ISCTE Business School
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EUROPEAN INFLATION-LINKED BONDS: AN HISTORICAL OVERVIEW AND THE BENEFITS AMID PORTFOLIO MANAGEMENT

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RESUMO

A presente dissertação propõe-se a introduzir de um ponto de vista geral a historia das Inflation-Linked Bonds (ILBs), coloquialmente conhecidas como linkers, dos países Europeus desenvolvidos e com especial enfoque em Franca, Alemanha e Italia sendo que estes são os principais emitentes de linkers excluindo o Reino Unido. Para alem da historia, a mecânica destes instrumentos assim como alguns dos conceitos base relacionados, tal como breakeven inflation rates, serão apresentados de forma a explicar como funcionam as ILBs e providenciam proteção contra a inflação. Adicionalmente, aponta para o estudo de alguns indicadores que ajudem, da perspetiva de um investidor, a concluir sobre os benefícios da inclusão de ILBs num portfolio. As principais conclusões a obter são esperadas estar relacionadas com diversificação e alocação de ativos num portfolio através da analise de correlações com ações e obrigações nominais assim como através de uma abordagem a partir do conceito da fronteira eficiente.

Palavras-Chave: inflation-linked bonds; European and developed markets; correlations and portfolio diversification; asset allocation

Classificação JEL: G11, G15

ABSTRACT

This dissertation proposes to introduce an historical overview on European developed countries' inflation-linked bonds (ILBs), colloquially known as linkers, with a special focus on France, German and Italian, since these countries are the main issuers of ILBs in the Europe excluding the United Kingdom. Besides from the history, the mechanics of these instruments as well as some key concepts as breakeven inflation rates will be presented showing how do ILBs work and provide inflation risk hedging. Further, this thesis aims to study some indicators that will help to conclude on the benefits of the inclusion of ILBs in a portfolio from the investor's perspective. The main conclusions are expected to be related with diversification and portfolio asset allocation through the analysis of correlations with equities and nominal bonds as well as through an approach using the mean-variance efficient frontier framework.

Keywords: inflation-linked bonds; European and developed markets; correlations and portfolio diversification; asset allocation

JEL Classification: G11, G15

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The present study is the result of my MSc. in Finance dissertation at ISCTE Business School. It was carried out during the year of 2014 and 2015, mainly during the summer of 2015. The main focus is on introducing European inflation-linked bonds, a relatively recent brand of securities issued by governments, which belong to the fixed income asset class.

Firstly I would like to thank my supervisor Prof. José Carlos Dias for all the guidance, advices and recommendations throughout all the process, always available and constantly incentivizing excellency in my study.

This thesis is a product of my passion towards the fixed income markets and belongs as much to me as to all my friends and family who always kept me pushing forward. I would like to express a special appreciation to my father, mother and brother, for the constant support in all possible ways as well as my Master's colleagues João Mendes and Miguel Ucha to who I frequently refer as my Brothers in Arms within finance.

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GLOSSARY

BEIR – Breakeven Inflation Rate

BTP – Buoni del Tesoro Poliennali

BUND/OBL –Bundesobligationen

CPI – Consumer Prices Index

EGILB – Barclays Euro Government Inflation-Linked Bonds Index

ECB – European Central Bank

EUR – Euro currency

EMU – European Monetary Union

GBP – Great Britain Pound currency

GOVIE – Nominal Government Bond

HICP – Harmonized Index of Consumer Prices

ILB – Inflation-Linked Bond

JGB – Japanese Government Bond

MoM – Month over Month

NTN – Notas do Tesouro Nacional

OAT – Obligation Assimilables du Tresor

SPGB – Spanish Government Bond

TIPS – Treasury Inflation Protected Treasuries

USD – United States Dollar currency

WGILB – Barclays World Government Inflation-Linked Bond Index

YoY – Year over Year

1. INTRODUCTION

Inflation-Linked Bonds (ILBs), have a recent history in the financial markets. Although there is evidence showing the early creation of these products back in the middle of the XVIII century, it was not until 1981 that they first appeared in Europe in the United Kingdom (UK).

An introduction on how ILBs were first created as well as how they function will compose the initial part of the thesis, being this a structural chapter and thus introducing the specificities of these securities grounding the questions and tests assessed later on.

Recently, inflation has been a mainstream topic in Finance and Economics as Europe is facing a period of low inflation similar to the one faced by Japan since the 1990s, and threatening the economic recovery following the sovereign debt crisis of 2010. Hence, it is important to assess the role of linkers in today's financial markets as well as from a portfolio management point of view. Apart from introducing linkers, conclusions on how they behave when faced with the risk/reward binomial relation and the benefits from including these securities in a portfolio are the basis originator of this dissertation.

ILBs are a relatively recent asset class where the first country to introduce these securities to the market was the UK with indexed-linked Gilts in the 1980s and the most liquid ILBs. United States of America (US) Treasury Inflation Protected Securities (TIPS), were only first issued in January 1997. The body of research is still considerably small when compared with other asset classes and with studies of relevance starting to be published in the latter years of the twentieth century. Campbell, Shiller and Viceira (2009) have studied, from a broader point, the history of ILBs in the US – TIPS – and UK – Gilts – relating and addressing yield levels, covariance and volatility with equities and bond supplies. Their main conclusions were related with the effect of long and short term real interest rates on ILBs yields. They also approached the evolution of these yields and justified the observed decrease in the period from 2000 to 2008 with an equal decreasing trend in the short term real interest rates, and then in 2008 in the peak of the US financial crisis, the sudden spike in ILBs yields was mainly due to the extreme market conditions causing a liquidity problem which led to the change in yields.

TIPS represent the ILBs subject to the most of the research due to the fact that they are more liquid and the US market for these instruments is considerably bigger. The majority of the research is related with the diversification benefits of ILBs from an asset allocation and investment perspective. Both Roll (2004) and Kothari and Shanken (2004) produced empirical

evidence that the inclusion of TIPS in a portfolio would enhance the diversification benefits in a portfolio composed by equities and nominal bonds. Later, Hunter and Simon (2005), by analyzing the real return betas of TIPS and the Sharpe ratios of both TIPS and the conventional nominal bonds concluded, that the primer showed evidence of superior volatility-adjusted returns.

However, as the ILB market increased in liquidity and as inflation expectations became more stable, and hence as the market matured, some studies, like the one developed by Brière and Signori (2009), showed that these factors contributed to the exponential increase in correlations with nominal bonds, therefore reducing the diversification benefits from 2003 on.

Currently, the benefits of ILBs are more closely related to inflation risk hedging benefits as demonstrated by Bekaert and Wang (2010) that by estimating and analyzing inflation betas[1] for equities and nominal bonds concluded that ILBs were a key instrument to hedge inflation risk. This is a type of risk with which numerous investors face as they have liabilities directly related to changes in inflation or wages.

The body of research on the Euro area developed countries' Inflation Linked Bonds is not very extensive. Hence this thesis intends to further analyze and extend the previous studies to the European Market by developing an analysis on the biggest issuers: Germany (Bundei/OBLei), France (OATei/i) and Italy (BTPei). Spain has also recently (last June), issued its first inflation linked bond the SPGBei 2024. However, since the data is scarce and very limited Spanish ILBs will be excluded from this study. Poland has also issued inflation linked debt securities. Yet by not having as much liquidity as the previous along with the focal point of this paper being to assess the properties of matured and developed markets including Poland might result in biased conclusions.

The main purpose of this dissertation is to introduce this new asset class that has recently been gaining notoriety. To do so the question that serves as cornerstone is: *How have Euro area developed countries' ILBs evolved since they first appear, how do they function and best serve investors amid Portfolio Management?* To get to a solid conclusion other sub questions will be addressed:

[1] As defined and computed by Bekaert and Wang (2010) the inflation betas define inflation hedging as how a security's nominal return relates to with inflation in terms of covariance resulting in the following regression: $R_{it} = \alpha + \beta\pi_t + \varepsilon_t$, where R_{it} is the monthly nominal return of stock i, π_i is the monthly rate of inflation, and ε_i is the residual of the regression that measures the part of the nominal return that is not explained by inflation.

1. What is the history of ILBs? Why were they created and how did they evolve? What are these instruments specificities? How do they work and what are breakeven rates?
2. How did the ILBs returns from the different countries considered behave in the past decade?
3. How do ILBs provide a better diversification benefits when compared with the traditional asset classes as equities and nominal bonds and how well do they perform in this topic according to the efficient frontier theory?

The remainder of the thesis is organized as follows: Section 2 provides an overview on the relevant literature related with ILBs which intends to provide some contextualization on what can be expected on the conclusions of the empirical analysis. Section 3 is the cornerstone of this dissertation as it is the chapter that introduces the history behind ILBs. It starts by giving an overview of how linkers first appeared and then focus more on the Euro area market, divided by country. It can be expected to acquire relevant insights on the origin of linkers, how they work and how these instruments are structured. The following section 4 details the data used in the present thesis, explaining the source of data and how Barclays Capital indices are used to study on ILBs' diversification power and asset allocation. Section 5 consists in presenting the descriptive statistics on all the data used in this study where the objective is to introduce the empirical analysis and the methodology used in the rest of the dissertation. The next section 6 is on the methodology used to access the proposed questions. There are presented in this chapter some well-known financial concepts and theories as the Fisher Equation and Markowitz's efficient frontier which will be later on addressed. Section 7 focus on the diversifying power of ILBs through the analysis of correlations with inflation, between asset class and cross-country. Asset allocation in section 8 is the one that concludes the empirical analysis and focus on optimizing a portfolio using equities, nominal sovereign bonds and linkers trough the efficient frontier framework as well as opposing portfolios composed by equites and ILBs and equites and govies then accessing the returns, volatility and Sharpe ratios. Concluding the study we have section 9 which summarizes the dissertation, provides the main conclusions and offers answers to the above mentioned questions by giving investor advices and guidelines on inflation-linked bonds.

2. LITERATURE REVIEW

ILBs have been addressed and researched in the past. Essentially in the past 20 years, several acknowledgeable authors have studied these instruments where the general focus was related with their diversification benefits and from a comparable point of view against nominal bonds. The focus here will be on papers which address ILBs of developed and matured markets, describing the behavior and specific characteristics, as volatility and correlation, of ILB among the financial markets. Therefore, an outline of the most relevant research of the matter is presented allowing the reader to pace himself along with the existing studies.

This chapter is divided in two sub sections as it is intended to separate the main findings regarding the correlations and volatilities conclusions from others regarding portfolio allocation and efficiency. Although correlations and volatility will affect and serve as the basis for an analysis regarding portfolio allocation, the aim here is to also set apart other conclusions such as price and yields discrepancies, duration, trends and inflation hedging properties.

2.1. Correlations and volatility

Roll (2004) took an empirical approach on the US ILB market (TIPS) and tried to infer on their specific characteristics and behavior. The author collected a sample of data of these instruments from July 1997 to August 2002. The first conclusion was on the correlation where TIPS returns were highly correlated to each other, mainly within similar maturities. Secondly, the volatility of TIPS was rather small between 1999 and 2000 and increased by a great deal after 2000. The correlation of TIPS returns with other assets was seen as positively related to nominal bonds and inversely correlated with equities.

Kothari and Shanken (2004) simulated hypothetical ILBs returns using historical yields of nominal US Treasury Bonds and an inflation forecasting model. They concluded that ILBs were less volatile than the equivalent nominal bonds and that the correlation with equities was considerably lower due to the inflation protection effect.

Hunter and Simon (2005) addressed the correlation between TIPS and nominal bonds. To do so, they collected weekly data from February 1997 to August 2001, and used a multivariate

GARCH model[2] to estimate the time-varying correlations. The conclusions led to an interesting finding. The results showed that the real rate components tended to increase with time which produced lower TIPS returns. Moreover they concluded that an increase in TIPS returns was always preceded by an increase in nominal yields returns, showing that nominal yield returns lead TIPS returns. In the case of a flatter (steeper) yield curve, there is an associated higher (lower) conditional correlation of returns within a confidence level of 5%. Also, the spreads have shown to have an effect on correlation as at the 1% confidence level; an increase in the spreads between Treasuries and TIPS often is allied with higher correlation.

Besides from the analysis made on TIPS regarding their correlation with nominal bonds, Hunter and Simon (2005) also approached TIPS from the risk/benefit binomial relationship and through the analysis of volatility they computed Sharpe ratios and conditional real betas which led them to conclude that TIPS showed evidence of higher volatility when compared with nominal bonds, particularly in times of superior inflation expectations.

Brière and Signori (2009) started their research on the diversifying power of ILBs using daily returns from a sampling period from 1997 to 2007. They focused on three asset classes in US and Europe (EU). For ILBs they used the Barclays Global Inflation Total Return indices for US and the French Linkers for EU. The nominal bonds were represented by Barclays Breakeven Comparator Bond indices for both US and EU and finally for Equities the authors used the S&P500 for US and the DJ Euro Stocx for EU. The results of their on the conditional correlations and volatilities between the referred asset classes indicated that in more recent times, mainly from 2003 and further, with higher liquidity in the linkers market along with stable inflation expectations, ILBs and nominal bonds both in the US and EU were almost substitutable assets. The main conclusion was that the higher correlation verified indicates similar volatility between the inflation protected bonds and the nominal equivalents, hence eliminating in most ways the diversification power that ILBs had in the past.

Campbell, Shiller and Viceira (2009) developed their research on ILBs based on data from the UK and US (these are the two largest and recognized ILBs markets). The authors analyzed several factors such as volatility, correlations, and the level of yields and the supply of these securities. The results on TIPS and inflation-indexed Gilts showed that there was a huge

[2] Generalized Auto Regressive Conditional Heteroskedasticity (GARCH) model developed by Engle (1982) is an econometric process used to estimate volatility in financial markets. It starts by estimating the best-fitting autoregressive model then computing autocorrelations of the error term and finally testing for significance.

decrease in long-term real interest rates from 1990 to 2008 when in the beginning of the financial crisis there was an abrupt increase, which was later concluded to have its cause on the liquidity problems that raised then and created inexorable market discrepancies. The breakeven inflation rates sooth until 2008 after when they showed striking decreases.

2.2. Portfolio allocation

Roll's (2004) main conclusion was related with the duration which due to the low real yield of TIPS was longer than the comparable nominal peers. However, when a daily analysis was conducted the author concluded that TIPS duration was less volatile due to the impact of changes of expect inflation being lower. Finally, Roll concluded that the Nominal Bond's yields reflected the expected inflation whereas TIPS did not. Based on this, adding inflation to the TIPS real yields would make them look more attractive as higher the inflation, being this the reason Roll used to justify the downturn in TIPS real yields in 2002; lower inflation expectations.

Based on the findings with regard to both the lower ILB's volatility with the nominal comparables and lower correlations with equities, Kothari and Shanken (2004) stated that ILBs provide additional diversification benefits when included in a portfolio composed by bonds and equities. The low correlation and volatility resulted in lower standard deviation of an equal-weighed portfolio of stocks and bonds when ILBs replaced the nominal and conventional equivalents. These findings were the base line in the authors' opinion on the importance and benefits of ILBs in investor's asset allocation decisions since Kothari and Shanken stated that investors depend on the expected return and risk of the available asset classes. Finally, they vowed that the fact that TIPS were a market with limited liquidity increased their yields, hence making them a more attractive investment in a long-term investment horizon period as was later supported with an analysis of TIPS actual returns from February 1997 to July 2003.

Hunter and Simon (2005) also presented results concerning the diversification benefits on including TIPS on a portfolio and concluded that the benefits differed for each portfolio according to their specific characteristics. During times of constant inflation rates, adding TIPS to a portfolio with other nominal bonds would increase considerably the risk-rewards benefits. Conversely, in the presence of a more diversified portfolio that would include nominal Treasuries, the benefits would be close to null. Yet, during high inflation periods linkers would still play a major contribute in increasing the portfolio efficiency regardless of the level of

diversification of the existing portfolio. Relating with Roll (2004), a similar suggestion was made, stating that during times of high expected inflation, adding TIPS to a portfolio of equities and nominal bonds would improve the portfolio efficiency.

Apart from the diversification analysis, Brière and Signori (2009) also approached the ILBs benefits by studying monthly dynamic portfolio optimization based on the previous computed estimates on volatility and conditional correlations. Again, the results indicated that although ILBs showed diversification benefits in portfolio asset allocation in developed countries before 2003, this effect was now mitigated and the weight in the optimal portfolio decreased exponentially. This decrease was more notable in the EU case where ILBs weight was close to nothing. This conclusion supports the same thesis presented before and simply comes to a point where the inclusion of ILBs in a portfolio nowadays resumes itself to the investors' inflation risk aversion and their consequent expected returns when compared with nominal bonds.

Campbell, Shiller and Viceira (2009) tried to explain the trends before 2008 when it came to short-term interest rates, liquidity and bond risks. Firstly, they re-ran the VaR analysis of Campbell and Shiller (1996) on the expectations hypothesis of the term structure of ILBs. They provided conclusions on the behavior of yields and their decrease from the beginning of the twenty first century and forth, that were greatly explained by the low levels of real interest rates. The asset pricing theory[3] was used to estimate a model of pricing from Campbell, Sunderam and Viceira (2009), with a time-varying systematic risk and concluded that the covariance between TIPS and equities has a strong effect on TIPS yields with strong and persistent risk variations.

