, Macrobond, MSCI, COMEX.