Bekaert and Wang (2010) developed their research on Gilts, TIPS and Euro area ILBs. The authors based their work on old academic papers to conclude on ILBs *pros and cons*. The main benefits were the support of market completeness and efficiency mainly in the distribution of risk; also they contributed to savings in government's debt costs, the reduction in government inflation measures and finally giving information on inflation expectations and real interest rates. However, the authors described weaknesses of the theoretical benefits, such as the size and liquidity of this market, mainly in the beginning years of TIPS.

[3] The asset pricing theory states that the expected return of a financial asset can be modeled as a linear function of various macroeconomic factors or theoretical market indices represented by a factor-specific beta coefficient. Here the authors used it to assess ILB's risk premium where they first started from a consumption based pricing model and then simplified it to a more empirical and less structural analysis based on changes of covariance between bonds and stocks.

Bekaert and Wang (2010) also approached the benefits of ILBs from another fundamental point of view: inflation risk hedging. Using a sample period between January 1970 and January 2010 (depending from country to country) and composed by data from countries, they estimated inflation betas for nominal sovereign bonds and equities. The results, both for short and long term investment horizons, showed that in half of the countries bond returns were inversely correlated with inflation and that equities did not provide hedging for inflation. Therefore, the authors stated that ILBs would be a crucial security to hedge inflation as they incorporated a better capacity of measuring inflation risk premium to investors.

3. HISTORICAL OVERVIEW

This chapter has as its main objective the introduction of ILBs through an overview of its history. Here it will be presented when, how, why and where these instruments were first created and issued as well as how they work in terms of its nominal and coupon payments. As this dissertation focus on the European developed market, a focus will be set on the issuers mentioned before: Germany, France and Italy.

It is important to provide the reader with this information and contextualization so that a further comprehension of the study is allowed and of easier understanding, as the main purpose here is to give notice of ILBs and their role in current financial markets.

Investment returns can be highly conditioned by inflation, as this macroeconomic factor can cut deeply into portfolio's returns if not considered and properly assessed its risk. Let us assume we are a portfolio manager working in Europe and during the year of 2014 we achieved an overall portfolio return of 10%, considering the ECB inflation target of close to 2%. In the event of a poor inflation analysis and hedging, the portfolio would see its returns diminished by 20%. ILBs would come to play its part here, as these instruments can help to offset and hedge inflation risk as they increase in value during inflationary periods.

Although inflation has not been a major economic factor in the recent past it is now gaining notoriety. ILBs markets have been developing fast and these fixed income securities are more and more seen as an instrument to reduce future uncertainty and hedging inflation, becoming a popular long-range planning investment vehicle both to institutional and individual investors.

3.1. The Origin of Linkers

ILBs go back to the 18th century when they were first issued to fight the corrosive impact of inflation on the real value of consumer goods during times of rise in prices. The Massachusetts Bay Company was the first company to issue this type of bonds, beginning in the 1780s with money market securities, indexing their bonds to the price of silver and other items, thus reflecting inflation. However, at the time the issue did not achieve the expected success as few investors were interested in it. On the other hand side, after the exponential economic growth following World War II, sovereign and governmental financial planners started to look to the possibility of using these securities. In the 1950s we saw the first capital markets ILBs issuing

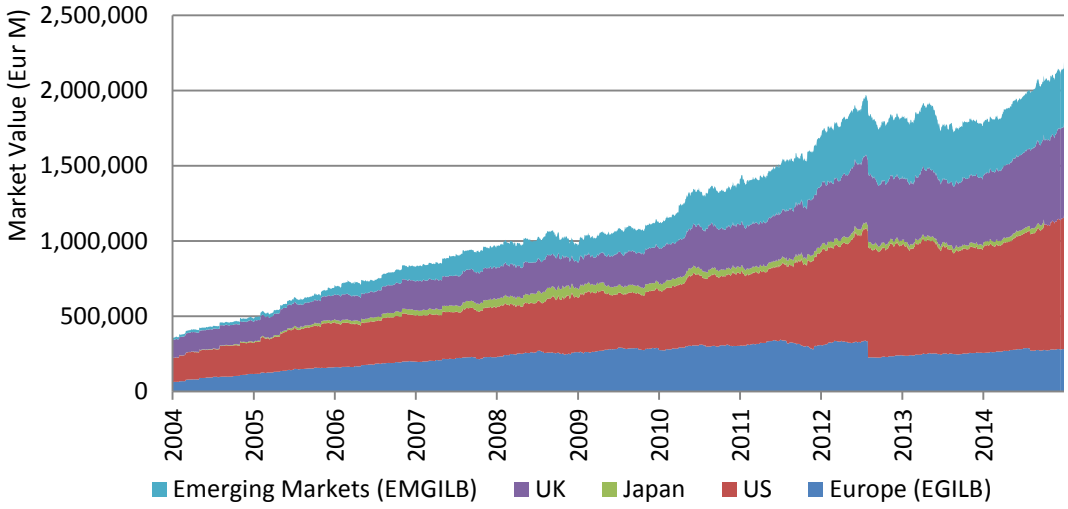
with Israel and Iceland that at the time aimed at fighting high inflation due to their rapid growth in GDP.

The first big issuing of ILBs happened in the 1980s and this was the moment that marked the birth of modern inflation-linked bond market which happened by the hands of United Kingdom, more precisely in 1981. This was followed by Australia in 1985, Canada in 1991, and Sweden in 1994, the United States reentered the market in 1997 with its famous TIPS, France in 1998 which bonds were linked to the French inflation (OATi) and Euro-zone inflation (OATie). Italy in 2003 as well as Greece entered the euro area linker market, Japan in 2004 (in spite of its deflationary environment), Germany in 2006 and most recently Spain issued its first inflation-linked debt security in 2014.

According to Barclays Inflation Indices, this market has been growing significantly in the past 10 years, where the WGILB index has grown about 400% in market value from about €381 billion in January 2004 to close to €2 trillion in 2014, going from having 39 bonds to 114. This increase is analogous to the evolution around the globe as shown in figure 1, where the biggest increase happened in Japan and in the Emerging Markets Government Inflation-Linked Bond (EMGILB) index with a rise of about 4000 and 2600 percent respectively in terms of market value. In the most developed countries the increase was also notable, however much more modest when compared with the two mentioned before. The EGILB index grew about 250% from €80.42bn to about €280bn in the 10 year period. In US and UK the market capitalization of linkers went from €183bn to €893bn in the first and a growth of €486bn in the second, from €129bn in January 2004 to €616bn in December 2014.

This growth had big influences in the dynamics of the inflation-linked bond market. As observed by Brière and Signori (2009), the increase in liquidity from 2003 and afterwards combined with other factors as stable inflation expectations, contributed to a increase in correlations and similar volatility between linkers and nominal bonds in the most developed markets, mainly in the US and Europe, concluding that the two asset classes were now almost substitutes. This reduced the role of linkers to inflation protection properties and financial planning. While this last point was stated by Bekaert and Wang (2010) as one of ILBs main benefits as they contribute to savings in government's debt costs, the reduction in government inflation measures and finally giving information on inflation expectations and real interest rates.

Figure 1: ILBs Indices Evolution by Market Value in Euros



Source: Barclays Capital

Other countries have also issued ILBs, mainly in Emerging Markets (EM) like Brazil, Turkey, South Africa and Mexico; however, these countries having a poor credit rating while others due to their small size and lack of liquidity are impeded of entering the major and most broadly used indices. An interesting fact occurred in some of these EM countries as at some stages, these countries could only issue ILBs since due to their weak currencies and persistent high inflation, investors would not buy nominal assets of these same countries. Brazil is currently the bigger issuer of linkers within the EM countries category, representing a large portion of this market, with over $300 billion in market value outstanding and dating its first issue back to 1964.

3.2. European Inflation-Linked Bonds

The history of European ILBs is undeniably interconnected with the birth of the HICP index in 1996 by Eurostat, the agency responsible for creating and managing common consumer price indices in Europe. This index also known as the Monetary Union Index of Consumer Prices (MUICP), serves as reference for the ECB within its monetary policy actions in order to fulfill its mandate of price stability with the index close but below 2%.

France was the first sovereign issuer from the euro area which presented its linkers in 1998 with the OATi 3% Jul 2009, at the time linked to the French CPIx. However, before that some inflation derivatives such as inflation swaps were already trading in the secondary markets and

indexed to the MUICP. Later in 2003 the Italian Government issued its first linker which was indexed to the HICPx as most Italian inflation liabilities also exclude tobacco and then confirming this as the benchmark index for both inflation-linked bonds and derivatives in the euro area.

Nowadays both HICP indices and CPI indices are computed via geometric chain weighted Laspeyres[4] indices with annual indexation reviews at the beginning of each year which aims to adjust and reflect consumption weights changes amid countries. The final MUICP is normally released around the 17th of the following month, however every month end it is released a flash estimate, with data collected from each individual country, which is then revised and adjusted if needed, hence reducing the uncertainty in the final inflation releases.

In 2006 Germany entered the ILB market, although the announcement was made in 2004, which then marked the inclusion of all G7 countries in the linkers market.

Greece, which in spite of being excluded from this dissertation and analysis, was the second euro area government to issued HICPx linked bonds in March 2003. Previous to that and joining the monetary union, Greece had also other small issues of bonds linked to the domestic CPI which matured in 2007.

Finally, Spain closed the euro area linker market with two issues in 2014. Both ILBs, a 5y and 10y references, where extremely successful which now puts Spain in a steady pace to becoming another large issuer of inflation-linked debt securities.

France

France first announced its intention to issue ILBs on December 3rd 1997 which was then effective on the 15th of December 1998 with the issue of the OATi 3% Jul 2009 via syndication with several re-openings by auction. As noted before, the index was then decided to be the one released by the French NSA (Institut national de la statistique et des études économiques – INSEE), with the official measure of French consumer prices, the CPI excluding tobacco. Although this index would best serve the interest of the government, as it would be a more accurate measure of the domestic price evolution and liabilities, investors soon started to demand a broader European measure. Yet the Eurostat HICP had been recently created and

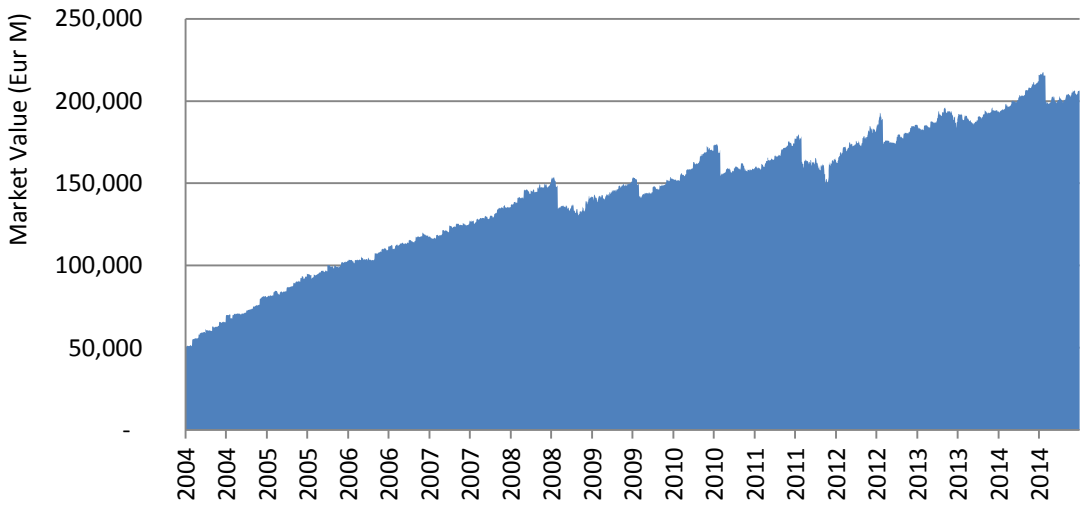
[4] The Laspeyres price index measures the price development of a basket of goods and services consumed in a base period today as opposed for example to a Paasche index which measure changes in the basket rather than its price.

still with some disadvantages, as lack of track records, partial index coverage in some countries and the tests on the index were not carried to the desired full exhaustive amount with some fears of significant revision adjustments.

Another fact that may be considered a coincidence was the fact of the first ILB issue timing concurrence with the beginning of the European Monetary Union (EMU). This was in fact a key consideration for the French authorities as this event was expected to drive the intensity, competition and liquidity in the European sovereign fixed income financing market. Hence France was looking for gaining advantage by being the first to issue inflation-linked bonds.

The OATi 3.4% Jul 2029 marked the second tapper of the French Government one year later in September 1999, once again linked to the national CPIx. The issuing followed the same steps of the previous one with an initial syndication with some occasional later re-openings. The growth in the outstanding value of the two issues showed a slow but steady pace which cause some worries regarding to the capture of euro area investors interest outside France. Later in October 2001, France determined to change the weak outstanding growth launching the first issue linked to the HICPx through syndication and exchanges out of the OATi Jul 2009. As there were some concerns considering the liquidity impact in the remaining linkers this proved not to be the case as this later issuing gave a lot of momentum to the French ILBs (figure 2), and to the sector as a whole, reflected in daily turnovers, making France the number one issuer in terms of outstanding amount by market value in the euro area with close to €206bn.

Figure 2: Evolution of the French ILB Market by Market Value

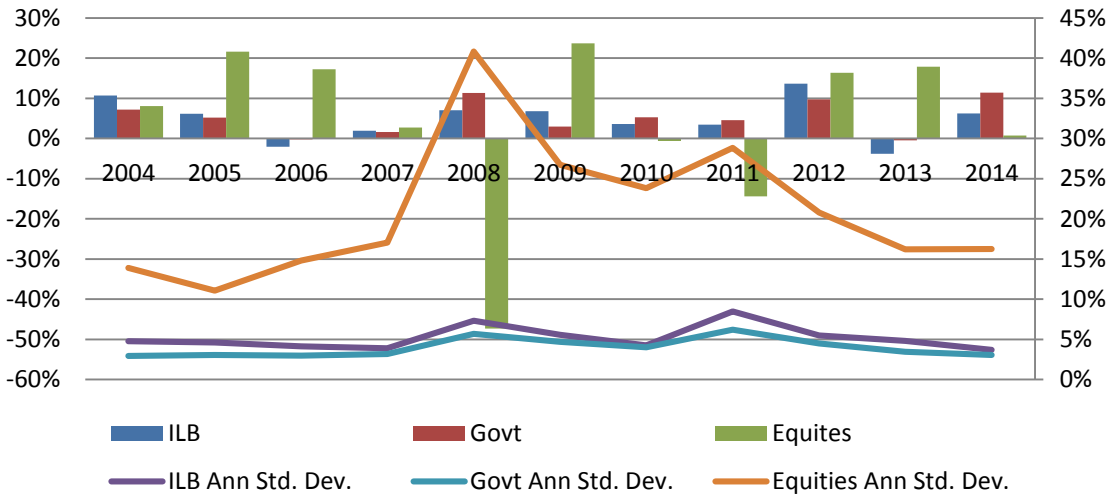


Source: Barclays Capital

After the noted increase in the interest in the linkers markets, France responded by quickly picking-up the supply. The responsible treasury French agency (Agence France Trésor – AFT) has been increasing ILB issuance with issuances occurring almost every month.

According to figure 3, ILB have had a good performance in the analyzed period with returns on average[5] around 4.87% while the nominal government equivalent averaged 5.3% and the equities with approximately 4.19%. When we also considered the average annual standard deviation and compute the ratio between the first and the annual returns we can see that the nominal bonds rank first with a value of 1.34, followed by the ILBs with 0.94 and lastly equities with 0.2. However, this last category was highly influenced by the financial turmoil starting in 2008 with the crisis in the US. These numbers suggest that in the French case, the investor, when deciding accordingly to the risk/return binominal relation would be better of investing in sovereign nominal bonds.

Figure 3: French Market – Historical Performance and Risk



Source: Author's calculation based on Barclays Capital

Germany

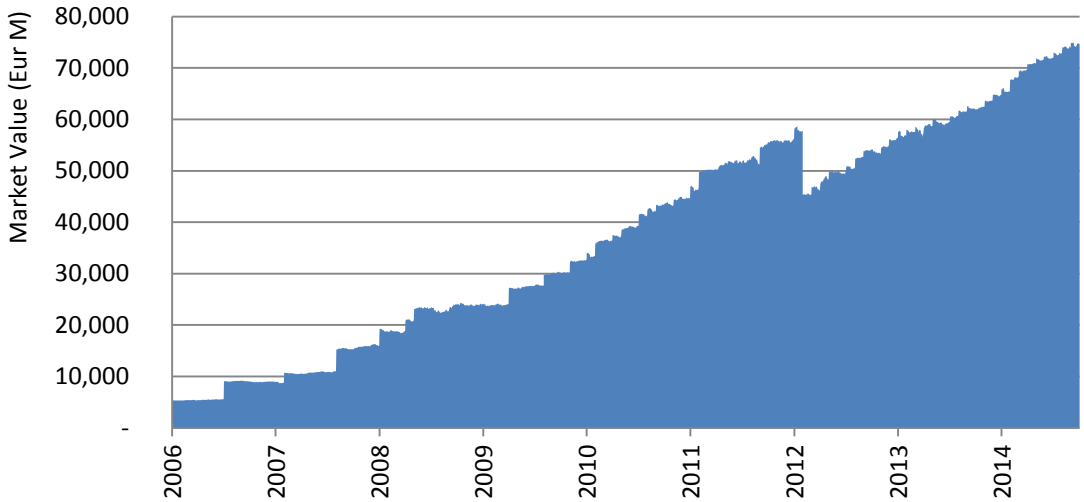
In Germany, the beginning of the inflation-linked market happened in March 2006 in spite of the announcement being made much earlier by the German officials in 2004. The Bund which had as a reference index the HICPx was issued with a maturity of 10 years, a coupon of 1.5% and with initial size of €5.5bn via syndication. The objective was to increment the size of this

[5] The computed averages are all average annualized returns.

same issue in later re-openings which did in fact happened in September 2006 (€3.5bn) via syndication and later switched to an auction mode tapering. In October 2007 the OBLei 2.25% April 2013 was issued and in June 2009 Germany decided to launch another linker, the Bundei 2020, which was the first one after the exponential deflationary decrease in inflation breakevens during the second semester of 2008.

The German development of its inflation-linked bond curve had been slower than previously anticipated and the Bundei 2020 came to reassure the linker market the commitment of the country. Later on the taper adopted a more steady pace although still quite moderate as seen in figure 4, with issues in April 2011 (OBLei 2018) and in March 2012 (DBRei 2023), with amounts circling between €8 to 12bn. In 2014 there were over 11 auctions totaling €17.2bn with a bid-to-cover ratio[6] of 1.8 making Germany, as of December 2014, the third larger issuer of ILBs in the euro area with approximately €74.6bn outstanding (market value).

Figure 4: Evolution of the German ILB Market by Market Value



Source: Barclays Capital

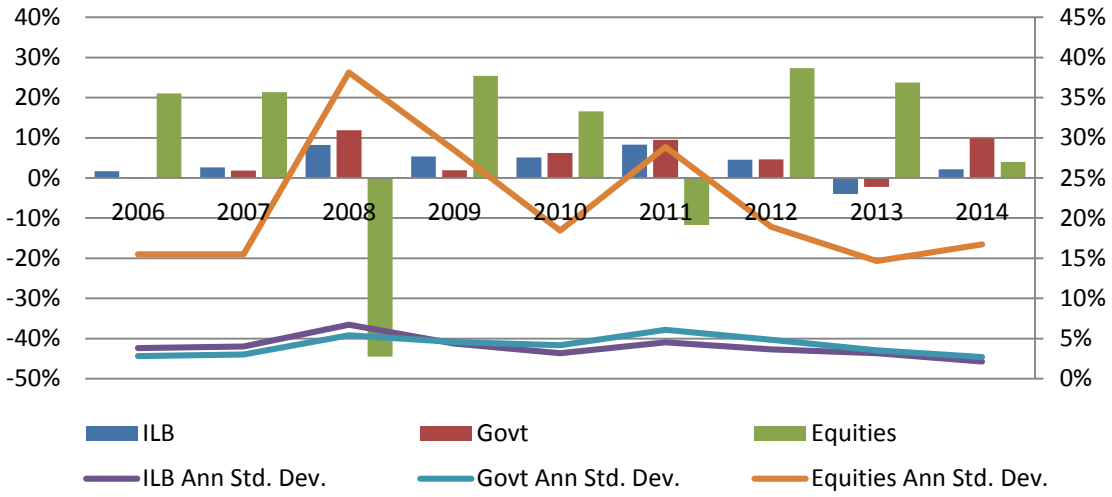
Germany ILBs have had a similar behavior when related with the French equivalents, showing since its inception an average return of 3.7%. The nominal government bonds and the equities had returns around 4.8% and 9.26% respectively as showed in figure 5, with equities showing more than 6 times the return when compared with the French equities. Both in France and

[6] The bid-to-cover ratio compares the number of bids received in a Treasury security auction to the number of bids accepted therefore signaling the strength of the demand. A ration above 2 represents a successful auction with aggressive bids while a number below 1 shows a disappointing auction and wider bid-ask spreads.

Germany, the government bonds act many times as refuge/safe investments due to these countries high credit ratings, more preeminently during stress periods, which lead one to think about their correlation being, theoretically, close to 1, potentially reducing their diversification benefits when included in an efficient portfolio.

When considering the standard deviation of the returns, we see that the nominal government bonds were the asset class that best behaved with a value around 1.16, followed by the linkers with 0.95 and finally equities with 0.43. It is important to mention that these results are heavily affected by the financial crises and the subsequent raise in volatility in the markets with due to the higher risk in equities is much more pronounced in this type of securities.

Figure 5: German Market – Historical Performance and Risk



Source: Author's calculations based on Barclays Capital

Italy

Italy first announced its intention to issue ILBs on September 2003 and after just five days took many by surprise by syndicating its first linker, a €7bn BTPei September 2008. Although this struck the market unprepared the issue was a success and was quickly embraced and accepted among all market participants which allowed a re-opening one month later increasing the outstanding amount issued to a little over €10bn.

This bond, like the conventional BTPs, paid a semiannual coupon and was priced via interpolation spread to the nominal curve. However, due to the tapering of the Italian Government of nominal bonds the following week with a matching maturity to the linker some breakeven trading took place, further enhancing the issue liquidity.

The Italian domestic demand for inflation-linked notes was high, however since there was not any 5y point in the French OATei (at the time the European-Inflation linked bonds reference curve), it was relatively difficult to investors to take positions in that maturity that until then were using structured products. This was the fact that served as basis for the choice of the maturity of the first BTPei, boosting demand and liquidity and assuring a successful launch of Italian linkers.

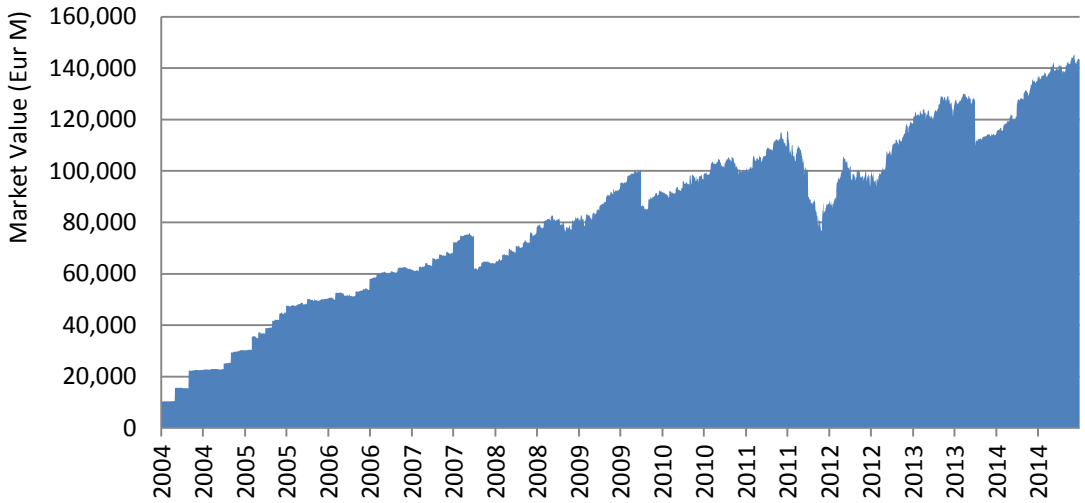
After the opportunistic 5y linker the next bond aimed to a longer maturity: the 10y BTPei 2.15% September 2014, which was placed initially through syndication and later via auctions going on to an outstanding close to €14.5bn. In the subsequent years Italy launched other ILBs starting the construction of its inflation-linked bond yield curve with bonds maturing up to 30 years.

March 2007 marked the first Italian linker issued and placed through auction leaving the syndication back with the BTPei 2012. Yet, the Italian Treasury went back to the syndication in June of the same year when it launched the BTPei 2023, their first 15y linker. Another issue that marks the history of ILBs in Italy was the private placement of two ultra-long dated bonds, with smaller amounts, maturing in September 2057 and 2062 that also motivated some extra activity in the ultra-long inflation linked swaps market.

2005 was also an important year for the Italian linker market as it surpassed France as the country with the higher number of bonds linked to the euro HICPx. The years of 2008 and 2009, due to the financial crises, reduced the number of ILBs issuances, in all euro area countries alike, with even issues being canceled. However, after these years, the issuance pace got back to a steady and growing pace with the Italian government issuing several bonds in the next couple of years. In spite of that, in 2012 in the height of the financial crisis in Europe, the Italian fixed income market suffered tremendously, much like other peripheral European countries, which culminated in the decision of including nominal bonds in the ECB securities market programme (SMP). The fact the the ILBs were excluded from the programme originated several discrepancies in terms of breakeven valuations which lead to a significant sell off in the linkers, as seen in figure 6, and pushing real yields very high without ECB to absorb the selling streak. The Italian authorities tried to balance the ILB market by conducting buybacks and switch auctions out of BTPei, but the public debt issuance agenda for 2012 indicated that the supply would likely fall due to some issues maturing but the Italian treasury

rescheduled the linkers taper so it could give them more room to maneuver the linkers issuance without creating too much of externalities and discrepancies in the market.

Figure 6: Evolution of the Italian ILB Market by Market Value



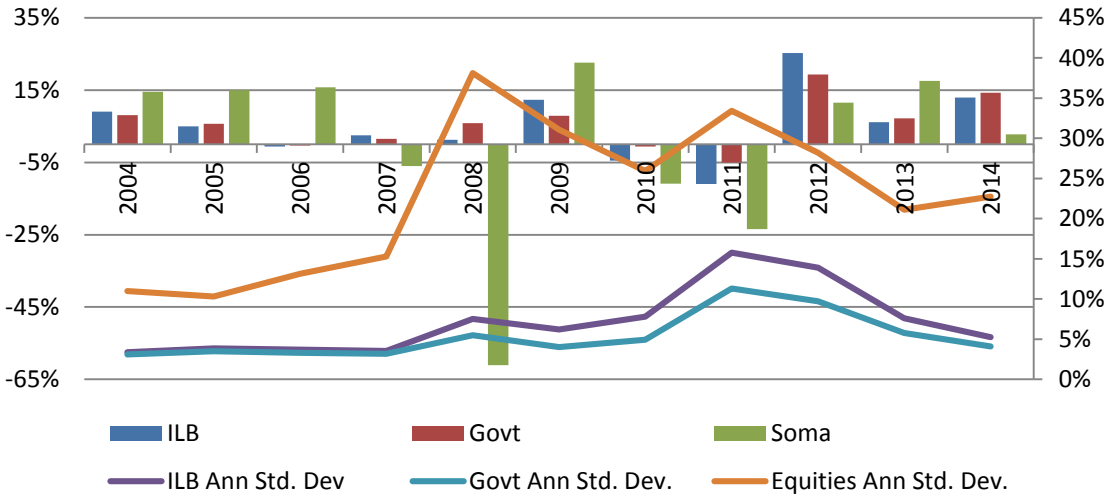
Source: Barclays Capital

Italy introduced to the market a new inflation-linked product in March 2012. This bond was intended to the domestic retail investors as it had as reference the Italian *Famiglie di Operai e Impiegati* (FOI) inflation excluding tobacco, which is an index that represents a basket of consumption goods of household's workers. This linker, maturing in 2016, was open to both institutional and individual investor during four days in an amount close to €7.3bn, where they could get access via banks or internet. The coupon was fixed in the end of the four days with a minimum of 2.25%. Later on the statistics revealed by the Italian Treasury showed that most of the bonds were sold in contracts over €50,000 which is commonly used as an indicator to distinguish between individual and institutional investors.

When analyzing the performance from the different asset classes presented in figure 7, we see that the returns of ILBs where quite similar to the ones of the nominal government equivalents as observed in France and Germany, with only 0.6% separating the two, 5.2% and 5.8% respectively, during the 10 year period from 2004 to 2014. The equities, on the other hand, suffered a much worse devaluation during the financial crisis and therefore have a negative return of -0.15%. Again, when dividing the returns by the standard deviation we observe the same ranking between the three asset classes with the nominal government bonds placing first with 1.1 followed by the linkers 0.74 and finally the equities with -0.007. Interestingly enough

is that in Italy the difference in this ratio is not as pronounced as it happened in both France and Germany, suggesting a higher correlation of returns and hence the substitutability between these two assets as suggested by Brière and Signori (2009).

Figure 7: Italian Market – Historical Performance and Risk



Source: Author's calculations based on Barclays Capital

Others

There are some other countries within the euro area who have also issued ILBs. Although they are mentioned here, they are not included in the quantitative analysis of this dissertation for reasons such as lower liquidity, credit quality, low outstanding or because there are simply too recent as in the case of Spain.

Starting with Greece, this ancient country had issued ILBs before it even entered the euro area. These bonds were linked to the Greek CPI and in small amounts having the last of these linkers matured in 2007. Although Greece ILBs are not included in the quantitative analysis they are part of the European linker market history as they were the second country to have issued a euro HICPx linked bond, the GGBei 2.9% Jul 2025 via syndication during Mach 2003.In March 2007 a new reference in the Greek inflation-linked curve was launched with the GGBei 2.3% July 2030 having the Greek Treasury also addressed the ultra-long-date market via private placement with a bond with maturity up to 50 years at the same time and once again in 2012.

Greek ILBs were also subject to the same binding program as the nominal bonds which, similar to the Italian comparators, created heavy discrepancies in this market and today there are no Greek ILBs on the market.

Much more recently and after months of studies and careful research, the Spanish authorities decided in May 2014 to launch its first HICPx ILB, a 10y reference of up to €5bn. The year of 2014 was a great year for fixed income securities in Europe as since 2013 there was a strong and consistent bull market after the peak in yields in 2012 when the financial sovereign debt crisis hit the strongest level in Europe. This fact, which leads to a confidence increase in investors and consequently successful nominal issuances, with high bid-to-cover ratios and lower financing costs, paved the way for the first Spanish linker.

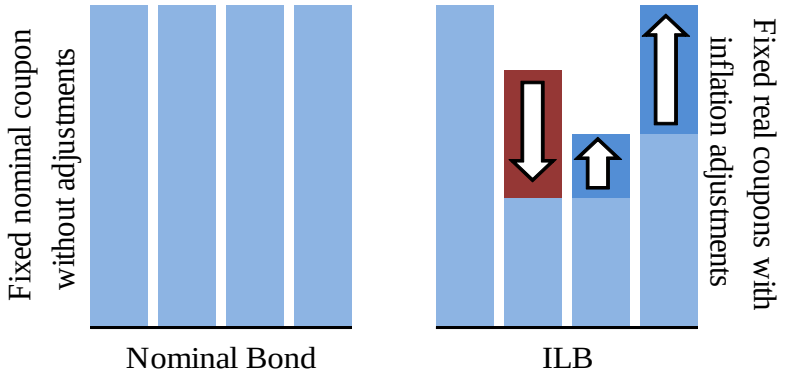
The timing was not the best in the point of view of investors as this was a period of low inflation expectations, which as studied by Roll (2004) was proven to drive down the real yields and push the prices upwards. However, Spain's objective was to assume the interest in issuing ILBs and entering the market then joining France, Germany and Italy, capturing a broader share of investors.

Still during 2014 Spain issued its second ILB, this time the bond had a maturity of 5 years in order to start constructing its inflation yield curve.

3.3. How do Linkers work?

Inflation-linked bonds have as their main objective the protection of investor's purchasing power over their investments. There is one main difference in ILBs when compared with nominal bonds: the principal/nominal and coupons value, which in the first is variable and depends on the value of the underlying inflation index (figure 8).

Figure 8: Comparison between Nominal and Inflation-Linked Bonds' Structure



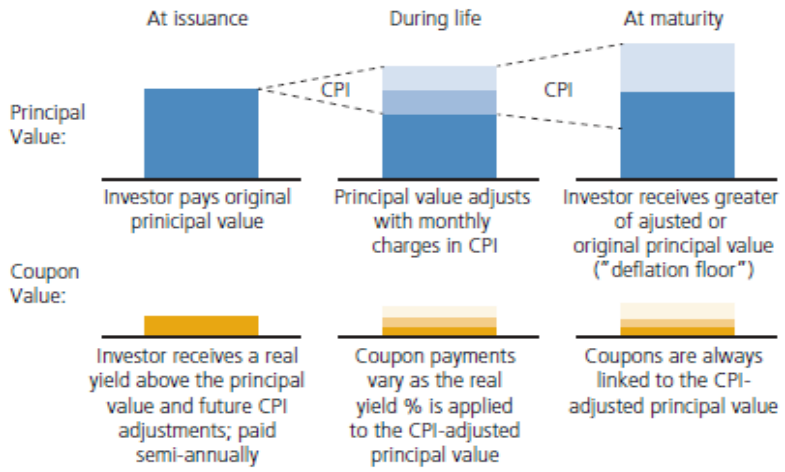
Source: Author's illustration

In short, in the nominal conventional bonds there is a nominal fixed coupon and redemption payment agreed at the issuance, including inflation expectations at the time. However, they are not adjusted during the life of the bond. By contrast, linkers are adjusted accordingly to the realized inflation in one of two ways:

1. The coupons are adjusted in line with inflation and the redemption remains constant;
2. The redemption value is indexed, continually, to inflation and the coupons are set as fixed, varying with the nominal redemption value.

The second method is the most commonly used in ILBs around the world and is illustrated in figure 9.

Figure 9: Illustration of ILBs' Principal and Coupon Mechanics



Source: Author's modifications based on Pacific Investment Management Company

The nominal face amount, thus the repayment of principal, and consequently the fixed coupons of ILBs are computed by taking into account the variations in the real quantities based on the variation of the inflation rate. A ratio is computed from the reference inflation index on every coupon date or principal repayment date and the reference inflation rate at the time of the linker issuance date: the Index Ratio; which is then multiplied by the values excluding inflation.

$$Index\ Ratio = \frac{Price\ Index_{current}}{Price\ Index_{t=0}} \quad (1)$$

As presented above, it is seen that the inflation index is the ratio that underlies any linker. To better understand the differences between an ILB and a nominal equivalent it is presented bellow an example opposing a 10y traditional bond (N) and an equivalent ILB. Both securities have a nominal value of €1,000.00, while for the linker it is assumed a real coupon of 2% and a constant inflation rate of 2% over the 10 year period until the maturity of the bonds. The nominal bond is assumed to have a coupon of 4.04% in order to match its expected real income to the real coupon of the linker:

$$Expected\ real\ rate\ of\ return_N = (1 + Coupon_{ILB}) * (1 + inflation\ rate) - 1$$

$$Expected\ real\ rate\ of\ returns\ _N = (1 + 2\%) * (1 + 2\%) - 1 = 4.04\%.$$

In table 1 it is presented the structure of cash flows for each bond, both in real and nominal terms. In the traditional bond, both the nominal face value and the nominal coupon remain unaltered during the entire time period as with the real value of the payments falls with the inflation as it is discounted to t=0, therefore accounting for the loss of purchasing power. Hence, we can derive the real value of the nominal payment and the coupons by including the inflation index with:

$$Real\ Value_t = \frac{Face\ Value}{(1 + inflation)^t} = \frac{1{,}000}{(1 + 2\%)^t}$$

and

$$Real\ Coupon_t = \frac{Coupon}{(1 + inflation)^t} = \frac{40.4}{(1 + 2\%)^t}\ .$$

In the ILB the values that remain unchanged are the real values of the principal and interest payments, where the variations happen in the nominal figures which vary over time with the inflation index:

$$Nominal\ Value_t = Face\ Value * (1 + inflation)^t = 1{,}000 * (1 + 2\%)^t$$

and

$$Nominal\ Coupon_t = Coupon * (1 + inflation)^t = 20 * (1 + 2\%)^t.$$

With respect to the inflation index, the point in time *t* value, assuming a base value of 100 at issuance, it is computed as in formula 1:

$$Index\ Ratio_t = \frac{Price\ Index_t}{Price\ Index_{t=0}} = \frac{100 * (1 + 2\%)^t}{100}$$

Table 1: Comparing Cash Flows between Traditional and Inflation-Linked Bonds

Euros	Traditional Bond				ILB			
Year	Nominal Value of Principal	Real Value of Principal	Nominal Interest Payment	Real Value of Interest Payments	Nominal Value of Principal	Real Value of Principal	Nominal Interest Payment	Real Value of Interest Payments
1	1.000,00	980,39	40,40	39,61	1.020,00	1.000,00	20,40	20,00
2	1.000,00	961,17	40,40	38,83	1.040,40	1.000,00	20,81	20,00
3	1.000,00	942,32	40,40	38,07	1.061,21	1.000,00	21,22	20,00
4	1.000,00	923,85	40,40	37,32	1.082,43	1.000,00	21,65	20,00
5	1.000,00	905,73	40,40	36,59	1.104,08	1.000,00	22,08	20,00
6	1.000,00	887,97	40,40	35,87	1.126,16	1.000,00	22,52	20,00
7	1.000,00	870,56	40,40	35,17	1.148,69	1.000,00	22,97	20,00
8	1.000,00	853,49	40,40	34,48	1.171,66	1.000,00	23,43	20,00
9	1.000,00	836,76	40,40	33,80	1.195,09	1.000,00	23,90	20,00
10	1.000,00	820,35	40,40	33,14	1.218,99	1.000,00	24,38	20,00
	Total Nominal Receipts	1.404,00			Total Nominal Receipts	1.442,37		
	Real value of principal at maturity	820,35			Real Value of Indexed principal	1.000,00		

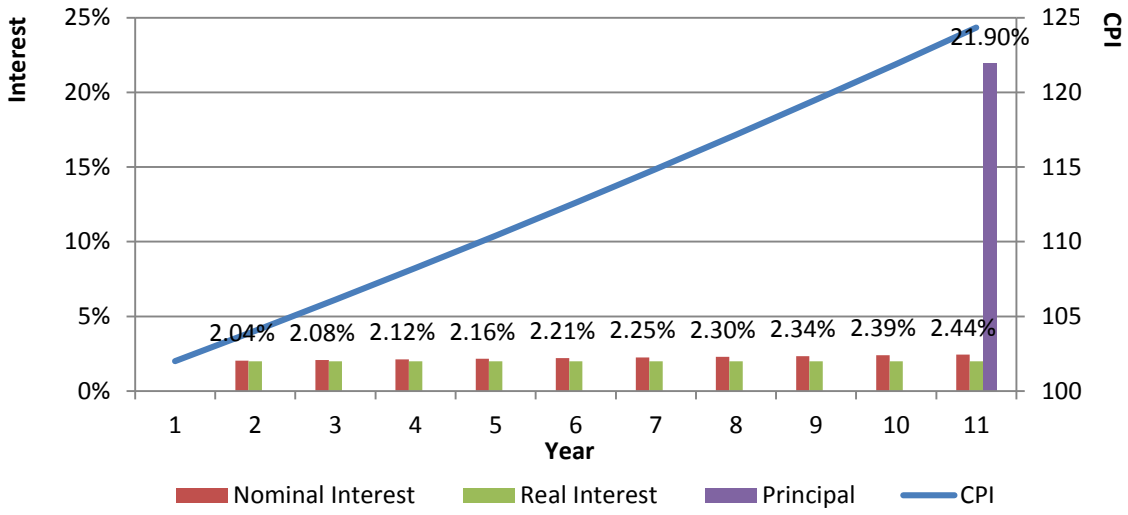
Source: Author's calculations based on example from Wrase (1997)

It is possible to conclude from the observed above that ILB have as characteristics inflation adjusted nominal value, this is given to these securities having inflation index relationship while the traditional bonds have their nominal values constant over the bond's life.

As shown by the total nominal receipts of both bonds, the smaller nominal interest payment during the life of the linkers is offset by a higher principal payment at maturity which reflects the 10 year inflationary period as illustrated in figure 10. In the traditional bond, although offering an equivalent real coupon at issuance, as it did not account for the inflation, resulted in lower nominal benefits at the maturity of the bonds. Looking through the Net Present Value

(NPV) approach in order to create a simple exercise, assuming a discount rate of 5%, we would be comparing a value of €390 for the linker and €312 for the traditional bond.

Figure 10: Cash Flow Structure of an ILB



Source: Author's calculations based on example from Wrase (1997)

4. DATA

This thesis, being based on the analysis of fixed income securities, will work mainly with yields instead of prices, although prices could be computed from the corresponding yields or obtained from data bases.

The main tool used to get the required data will be the Bloomberg Terminal and Barclays Capital website. Regarding the periodicity of the data the focus is on daily figures for every asset class, being nominal government bonds, ILBs, corporate bonds or equities. The sampling period is comprised between January 2004 and December 2014.

The data will be divided by country where the bonds will be represented through the indices provided by Barclays for Inflation Linked Bonds, Sovereign Bonds and Corporate Bonds. Equities will be represented by the countries' main stock indexes. The data will always be compared for each individual country or if not stated so, for Europe as whole. As an example, if we are analyzing the particular results for France we will use Barclays Inflation Linked France Govt index, CAC 40, and the French CPI. If there is not an index representing the desired asset class it may be constructed with characteristics resembling the used ones for the sake of comparison, though, to avoid biased results coming from different data sources, the Barclays Index Products time series will be the preferred source.

Barclays' Indices Products provide the information using the total return index (TRI). TRI is an index that measures the performance of a group of components by assuming that all cash distributions are reinvested, in addition to tracking the components' price movements. Conversely, a price index only considers price movements (capital gains or losses) of the securities that make up the index, while a TRI includes dividends, interest, rights offerings and other distributions realized over a given period of time. Looking at an index's total return it is usually considered a more accurate measure of performance.

$$TRI = R_t = \frac{P_t}{P_{t-1}} - 1 \qquad (2)$$

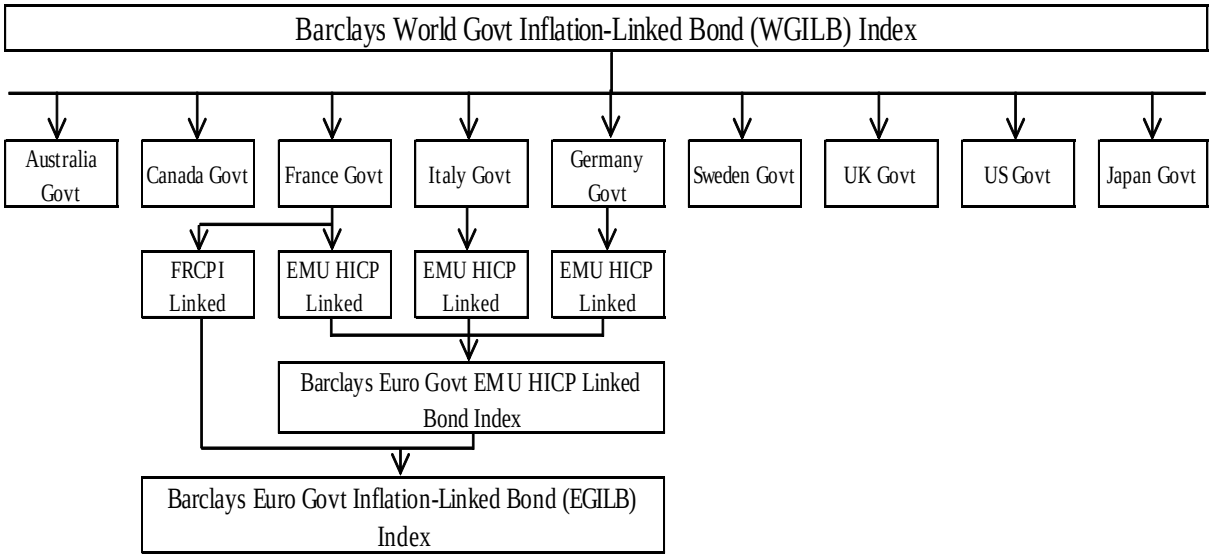
Where

$R_t = rate\ of\ return\ at\ time\ t$

$P_t = TRI\ of\ the\ asset\ under\ analysis$

Barclays Index Products offer a variety of indices, which as mention before will serve as the base data source for this dissertation. The Barclays Euro Government Inflation-Linked Bond (EGILB) index as of July 2015 comprises 33 bonds, with an average duration of 7.57 years and a market capitalization of approximately €449 billion. The EGILB index has been commonly adopted as a benchmark for public, institutional and exchange trade funds, while it is also the second largest constituent of the World Government Inflation-Linked Bond (WGILB) Index where its decomposition is showed in figure 11.

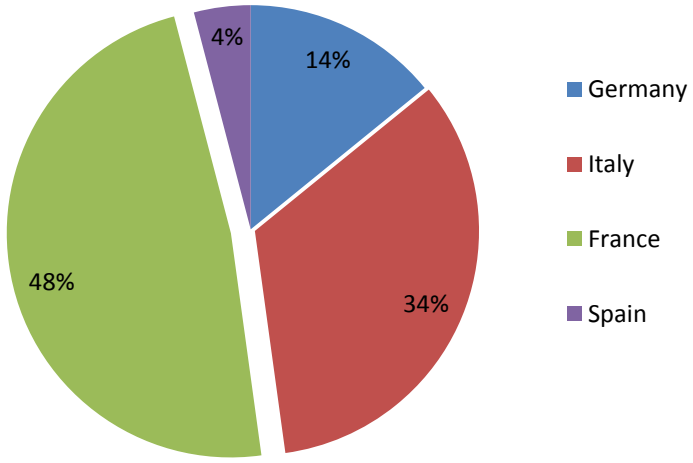
Figure 11: World Government Inflation-Linked Bond Index Structure



Source: Barclays Capital/Global Inflation-linked Products-A User's Guide

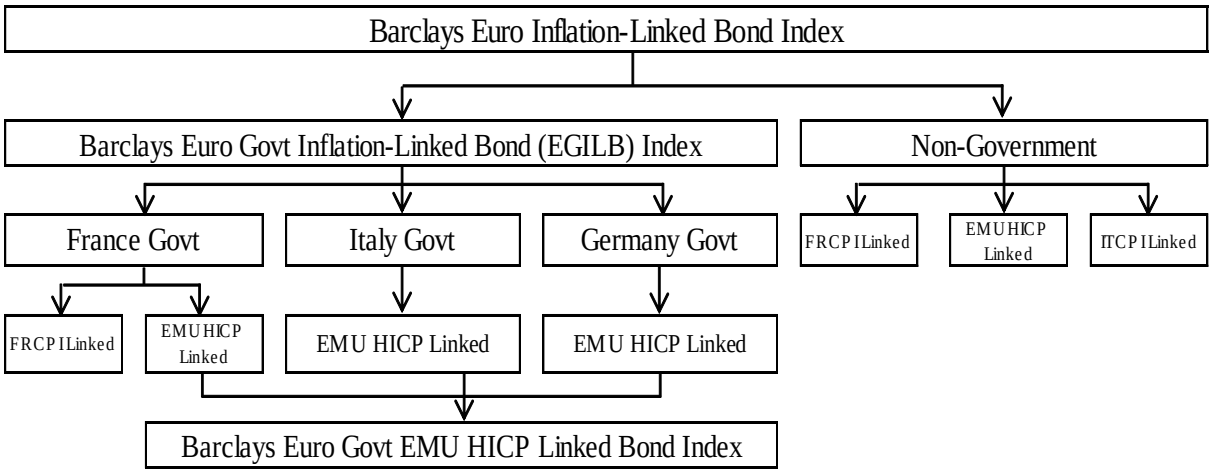
There are also sub-indices available by maturity, issuer or linking-index which will be used with regard to each country analyzed in this thesis. The prices used are end of day mid-prices and the weights of EGILB by market capitalization and number of bonds is presented in figure 12 as well as its structure in figure 33.

Figure 12: EGILB Market Capitalization Weights



Source: Barclays Capital/Author's calculations

Figure 13: World Government Inflation-Linked Bond Index Structure



Source: Barclays Capital/Global Inflation-linked Products-A User's Guide

Apart from yields and prices Barclay's indices time series also make available other data as the market capitalization, nominal value, duration, underlying consumer price index (CPI) and number of bonds composing the index which may support some additional analysis and computations. Therefore, for the sake of cross country inflation comparison, the CPI data for all the countries analyzed and for Europe as well as other macroeconomic data collected, will be gathered from the National Bureau of Statistics/National Statistics Agency (NSA) of each corresponding country/area or the Eurostat. However, the reference index for each ILBs may differ depending on the issuer and therefore some differences in price and yield calculations

for each issue. For example, one country may use the Harmonized Index of Consumer Prices (HICP)[7], the CPI or in some cases the CPI an HICP excluding some items such as tobacco (commonly referred as CPIx and HICPx respectively). The differences in the indices used are shown in figure 14 and the inflation index of each ILB are presented in table 2. Therefore, as analyzing the inflation index behind ILBs from each issuer, the CPI presented in the Barclays Index time series may be used so it is adjusted to the specific index used in each case.

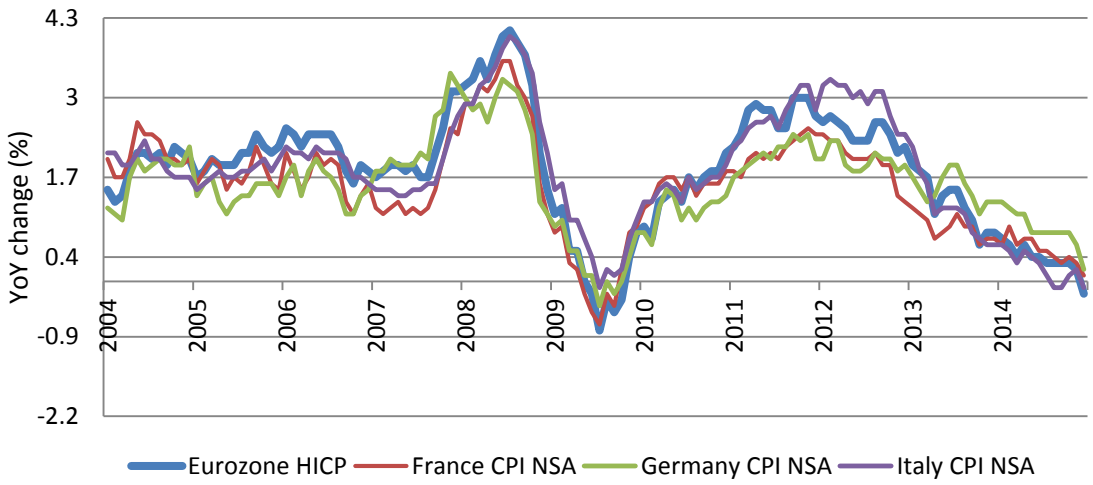
$$\pi_t = \frac{CPI_t}{CPI_{t-1}} - 1 \qquad (3)$$

Where

$\pi_t = inflation\ rate\ at\ time\ t$

$CPI_t = Consumer\ Price\ Index\ at\ time\ t$

Figure 14: Inflation Evolution in the Considered Countries Year over Year (YoY)



Source: Bloomberg

[7] The harmonized index of consumer prices is a consumer price index which is used to measure inflation in the context of international, mostly inner-European comparisons. Its calculation, which relies on harmonized concepts, methods and procedures, reflects the development of prices in the individual states based on national consumption patterns and it is the index used by the European Central Bank (ECB) in the pursue of its mandate of a stable inflation rate around 2%.

Table 2: Key features and Inflation Indices of Major ILBs in Global Markets

Index	Known as	Inflation Index	Index lag (months)
Europe			
France	*OATei/i*	*Euro zone HICP ex-tobacco/ French CPI ex-tobacco*	*3*
Germany	*Bundei/OLBei*	*Euro zone HICP ex-tobacco*	*3*
Italy	*BTPei*	*Euro zone HICP ex-tobacco*	*3*
UK	IL Gilt	UK RPI	*3 to 8*
Rest of the world			
US	TIPS	US CPI Urban NSA	3
Japan	JGBi	Japan headline inflation CPI	3
Canada	CANi	Canada CPI NSA	3
Brazil	NTN-B/NTN-C	IPCA/IGP-M	N/a

Only the bigger/most relevant issuers

As of December 2014

Source: Lazard Investment

The collected data will be used to compute the dynamics of volatility, correlations and returns between the different asset classes to obtain descriptive statistics and later on attain results considering the modern portfolio theory of the mean-variance efficient frontier by Markowitz (1952).

5. DESCRIPTIVE STATISTICS

This section introduces the descriptive statistics for conducting the empirical analysis of this study. The focus will be on the main countries, which are Germany, France and Italy. However, it is also showed data for other relevant issuers, namely the UK and the US, which can provide useful information and conclusions.

Table 3 bellow displays the summary statistics of the three analyzed asset classes in 5 developed countries. The inflation rates have been derived from the correspondent National Bureau of Statistics and Bloomberg.

Table 3: Descriptive Statistics

CPI inflation rate monthly YoY and local currency monthly returns

Sample	Item	Mean	Median	Std Dev	Min	Max	Kurtosis	Skewness
France	*ILB*	0.41%	0.55%	1.51%	-4.90%	6.19%	2.97	0.11
Jan-04	*Govt*	0.44%	0.57%	1.21%	-2.68%	4.34%	0.87	0.35
Dec-04	*Equities*	0.35%	1.08%	4.55%	-13.56%	12.24%	0.62	-0.62
Obs. 132	*Inflation*	1.55%	1.60%	0.83%	-0.70%	3.60%	0.20	-0.16
Germany	*ILB*	0.32%	0.29%	1.23%	-4.63%	5.56%	4.87	0.33
Apr-06	*Govt*	0.43%	0.48%	1.23%	-2.59%	3.88%	0.35	0.43
Dec-14	*Equities*	0.70%	1.44%	5.42%	-20.41%	15.97%	2.57	-0.86
Obs. 105	*Inflation*	1.58%	1.70%	0.83%	-0.40%	3.40%	-0.11	-0.08
Italy	*ILB*	0.44%	0.72%	2.55%	-9.82%	12.09%	7.04	0.10
Jan-04	*Govt*	0.48%	0.59%	1.64%	-5.20%	5.39%	2.59	-0.14
Dec-04	*Equities*	-0.01%	0.65%	5.82%	-15.89%	19.36%	0.82	-0.30
Obs. 132	*Inflation*	1.82%	1.80%	0.95%	-0.10%	4.00%	-0.37	-0.03
UK	*ILB*	0.66%	0.64%	2.15%	-7.48%	9.33%	2.86	0.04
Jan-04	*Govt*	0.51%	0.56%	1.58%	-4.79%	5.22%	1.05	0.22
Dec-04	*Equities*	0.44%	0.82%	3.75%	-13.00%	8.29%	0.86	-0.59
Obs. 132	*Inflation*	3.20%	3.20%	1.55%	-1.60%	5.60%	2.00	-1.26
US	*ILB*	0.41%	0.49%	1.84%	-8.53%	5.81%	4.56	-1.05
Jan-04	*Govt*	0.36%	0.46%	1.26%	-3.22%	6.42%	3.52	0.49
Dec-04	*Equities*	0.63%	1.25%	3.99%	-15.69%	10.60%	2.19	-0.83
Obs. 132	*Inflation*	2.34%	2.30%	1.42%	-2.10%	5.60%	0.78	-0.55

Source: Author's calculations based on Barclays Capital and Bloomberg

Table 3 shows balanced average returns results between the three main asset classes. In France, Italy and UK sovereign debt yielded the best results, while in Germany and US equities were dominant over ILBs and sovereign nominal bonds.

In the UK we see the highest inflation which in turn contributed for this being the area where ILBs performed the best. As nominal bonds should include future inflation risk premium, their

average returns should, in theory, be slightly higher than those of linkers of similar maturity. This fact is observed in Euro area countries whereas in the US and UK, ILBs performed better than the nominal equivalents. This however, can be justified by differences in the indices compositions, which may differ in maturity and consequently duration of the composing bonds.

With regard to volatility, it is observable that within all countries, equities, due to this asset class having a higher risk profile and no investment protection, showed evidence of higher standard deviation. Secondly, we see ILBs exhibiting higher volatility than nominal sovereign bonds across all countries as well as a higher drawdown[8]. This, however, contradicts the findings by Kothari and Shanken (2004), where it was stated that one of the benefits of ILBs was their lower average volatility when compared with nominal bonds.

In spite of ILBs showing an average higher volatility, the trend between those and sovereign bonds is very similar as can be observed in appendix III. This can be justified by the fact that ILBs yields volatility is closely related with the nominal equivalent yields and along the years breakeven rates have been stabilizing.

When studying the distribution characteristics of ILBs we see that the US shows negative skewness with all the remaining countries showing positive a skew. A normal distribution has skewedness of zero which implies that symmetric figures should also have a skewness of zero or close to zero. A positive skewness indicates that the distribution is skewed to the right with a longer right tail relative to the left tail, while negative skewed data shows that the distribution shows a skew to the left with the left tail being longer relative to the right one. There is a classic example often used in behavioral finance which relates with lottery tickets, which have a very low probability of hitting the jackpot. However, when this event does occur the benefits are extremely high. Therefore, to take on negative skewness (low or even negative expected returns), the investor demands higher expected returns. European linkers having a positive skew (the preferred by investors according to Swedroe, 2003), mean that there are more frequent small losses and infrequent extreme gains. This finding is then supported by the higher excess kurtosis values observed in ILBs indicating that there are higher probabilities of extreme gains or losses in this asset class distribution of returns. The ILBs distribution would be considered as leptokurtic (excess kurtosis over the normal distribution value of 3), while

[8] The difference between the maximum (peak) to minimum (trough), during a specific time period of an investment.

Inflation shows the lower kurtosis values and would be categorized as platykurtic hence, with lower probability of extreme results.

Both nominal sovereign bonds and equities show evidence of inferior kurtosis and skewness when compared with ILBs. This, however, can again be influenced by the duration of the fixed income indices and by the lower liquidity in the inflation-linked market which could biased the returns.

Finally, it is important to point out the higher inflation average over the analyzed time period verified in the UK as well as higher standard deviation. This fact can justify the UK Gilts having the higher returns. Yet, this is a much more mature market, being the first major linker issuer and, therefore, according to the descriptive statistic appearing to be the best inflation-linked investment supported by a close to zero skew and a smaller kurtosis.

6. METHODOLOGY

There are some theoretic base concepts that are essential in order to understand fixed income instruments and, therefore, linkers. It is in this chapter that they are presented and introduced to a better perception of ILBs, its market and the later conclusions.

Concepts like the Fisher Equation, Breakeven Inflation Rates (beir), ILBs' duration and efficient frontier framework play an important role in analyzing the linker market in Europe and being the ground base of this dissertation the introduction of these instruments it is important that they are present.

6.1. Fisher Equation

The Fisher Equation by Irvine Fisher (1930) is part of the author's work on a theoretical approach on interest rates which is often used in finance in the Yield to Maturity (YTM), cost of capital definition and Internal Rate of Returns (IRR) calculations of different investments in a variety of business and industries. The main conclusion presented by Fisher is that inflation expectations along with the real yield and an inflation risk premium equate the nominal yield.

$$(1 + i) = (1 + r)(1 + \pi^e)(1 + prem) \quad (4)$$

Where

$i = nominal\ yield$

$r = real\ yield$

$\pi^e = inflation\ expectation$

$prem = inflation\ risk\ premium$

The Fisher equation has plenty of uses, where it can be used in cost-benefit analysis as the net present computations must obey to the Fisher equation being the prices and rates should be used either in real or nominal terms. In monetary policy it has implications in the Fisher hypothesis (also described as Fisher effect), which states that the real interest rate is independent of monetary measures, specifically the nominal interest rate and the expected inflation rate meaning that the real interest rate is the nominal interest rate adjusted for the effect of inflation on the purchasing power overtime and as proven by Hanke, Carver, and

Bugg (1975) can lead to significant distortions if the exact Fisher Equation is not applied. Finally, in ILBs trading where the coupons are influenced by changes in nominal interest rates, breakeven inflation and real interest rates.

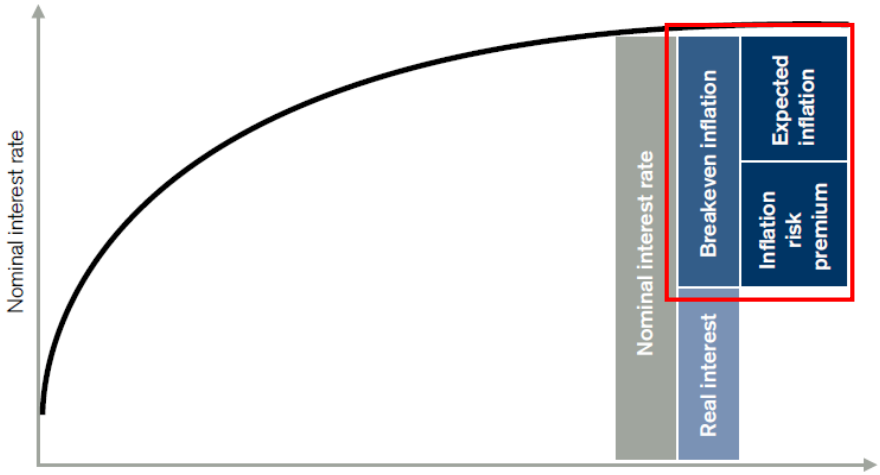
6.2. Breakeven Inflation Rate

The breakeven inflation rate (beir) is a crucial concept when addressed inflation linked products, defined as simply subtracting the nominal yield by the yield of the comparable ILB as demonstrated in figure 15.

Deriving the Fisher equation *(4)*:

$$i = r + beir \qquad (5)$$

Figure 15: Graphical Relation between Nominal, Real and Breakeven Inflation Rates



Source: Author's modifications based on figure from Credit Suisse Research

Beir is nowadays the most important indicator of inflation expectations. Since most major economies have issued inflation-linked debt in recent years, measures of these rates are now widely available and provide timely information about inflation expectations over a large number of horizons. Central banks, market participants and media regularly discuss changes in beir. However, the interpretation of beir may be difficult and far from straightforward, mainly in the context of macroeconomic and financial analysis; hence, some problems may arise when following this simple method. Firstly, the risk of inflation bared by investors in nominal bonds may be different from the level that markets are expecting, so as ILBs adjust to the verified inflation rate, nominal bonds may incur in an extra premium compensating this risk while

additionally there are some deviations from the real yield caused by the indexation lag (James, 2004), usually 3 months; secondly, we have the liquidity issue, where nominal bonds are considerably more liquid than the comparable inflation linkers, though, this problem were more observable in the first issues of ILBs; third, and relating to future benefits from diversifications, the governments would often pay a premium and accept a lower yield distorting furthermore the relation between the observable breakeven inflation rate (Shen, 2006). Other obstacles may also surge, like the difficulty in finding comparable bonds. Nevertheless, this problem is more prone to happen in emerging markets as the number of inflation indexed securities is smaller in these countries.

Despite the several complications and simplistic approach from the use of beir as a proxy for inflation expectations and risk premium it is often used as foundation in academic studies due to the difficulties in separating the two components from breakeven inflation rates.

6.3. Inflation-Linked Bonds Duration

The concept of duration is also applicable to ILBs although with some minor adjustments. In nominal bonds duration is used as a measure of interest rate risk, representing an approximation of a bond's price change due to a shift in nominal yields. For ILBs we must adjust the change in yields to real terms. Comparing to traditional bonds we know that ILBs' coupons are smaller than the nominal equivalents whereas the principal repayment, adjusted to inflation, is larger. Hence the duration of inflation –linked bonds is greater than that of the traditional nominal comparable bonds (Hammond, 2002).

Campbell, Shiller and Viceira (2009) also stated that there are two factor affecting ILBs returns volatility: volatility of the yields, associating the correlation of real interest rates changes and breakeven inflation rates changes; and duration, where again, due to the larger duration one could imply larger sensitivity to yield changes. However, historically, the price determining input of linkers, real rates shows evidence of considerable lower volatily when compared with the nominal bonds' price determining input, nominal rates. This implies lower price volatility in linkers which would in turn lead to a conclusion that duration is not a measure that can, reliably, be used in comparing ILBs and nominal bonds, but just a risk measure when analyzing linkers alone.

In this dissertation the indices considered, when it comes to their construction, have little constrains in view of the maturity of the bonds used (maturity equal or higher than one year),

and denominated "all maturities". This implies different durations in the different indices used as it is highly dependent on the number of issues outstanding from each issuer.

Again, it is a difficult task to match linkers and comparable nominal bonds with the exact same time to maturity and the duration of the two asset classes would be incomparable.

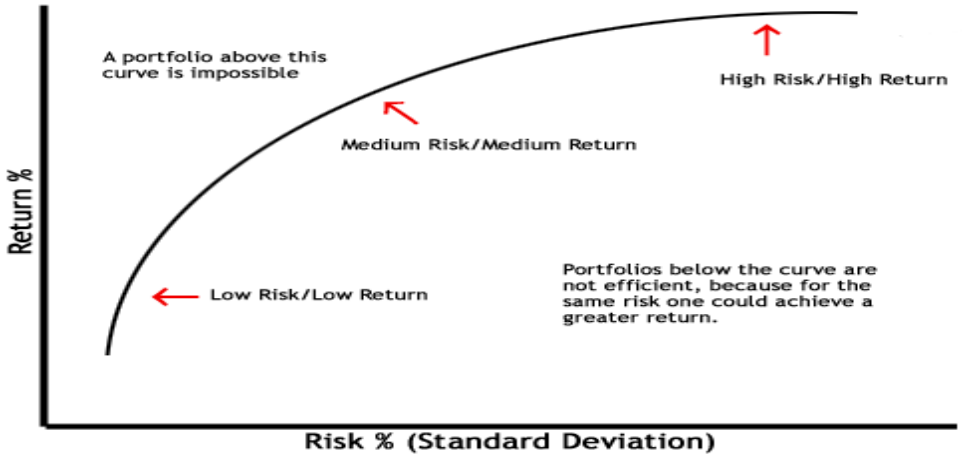
In order to simplify the analysis, we use the same indices for both nominal and inflation-linked bonds (all maturities) so that the indices obey to the same constrains and are a representation off all the eligible outstanding instruments in the period analyzed.

6.4. Efficient Frontier

The Mean-Variance Efficient Frontier by Markowitz (1952) is the cornerstone of modern portfolio theory although the author reject the "modern" in the naming, stating at the time: "there is nothing modern about it".

This theory defines an "optimal portfolio" as being the portfolio that for a specified amount of risk maximizes the expected returns or the portfolio that minimizes the volatility for the expected returns. The result of the combined set of optimal portfolios creates the efficient frontier. We can then differentiate the portfolio in this framework as being sub-optimal when lying below or to the right of the efficient frontier, due to the low returns for a given level of risk and inexistent to right up side of the efficient frontier as illustrated in figure 16:

Figure 16: Efficient Frontier Illustration



Source: web[9]

The different portfolios that are located on the efficient frontier will then show the best set of assets that minimizes the risk for each expected return. This dissertation proposes to assess different combinations of nominal and inflation-linked bonds along with equities in order to conclude on the more efficient combination of assets that maximizes the risk/return binomial.

[9] http://www.investopedia.com/articles/financial-theory/08/three-risk-types.asp

7. ANALYZING ILBS CORRELATIONS AND DIVERSIFICATION POWER

This chapter proposes to study the diversification power of ILBs through an analysis of correlations. Before turning to the asset allocation and drawing the efficient frontier, we will infer on the diversification power through several factors by computing correlations. Initially, the correlations are computed for the different asset classes returns with inflation followed by intra-market returns correlations and finalizing with a cross-country correlation analysis.

It is expected to be obtained an understanding through empirical analysis with regard to the relationship between the different asset classes as well as the relationship of these asset classes with inflation. The data will be supporting some conclusions on the diversification power of linkers as well as the final conclusions on asset allocation and advices to investors.

Although the main focus of this study in on Euro area linkers, data for the UK and US is also included for the sake of comparison as this are the most liquid and mature inflation-linked markets.

7.1. Inflation Correlations

According to Bekaert and Wang (2010), ILBs are expected to have their returns maintaining a high and positive correlation with domestic inflation, in opposition to other asset classes. In spite of the above statement, the results show slight different conclusions as can be observed in table 4. The table reveals correlations for both short term and long term windows. First, it is shown monthly inflation data and the correspondent monthly returns and then the yearly returns and yearly average inflation figures.

Table 4: Inflation Correlations by Country and Asset Class

January 2004 to December 2014, Domestic CPI and local currency returns

Country	Asset Class	Monthly Data	Yearly Data
France	ILBs	-0.02	0.25
	Govt	-0.02	0.32
	Equities	-0.24	-0.61
Germany	ILBs	0.03	0.24
	Govt	-0.07	0.20
	Equities	-0.14	-0.44

Italy	ILBs	-0.09	-0.17
	Govt	-0.08	-0.14
	Equities	-0.22	-0.57
UK	ILBs	-0.06	0.55
	Govt	0.05	0.36
	Equities	-0.19	-0.05
US	ILBs	-0.09	0.04
	Govt	0.18	0.02
	Equities	-0.28	0.15

Source: Author's calculations based on Barclays Capital and Bloomberg

Referring back to the study of Bekeart and Wang (2010), nominal bonds are negatively affected by unexpected inflation, which justifies the negative correlations in a shorter time period in the Euro area. In fact, it is seen that when analyzing monthly returns and comparing them with monthly changes in the domestic inflation all the three asset classes in the analyzed countries have negative or close to zero correlations. These findings also support lower inflation hedging properties of each asset class while, at the same time, the real return might be negative during some time periods, increasing an extra degree of uncertainty of future expected returns.

Still, on the monthly figures, we can see that equities showed the lowest correlation with inflation which would mean that this asset class is more prone to move inversely with inflation, therefore supporting the conclusion from Bekeart and Wang (2010) that equities have poor inflation hedging properties. In the Euro area sample, only German linkers showed a slightly positive correlation with its domestic inflation (0.03), while in France the correlation coefficient is the same for both sovereign bonds and ILBs and in Italy the sovereign debt outperforms the linkers. These findings, at the analyzed time period, can be justified by the time lag (on average three months) of the inflation index used in linkers coupons computations, from where we can conclude that nominal bonds and, therefore, the markets, can better value the expected inflation in the short term.

When turned to the yearly returns and changes in CPI, the results regarding ILBs inflation hedging properties change, where now the correlation coefficients are higher while, at the same time, in equities we see a more negative correlation with inflation across all countries except in Italian linkers and US equities. US equities in fact showed increased correlation when analyzed yearly returns which is contrary to what Bekaert and Wang (2010) stated. Again, the authors concluded, both in their short term and long term outputs, that nominal bonds returns were inversely correlated to inflation while here we observe the opposite in the long term

results. The reasons that can justify such discrepancies in correlation results can be summarized in four main points: The duration of the bonds affect inflation correlations. The shorter the maturity of an ILB the less it is affected by market sentiment and interest rate moves, increasing the inflation correlation coefficient; secondly, there is the time lag mentioned before. The returns are computed at the end of the month while the actual inflation rates take on average three months, which also supports the better results observed in the longer time period; third, yields are driven by inflation expectations and not unquestionably actual inflation, moreover in the short term, where past performance does not guarantee future results; finally, the authors conducted an analysis for a much longer time horizon, an essentially different time period, also using estimated returns, from 1970 to 2010, which can also create some inconsistencies.

Within the Euro area, France has the linkers that best behaved in terms of inflation hedging with 0.25 but followed closely by Germany with 0.24. Italy, however, still presented negative correlation indicating that ILBs returns move conversely to the domestic inflation. It should, however, be taken into consideration that while analyzing correlation with the domestic CPI, Euro Area linkers have the majority of their index linked to the HICPx which could potentially create small biases in results, and while in the analyzed time frame France had at some point the majority of their ILBs linked to the NSA CPIx, Italy has always had their linkers linked to the HICPx.

When also considering the UK and US, the inflation-linked Gilts outperformed all other countries and asset classes, where, again, this is one of the most liquids and mature ILBs markets.

7.2. Asset Classes Correlations

Portfolio and consequently risk diversification has always been a major concern for investors, where those in order to reduce the uncertainty and risk of their holdings normally prefer to have a portfolio composed of different asset classes where their returns have an historic weak correlation. The objective is to when a determined asset class has negative returns the portfolio overall performance can be compensated with returns of other asset classes.

There are studies from well acknowledge authors on the portfolio diversification power of ILBs. We can divide them in two: The first studies, as the ones by Roll (2004), Kothari and Shanken (2004) and Hunter and Simon (2005), analyzed linkers in an early and still embryonic stage of the inflation-linked market, where they concluded that ILBs showed evidence of low

correlation with equities and moderate correlation with the nominal equivalent bonds, therefore having a strong diversification power when included in a balanced portfolio. Later on, the same analysis was undergone by Brière and Signori (2009) and Campbell, Shiller and Viceira (2009), where the authors after including a more recent period of data to their analysis concluded that mainly after 2003, with the maturing of the ILB market and higher liquidity, these and nominal bonds were almost substitutable assets. The main conclusion was that the higher correlation verified indicates similar volatility between the inflation protected bonds and the nominal equivalents, hence eliminating in most ways the diversification power that ILBs had in the past.

In table 5 highlights the numbers for the intra-market correlations in the three subjects of study of this dissertation as well as for the UK and US. It is expected to add some value to the previous authors' conclusions and inferring about the decreasing diversification power of linkers by having a more recent time period under scrutiny.

Table 5: Monthly Returns Correlations between the Different Asset Classes

January 2004 to December 2014, monthly returns in local currency

Country	Correlations		
	Govt vs. ILBs	Govt vs. Equities	ILBs vs. Equities
France	0.72	-0.29	0.06
Germany	0.57	-0.41	0.03
Italy	0.86	0.31	0.43
UK	0.63	-0.12	0.16
US	-0.18	-0.32	0.16

Source: Author's calculations based on Barclays Capital

As stated in the previously mentioned authors' conclusions, it is possibly to observe that in all countries except Italy (0.31), sovereign bonds have negative correlation with the correspondent main equity domestic indices, with Germany having the lowest correlation coefficient with -0.41. Overall, ILBs have positive and strong correlation with sovereign nominal bonds except in the US where we can observe a slightly negative correlation coefficient of -0.18 between these two asset classes. In the opposite side, we have Italy with a close to perfect correlation between linkers and nominal government bonds. Please note that ILBs returns are positively

affected by inflation due to the inverse relation between inflation and real interest rates. In nominal bonds and equities the exact opposite occurs, where these asset classes are negatively affected by unanticipated inflation and therefore, due to their similar sensitivity to inflation, are expected to show a positive correlation of returns. However, the data shows the contrary as what was stated and concluded by Kothari and Shanken (2004) and Brière and Signori (2009). In fact, the correlations between nominal bonds and equities are the ones that appear as negative allowing us to conclude that this asset class is the one that would best diversify a portfolio of equities. When it comes to diversifying a portfolio of equities, ILBs can also provide good results, except in Italy, where we have a positive correlation coefficient of 0.43.

It is interesting to note that the correlation between nominal and inflation-linked bonds is greatly dependent on whether nominal interest rate movements are more responsive to changes in real interest rates or in inflation expectations. When inflation expectations drive the nominal interest rate one can expect a lower correlation as opposed to the real rates are the moving the market. This can be easily related to the inferences on the TIPS analysis conducted by Hunter and Simon (2005), which led the authors to conclude that during times of higher expected inflation linkers exhibited higher volatility.

In summary, it is possible to agree with Brière and Signori (2009) when referring to the ILBs and the correspondent sovereign bonds being almost substitutable asset classes, mainly during times of stable inflation expectations since the factors driving their yields resume to be the same. In spite of this reducing the diversifying power of linkers, they are still a useful security when it comes to diversifying an equity portfolio. However, sovereign bonds are a better option since they exhibit a lower correlation coefficient and they also have a considerable higher liquidity.

7.3. Cross-Country Correlations

The final analysis of correlations is based on comparing the three main asset classes and the correlations between the three main countries on which this study is based on as well as with the two most developed linkers markets: UK and US.

As we have seen before, it is of great importance, in order to infer on linkers diversifying power, to compare and conclude on these securities correlations with inflation and other asset classes. However, from a portfolio construction perspective, it is also important to gather conclusions on the correlations between countries so the optimization process is maximized.

Another important consideration is that Euro area linkers inflation indices are all very closely correlated, i.e., inflation in France, Germany and Italy is closely correlated (appendix II), which means that investors looking to hedge inflation, lets say in France, can create value by investing in a cheaper German neighbor equivalent ILB.

Table 6 to table 8 show the cross-country correlations of monthly returns in the different asset classes from the analyzed countries, starting with ILBs.

Table 6: ILBs Cross-Country Correlations

January 2004 – December 2014, monthly returns in local currency

	France	*Germany*	*Italy*	*UK*	*US*
France	1.00				
Germany	0.78	1.00			
Italy	0.48	0.30	1.00		
UK	0.52	0.57	0.09	1.00	
US	0.60	0.62	0.21	0.61	1.00

Source: Author's calculations based on Barclays Capital

As it is observable, linkers have all positive correlation among the presented countries. In Euro area, we see German and French linkers having a strong and positive correlation (0.78), in fact the highest coefficient visible in table 5. Italy, on the other hand, has lower correlation, though still positive. The lowest observable value is between UK inflation-linked Gilts and Italian linkers with a coefficient of only 0.09. Both the Gilts and TIPS are positively correlated with Euro area ILBs as again, referring to appendix II, inflation shows evidence of strong correlation.

The conclusion here comes to be that in the analyzed sample and time period, in general, ILBs demonstrate strong positive correlation, acting more often as substitutable assets.

Table 7: Nominal Bonds Cross-Country Correlations

January 2004 – December 2014, monthly returns, local currency

	France	*Germany*	*Italy*	*UK*	*US*
France	1.00				
Germany	0.94	1.00			
Italy	0.35	0.22	1.00		
UK	0.72	0.77	0.09	1.00	

US	0.07	0.13	-0.12	0.07	1.00

Source: Author's calculations based on Barclays Capital

Within nominal sovereign bonds, we observe similar results as in ILBs cross-country correlations in the Euro area countries. Once again, French and German bonds are almost perfectly correlated. They are inserted in the commonly called "Core" European countries where Italy is characterized as a "peripheral" along with other countries such as Spain and Portugal. Nominal sovereign bonds are closely related with the countries respective credit ratings as in times of market turmoil, German, and to some extent, French bonds are used by fixed income investors as a safety asset. This fact reduces the correlations as in these stress periods the yields perform inversely as investors refuge themselves in Germany or France moving away from the higher yielding peripherals which is observable in the lower correlation coefficient between Italy and the "Core" countries.

Gilts have also a positive and strong correlation with France and Germany while, Italy, similar with the linkers results, show lower correlation of monthly returns. US treasuries, interestingly, show a very low correlation with all of the remaining countries, having even a negative correlation with Italian BTPs. This can be explained by the different market cycles that we saw in these 10 year period, mainly in the recent past, where the financial crises created large market distortions, and while in the US we saw interest rates in minimums and a Quantitative Easing program (QE) finishing in 2013, we only now see this expansionist monetary policies being adopted in Europe. This undoubtedly creates disparities in returns as fixed income securities are greatly affected by monetary policy.

To sum up we can state that in terms of diversification, investors would benefit from combining US treasuries and sovereign bonds from other countries, while the rest of the securities are strongly to moderately positively correlated.

Table 8: Equities Cross-Country Correlations

January 2004 – December 2014, monthly returns, local currency

	France	*Germany*	*Italy*	*UK*	*US*
France	1.00				
Germany	0.90	1.00			
Italy	0.90	0.81	1.00		
UK	0.88	0.81	0.79	1.00	
US	0.84	0.82	0.75	0.84	1.00

Source: Author's calculations based on Barclays Capital

Closing the cross-country correlations there are equities. As can be seen see they have the highest and strongest correlations when compared with ILBs and nominal bonds. On average they are very strongly positively correlated, with the lower correlation being between the Italian FTSE MIB and the US S&P 500 with 0.75. The higher correlation is again between France and Germany with the CAC having an almost prefect positive correlation 0.9 correlation with the DAX.

These figures can be justified by the fact that there have only been considered extremely developed markets, which are all strongly globally interconnected and are all enormously efficient markets. In terms of diversification, for an investor looking at these markets is clear that it will not get much diversification when only considering these five countries main equities indices.

8. ASSET ALLOCATION

In this chapter, once again will be tackled the benefits of the insertion of ILBs in a diversified portfolio. In a similar way as in section 7.2, the three main asset classes are combined and analyzed alongside, mainly within fixed income where we want to infer extra conclusions on the diversification benefits of including linkers on an equity portfolio when compared with the nominal governmental bonds. It is important however to state that in the real world, from a portfolio optimization perspective, an investor would not be limited to these three asset classes having others as for example commodities or real estate. Yet, it should be possible to gather some interesting conclusions as the objectives are, to a certain extent, related with the diversification benefits obtainable by a common private investor, who has less access to more complex and exotic markets and asset classes.

8.1. Efficient Frontier

In order to conclude on the importance of linkers from an asset allocation perspective it is addressed a further analysis based on the efficient frontier framework of Markowitz (1952). The main objective is to conclude about the benefits of including ILBs in a portfolio composed of equities and nominal bonds. To do so, there are presented below, from figure 17 to figure 19, the efficient frontiers per country resulting from two portfolios:

- Portfolio A is composed by government nominal bonds and equities;
- Portfolio B is composed by government nominal bonds, equities and inflation-linked bonds.

If including ILBs to Portfolio A, therefore creating Portfolio B, results in higher mean-variance portfolio optimization results that the second portfolio's frontier will lye above the one of the first, i.e., the investor's binomial risk/return relationship will be improved from investing in linkers. The results for UK and US are presented in Appendix IV.

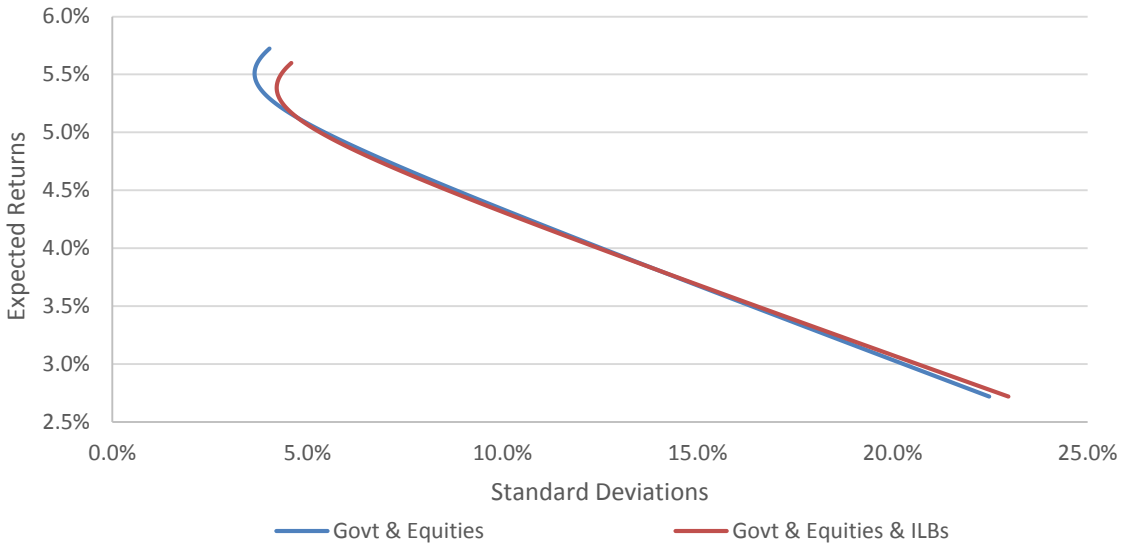
France

What first catches the eye in figure 17 is the odd shape of the efficient frontier. However, as seen in appendix I (Table I – 1), the French equity market had lower cumulative returns performance and higher volatility when compared with ILBs and nominal sovereign bonds. In addition, there is also table 3, where in the descriptive statistics we see that equities have lower

mean monthly returns (0.35%) than both ILBs and nominal bonds (0.44% and 0.41% respectively), with higher standard deviation (4.55% versus 0.57% and 0.55%). This explains the shape of the efficient frontier which is basically showing that a portfolio with higher standard deviation – risk – does not offer higher expected returns, in fact the opposite occurs.

When comparing portfolio A and B, we see that ILBs did not improve the results from a mean-variance asset allocation optimization standpoint. This can be justified by the high correlation between linkers and nominal govies (0.72) as observed in table 5. In general, both frontiers appear to be the same, diverging only at lower level of standard deviation. The portfolio with higher return lies in portfolio A efficient frontier and is composed by 100% of nominal bonds.

Figure 17: Efficient Frontier, France



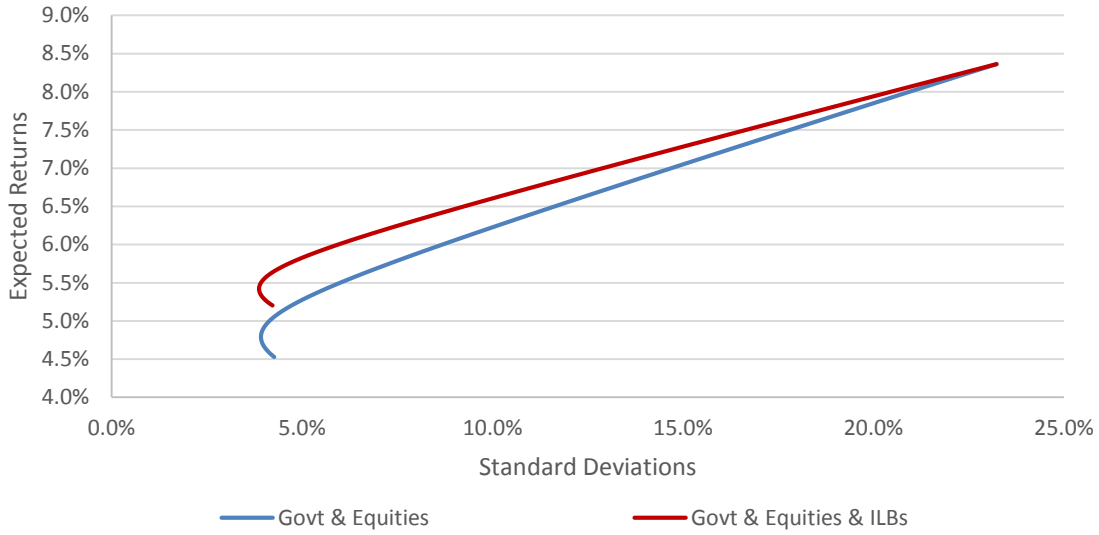
Source: Author's calculations

Germany

The German portfolios' efficient frontiers show opposite results of what was observed in France. It is observable the common concave shape as taught in Finance textbooks and, in addition, it is seen that adding ILBs to a portfolio composed of equities and nominal sovereign bonds improves the risk/returns binomial relationship under the mean-variance optimization framework. Relating with the descriptive statistics in table 3, equities are the asset class that shows evidence of higher average monthly returns with 0.70% in equities, 0.43% and 0.32% in nominal and inflation-linked bonds respectively. Although having higher volatility, as seen in appendix I, table I – 2, the cumulative returns appear to be the highest during the analyzed time period for equities.

With regard to the benefits of including ILBs to portfolio A, the higher risk/return results are justified by the lower correlation between ILBs and equities (0.03), as well as by showing evidence of a slightly lower standard deviation when compared with nominal bonds. The highest return portfolio is composed of 100% equites. Here we can state that Germany is the first country where its linkers improve the overall portfolio efficiency when investing merely in these three asset classes.

Figure 18: Efficient Frontier, Germany



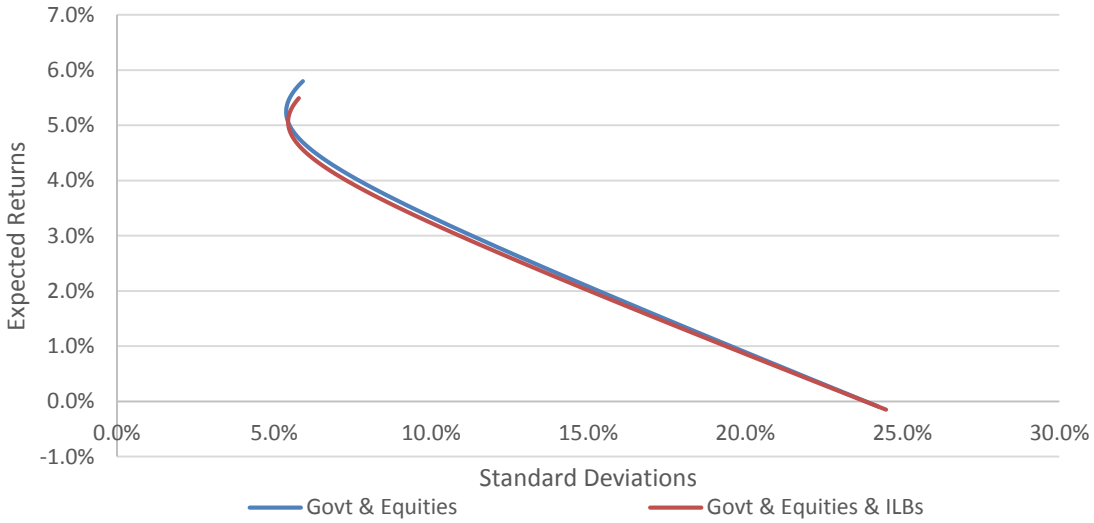
Source: Author's calculations

Italy

Italian portfolios draw a very similar picture as of the French portfolios with regard to the efficient frontiers. Again, it is observable that the normal risk/return positive relationship does not apply to the portfolios composed of equities, nominal and inflation-linked bonds. Moreover, as in France, equities went through a rough path during the considered time frame as can be seen in table I – 3 in appendix I, which shows negative cumulative returns for an investor that would have allocated his money in the FTSE MIB in 2004. Also it is seen that Italian equities were the ones that suffered the most during the financial crises and this fact invariably affects all the results and in consequence any efficient frontier containing this asset class. Supporting the previous argument, the descriptive statistics in table 3 show that not only Italian equities have negative mean monthly returns (-0.01%), but also the highest standard deviation from all asset classes within all the considered countries (5.42%).

With respect to concerns to the benefits from a mean-variance perspective, after analyzing both portfolios' efficient frontiers, it is seen that these are practically coincident allowing one to conclude that adding ILBs to a portfolio composed by equities and govies would not improve its efficiency. This is justified by the fact that Italy is, among the considered countries, the one that exhibits a higher correlation between asset classes. As seen in table 5, ILBs show almost perfect correlation with the nominal government equivalents (0.86) as well as a strong correlation with equities (0.43), while at the same time having lower mean monthly returns when compared with nominal bonds.

Figure 19: Efficient Frontier, Italy



Source: Author's calculations

8.2 Nominal vs Inflation-Linked Bonds

In the sequence of the asset allocation chapter and analysis on the benefits of investing in ILBs it is important to put them against their nominal equivalents and from the conclusions try to make some extra inferences on what can an investor expect to achieve in terms of risk and returns when allocating funds to linkers. In this section it is shown the results, per country, for two portfolios:

- Portfolio C is composed by equities and nominal government bonds;
- Portfolio D is composed by equities and inflation-linked bonds.

Each portfolio is analyzed through applying different allocations changing the bonds and equities correspondent weights. It is also presented the correspondent Sharpe Ratios[10], where the risk free rate is derived from 10 year average of the money market Euribor 12 months. The returns and standard deviations are represented by each respective asset class average annualized figures. The results appear illustrated from tables 9 to 11. Additionally, it is shown the results for both the UK[11] and US in appendix V.

France

As seen in table 9, the best portfolio is composed by 100% of nominal government bonds and 100% of ILBs in Portfolio C and D respectively. Again, and referring back to the efficient frontier conclusions on France, the fact that equities performed worse along with higher standard deviation when compared with the fixed income securities justifies the optimal portfolios' allocations. The Sharpe ratio also confirms the optimal allocation.

When it comes to comparing inflation-linked and nominal bonds it is observable that Portfolio C, which invests in nominal bonds outperforms, as seen in the presented higher returns, lower volatility and consequently higher Sharpe ratios.

Table 9: Nominal vs Inflation-Linked Bonds in an Equity Portfolio, France

	% of Portfolio Allocated to Bonds				
	0	25	50	75	100
Portfolio C					
Return	4.19%	4.47%	4.76%	5.05%	***5.33%***
Standard Deviation	22.47%	16.56%	10.76%	5.48%	***4.12%***
Sharpe Ratio	8.75%	13.61%	23.60%	51.54%	***75.48%***
Portfolio D					
Return	4.19%	4.36%	4.53%	4.70%	***4.87%***
Standard Deviation	22.47%	16.72%	11.18%	6.43%	***5.37%***
Sharpe Ratio	8.75%	12.78%	20.65%	38.53%	***49.32%***

Source: Author's calculations based on Barclays Capital and Bloomberg

Germany

German portfolios optimal allocation differ from the previous French example. Here, both when considering nominal govies and linkers it is seen that the optimal allocation, according

[10] The Sharpe ratio is a measure of risk-adjusted returns and represents the average return in excess to the risk-free rate per unit of risk.
[11] The risk-free rate applied to UK and US is Libor 12 months.

to the Sharpe ratio optimization given the weights under analysis, occurs with an investment of 75% in fixed income and 25% in equities. With regard to the comparisons between investing either in ILBs or the nominal equivalents Portfolio C, composed by nominal sovereign bonds, performs better having the best risk/returns relationship, where the optimal asset allocated portfolio shows higher returns when compared with Portfolio D of about 97 basis points and approximately 52 basis points lower in volatility. The result is a Sharpe ratio higher of about 24%.

It is observed similar results to Germany in the UK and US were both optimal allocations occur when combined 75% in fixed income and 25% in equities. However, as opposed to Germany, ILBs show higher Sharpe ratios when compared with nominal bonds, therefore contributing in achieving better risk-adjusted returns (Appendix V).

Table 10: Nominal vs Inflation-Linked Bonds in an Equity Portfolio, Germany

	% of Portfolio Allocated to Bonds				
	0	25	50	75	100
Portfolio C					
Return	8.36%	7.56%	6.77%	***5.97%***	5.17%
Standard Deviation	23.23%	16.94%	10.76%	***5.15%***	4.33%
Sharpe Ratio	26.45%	31.56%	42.24%	***72.83%***	68.10%
Portfolio D					
Return	8.36%	7.24%	6.12%	***5.00%***	3.88%
Standard Deviation	23.23%	17.12%	11.13%	***5.67%***	4.20%
Sharpe Ratio	26.45%	29.34%	35.06%	***49.12%***	39.65%

Source: Author's calculations based on Barclays Capital and Bloomberg

Italy

In Italy, the results are pretty much the same as those observed in France. The optimal allocation in Portfolio C and D occur when invested 100% in the fixed income asset classes. As in France, this is justified by the worse results in equities performance combined with higher standard deviation as it is seen, a portfolio composed 100% of equities had an average annualized negative performance of approximately -0.15%.

The returns of Portfolio C are continuously higher than those of Portfolio D where at the same time the volatility is lower. This results in higher Sharpe ratios within all percentages invested in fixed income of Portfolio C, and leading to the conclusion that linkers do not provide benefits and in fact nominal government bonds produce the best risk-adjusted asset allocations in Italy.

Table 11: Nominal vs Inflation-Linked Bonds in an Equity Portfolio, Italy

	% of Portfolio Allocated to Bonds				
	0	25	50	75	100
Portfolio C					
Return	-0.15%	1.34%	2.82%	4.31%	***5.80%***
Standard Deviation	24.49%	18.78%	13.29%	8.40%	***5.92%***
Sharpe Ratio	-9.68%	-4.70%	4.56%	24.91%	***60.45%***
Portfolio D					
Return	-0.15%	1.21%	2.57%	3.93%	***5.30%***
Standard Deviation	24.49%	19.07%	14.01%	9.87%	***8.17%***
Sharpe Ratio	-9.68%	-5.29%	2.52%	17.38%	***37.64%***

Source: Author's calculations based on Barclays Capital and Bloomberg

9. CONCLUSIONS

This dissertation focused on the analysis of European ILBs excluding the UK and had as its main purpose to present these securities which are quite recent and are still growing and maturing even in developed countries. It is fair to say that, although pretending to infer on the consequences of investing in linkers along with nominal government bonds and equities, the main objective is to give an introduction and, in some ways a guide, on inflation-linked bonds. The gathered data was mainly from Barclays Capital and Bloomberg and the findings are based on daily returns from 2004 to 2014.

The time period under analysis was undoubtedly turbulent, where it includes the financial crisis of 2007 in the US and the global repercussions of the same which spread into Europe having the financial sovereign crisis in 2009. These events are global history and financial marks. This is certainly a fact that has considerable implications on the gathered data and ultimately in the empirical conclusions. It is important to speak of the political environment along with the economic and financial conditions as fixed income securities are closely related to fiscal and essentially monetary policies. In the considered time frame, as an example, there were two expansionary monetary policies big events, known as quantitative easing in Japan and in the UE. The European QE was announced by the ECB in January 2015 and started in March of the same year, however, the markets expectations about this policy drove much of the results for European fixed income securities in the second half of 2014.

ILBs returns during the analyzed period were however quite stable, showing a maximum of 25% in Italy in 2012 and a minimum of -10% also in Italy in 2011 (in annual terms). France and Germany showed evidence of smother returns as well as lower volatility both in linkers and in all the remaining asset classes. Among the three analyzed asset classes, government bonds were the ones that outperformed equities and ILBs both in France and Italy with annualized returns of 5.3% and 5.8% respectively. In Germany, equities outperformed with average annualized returns of approximately 9.3%. When it comes to risk, the asset class that exhibited higher standard deviation were the Italian equities with close to 22.8% annualized average. Both ILBs and nominal bonds showed much lower levels around 4 to 5 percent and in all countries the nominal fixed income securities had higher volatility, on average an excess of about 70 basis points.

Tackling inflation and its correlation with linkers, as ILBs' nominal value is linked to inflation, being CPI or HICP, one would expect a high correlation between the two. However, the empirical analysis showed the opposite, mainly when considering monthly data. In the three considered countries the results showed a close to zero correlation coefficients between inflation and ILBs. In spite of that, when analyzing annual returns and inflation, the results improved slightly with exception to Italy which showed negative correlation between inflation and ILBs. These findings can be attributable and summarized in four main points: The duration of the bonds affect inflation correlations. The shorter the maturity of an ILB the less it is affected by market sentiment and interest rate moves, increasing the inflation correlation coefficient; secondly, there is the time lag mentioned before. The returns are computed at the end of the month while the actual inflation rates take on average three months which also supports the better results observed in the longer time period; third, yields are driven by inflation expectations and not unquestionably actual inflation, moreover in the short term, where past performance does not guarantee future results; finally, the short time frame under analysis and being this same period one where these securities were basically entering the financial markets being more prone to market distortions events due to liquidity issues. These findings introduce the idea that linkers may not be a proper inflation hedging instrument. However, the reader should bear in mind all the above mentioned facts about potential biases in the presented analysis and results.

To conclude on ILBs diversification power, it has been computed intra-market and cross-country correlations. The results of the calculations showed that ILBs have a strong correlation with their nominal government bonds equivalents in all countries as well as between the countries themselves, mainly between France and Germany. With regard to the relationship with equities, ILBs showed a close to zero correlation, which indicates they can act as a diversification instrument in a portfolio composed by these two assets. However, the asset class that showed evidence of lower correlations were the sovereign nominal bonds, with negative correlations as was expected and indicate in the literature review. Among the three European countries, Italy was the country that exhibited lower correlations with France and Germany, both in nominal and in inflation-linked bonds. The main equity indices of all the three countries are strongly correlated, in average showing a correlation of about 0.88. After analyzing these results it is possible to conclude that, when trying to diversify a portfolio composed by equities, nominal bonds would achieve better results than ILBs. Adding linkers to a portfolio of govies would not yield diversification benefits.

Summing up the analysis on the benefits of including linkers in a portfolio, the final section on asset allocation approached the issue through the mean-variance optimization perspective and there were drawn efficient frontiers and compared the results of including ILBs in a portfolio of nominal bonds and equities. The results showed that ILBs only improved the risk-adjusted returns in Germany while both in France and Italy, including ILBs in the portfolio would practically yield no results with regards to the risk/return portfolio binomial relationship. It is important to underline the simplicity of the analysis as there were only considered these three asset classes, therefore excluding others that may improve the results of the efficient frontiers. Additionally, linkers were directly put against their nominal equivalents by creating two portfolios with different weights in equities and fixed then analyzing the results in terms of annualized returns, volatility and Sharpe ratios. In all three countries, the portfolios composed by equities and nominal sovereign bonds outperformed the ones composed by equities and linkers.

The main conclusions on this study are that linkers do not promote significant efficiency or diversification benefits when combined with equities or govies. However, there are still other angles that can be analyzed like simply trading linkers by betting on inflation and inflation expectations. It is important to note that the results presented in this dissertation are based on historic and past performance, and thus are not a guide nor guarantee future results.

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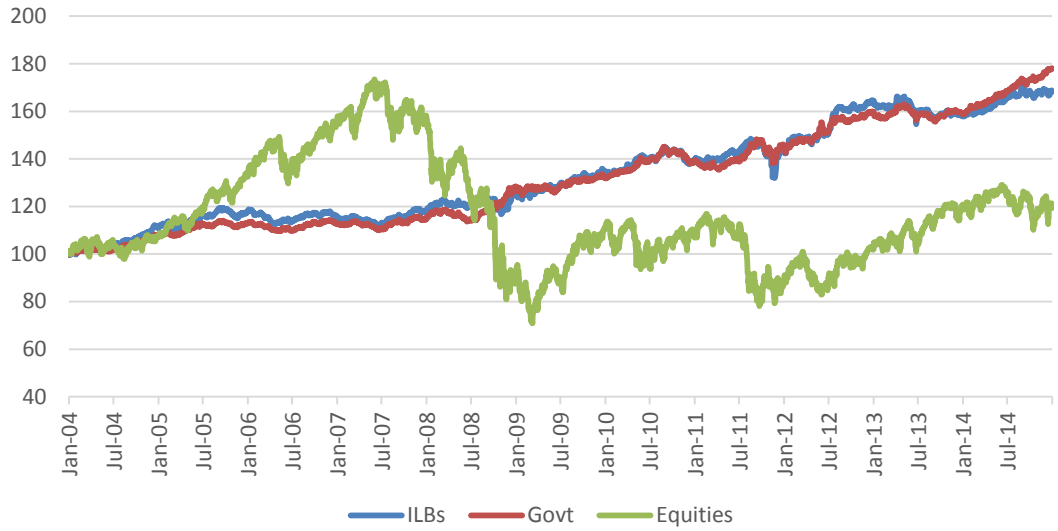
Appendix I

Figure I-1 Cumulative Daily Returns, France

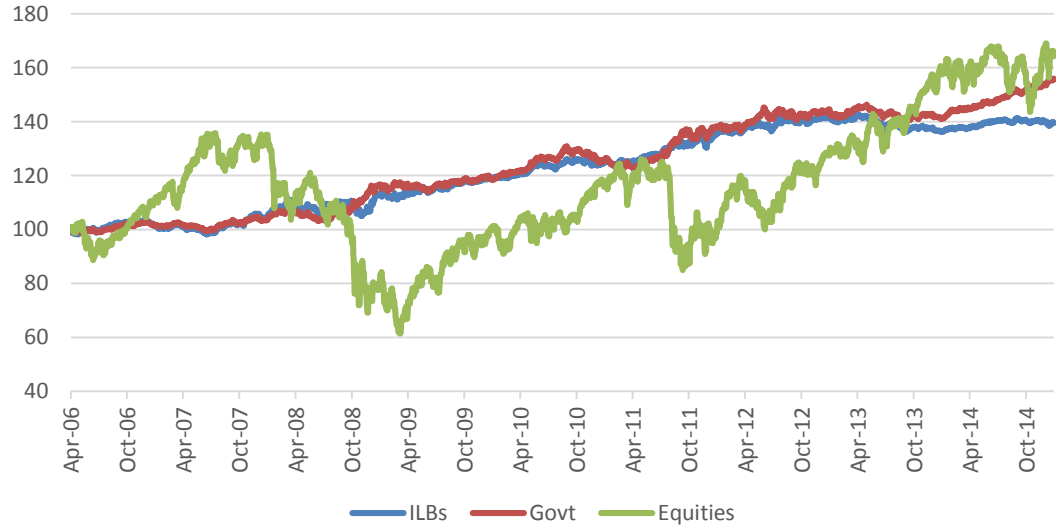
January 2004 – December 2014



Source: Author's calculations based on Barclays Capital and Bloomberg

Figure I-2 Cumulative Daily Returns, Germany

April 2006 – December 2014



Source: Author's calculations based on Barclays Capital and Bloomberg

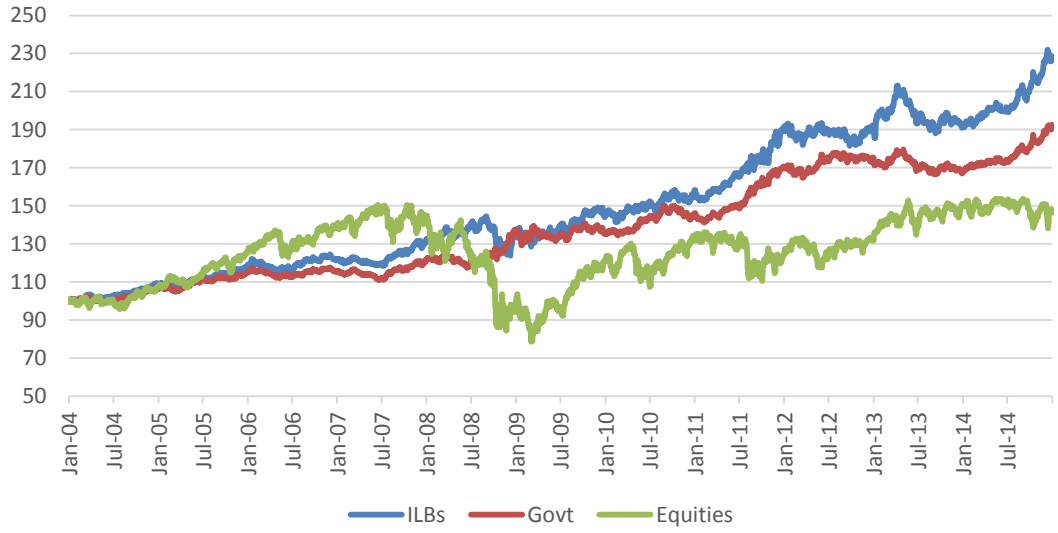
Figure I-3 Cumulative Daily Returns, Italy

January 2004 – December 2014

Source: Author's calculations based on Barclays Capital and Bloomberg

Figure I-4 Cumulative Daily Returns, UK

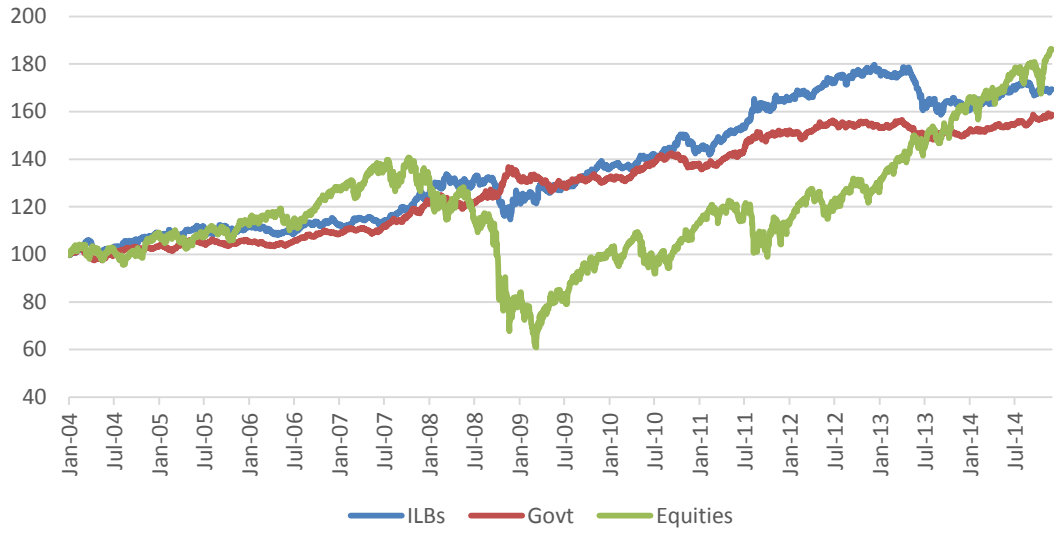
January 2004 – December 2014



Source: Author's calculations based on Barclays Capital and Bloomberg

Figure I-5 Cumulative Daily Returns, US

January 2004 – November 2014



Source: Author's calculations based on Barclays Capital and Bloomberg

Appendix II

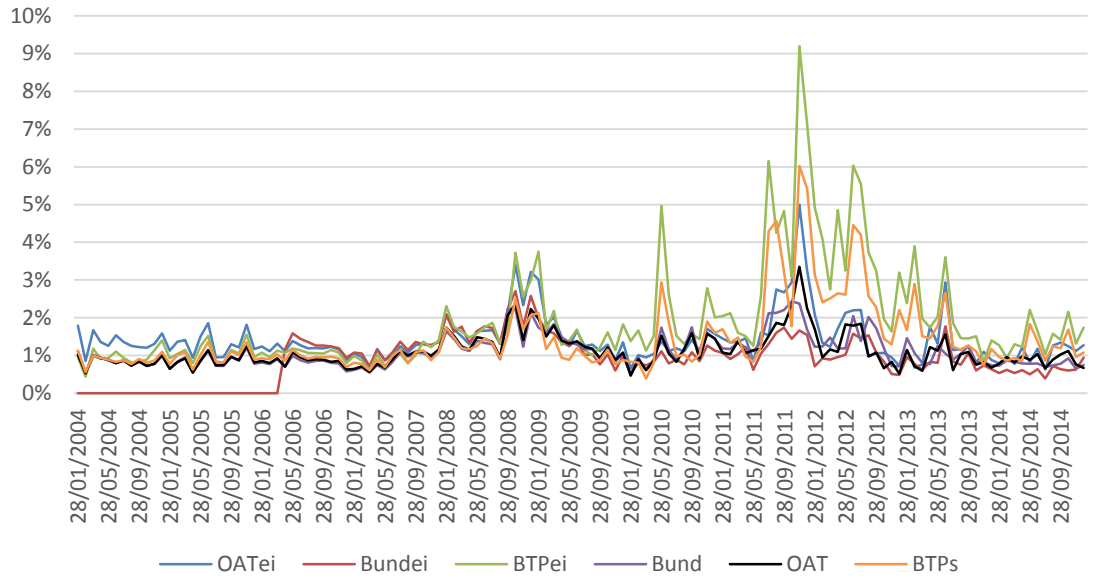
Table II-1 Inflation Cross-Country Correlations

	France HICP	Germany HICP	Italy HICP	France CPI	Germany CPI	Italy CPI	US CPI NSA	UK RPI
France HICP	1.00							
Germany HICP	0.86	1.00						
Italy HICP	0.89	0.81	1.00					
France CPI	0.98	0.84	0.88	1.00				
Germany CPI	0.81	0.91	0.74	0.81	1.00			
Italy CPI	0.91	0.83	0.98	0.90	0.75	1.00		
US CPI NSA	0.83	0.79	0.64	0.82	0.75	0.64	1.00	
UK RPI	0.68	0.69	0.54	0.67	0.69	0.55	0.65	1.00

Source: Author's calculations based on Bloomberg

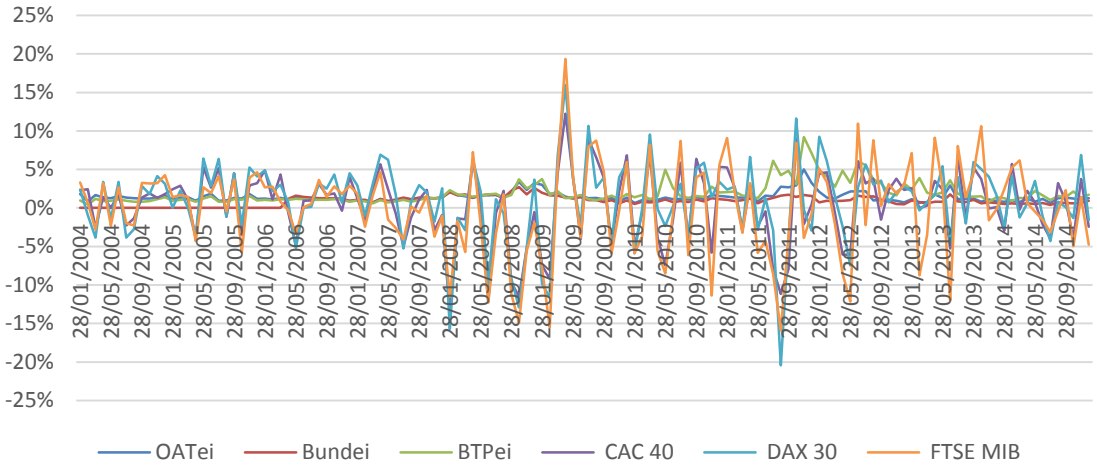
Appendix III

Figure III-1 Volatility trends ILBs vs Nominal Bonds



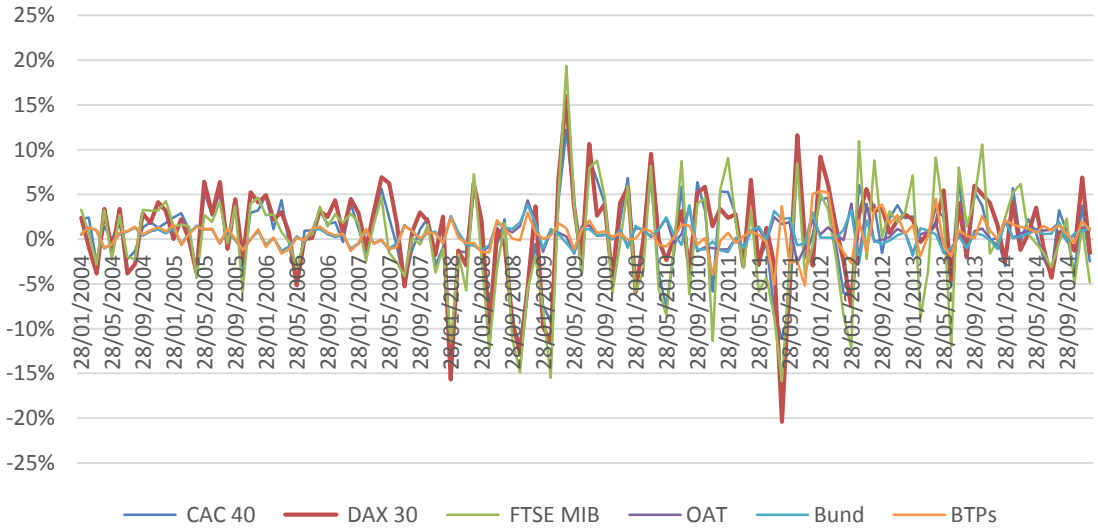
Source: Author's calculations based on Barclays Capital

Figure III-2 Volatility trends ILBs vs Equities



Source: Author's calculations based on Barclays Capital

Figure III-3 Volatility trends Nominal Bonds vs Equities



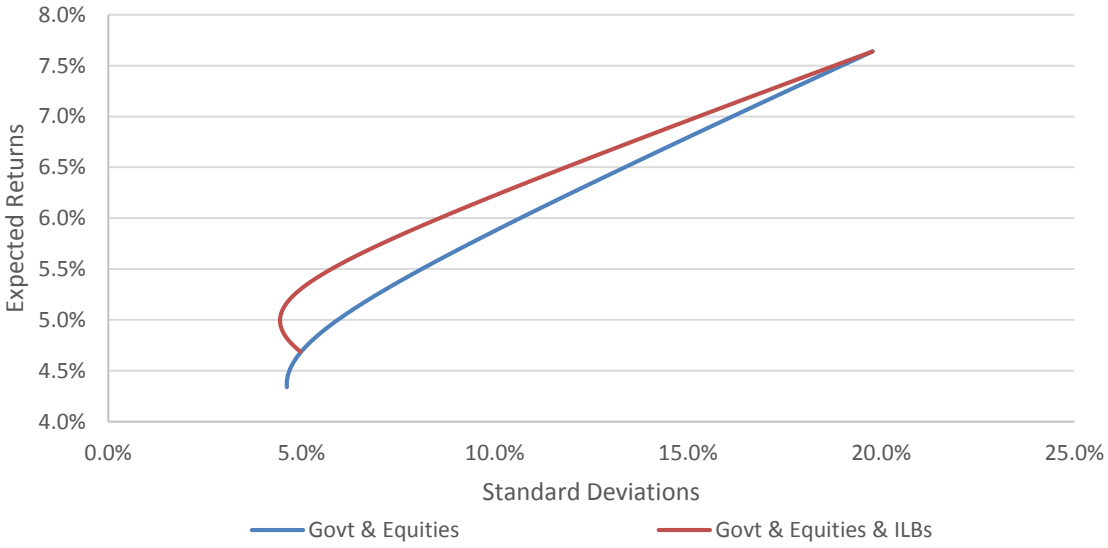
Source: Author's calculations based on Barclays Capital

Appendix IV

Figure IV-1 Efficient Frontier UK

Source: Author's calculations

Figure IV-2 Efficient Frontier US



Source: Author's calculations

Appendix V

Table V – 1: Nominal vs Inflation-Linked Bonds in an Equity Portfolio, UK

	% of Portfolio Allocated to Bonds				
	0	25	50	75	100
Portfolio C					
Return	5.22%	5.45%	5.68%	***5.91%***	6.14%
Standard Deviation	18.67%	13.51%	8.67%	***5.19%***	6.12%
Sharpe Ratio	16.09%	23.94%	39.93%	***71.19%***	64.01%
Portfolio D					
Return	5.22%	5.89%	6.56%	***7.22%***	7.89%
Standard Deviation	18.67%	13.57%	9.15%	***6.89%***	8.66%
Sharpe Ratio	16.09%	27.05%	47.37%	***72.65%***	65.45%

Source: Author's calculations based on Barclays Capital and Bloomberg

Table V – 2: Nominal vs Inflation-Linked Bonds in an Equity Portfolio, US

	% of Portfolio Allocated to Bonds				
	0	25	50	75	100
Portfolio C					
Return	7.64%	6.81%	5.99%	***5.16%***	4.34%
Standard Deviation	19.77%	14.84%	10.08%	***5.94%***	4.62%
Sharpe Ratio	27.41%	30.96%	37.39%	***49.53%***	45.84%
Portfolio D					
Return	7.64%	6.99%	6.34%	***5.69%***	5.04%
Standard Deviation	19.77%	14.58%	9.73%	***6.13%***	6.41%
Sharpe Ratio	27.41%	32.71%	42.31%	***56.57%***	43.96%

Source: Author's calculations based on Barclays Capital and Bloomberg