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Asset Allocation with Inflation Linked Bonds in Emerging Markets

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PREFACE AND ACKNOWLEDGEMENTS

This study is the result of my Master Thesis, which has been carried out during the summer of 2010, and represents the end of my MSc Economics & Business degree, specialized in Financial Economics in Erasmus University Rotterdam (EUR). Its main topic refers to the asset allocation with inflation-linked bonds in emerging markets.

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ABSTRACT

In the study reported here, we aim at examining whether and how the availability of inflation-linked bonds (ILBs) in emerging markets may affect investors' asset allocation decisions. We used monthly return data of ILBs, nominal bonds, and equities from eight emerging countries and two developed ones, in both local currency and US dollars. We found that the returns on ILBs in emerging markets are higher and more volatile than nominal bonds. Moreover, none of the asset classes have shown high correlations with inflation, while ILBs perform the best in hedging the inflation risk. Regarding the diversifying power, the correlation with nominal bond returns and equity returns is much lower for the ILBs. We related this finding to country risk rating and inflation volatility. We also found the cross-country correlation is much lower for ILBs than equities. For local investors, an examination of asset allocation among three asset classes suggests that substantial weight should be given to ILBs in emerging markets. For the US investors, such conclusion only applies to several countries.

Keywords: inflation-linked bonds, emerging markets, asset allocation, portfolio diversification, mean-variance spanning test

JEL Classification: G11

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CHAPTER 1 Introduction

With relatively low correlation of returns between traditional asset classes, inflation-linked bonds (ILBs) can guarantee stable real returns against inflation, and thus provides significant portfolio benefits to investors. However, according to an empirical research of Brière and Signori (2009) the diversifying power of ILBs in developed markets has been found diminishing after 2003. On the one hand, the deepening financial crisis had caused a significant sell-off in developed markets during 2008-2009, as investors favored more liquid, regular Treasuries. On the other hand, while having been a fertile ground for the development of the ILBs, the emerging markets could also not escape from the recession during the period either.

As a relatively new asset class, ILBs are still not fully investigated by the existing bodies of research. Considering the mature degree of the markets, the ILBs of developed countries have always been used as the research targets. Hunter and Simon (2005) have studied the predictable time-variation in the real return beta of U.S. Treasury inflation protected securities (TIPS) and in the Sharpe ratios of both inflation-linked and conventional bonds. During the sample period from Feb 1997 to Aug 2001, they found that TIPS had superior volatility-adjusted returns relative to nominal bonds. Similarly, Roll (2004), Kothari and Shanken (2004) both demonstrated that an investment portfolio diversified across equities and nominal bonds would be improved by the addition of TIPS. From a broader view, Campbell, Shiller and Viceira (2009) have explored the history of TIPS markets during 1990's to 2008, by discussing the bond supplies, the levels of yields, the volatility as well as the covariance with stocks of high-frequency movements in the yields.

To our knowledge, we are the first to investigate the asset allocation of the ILBs in the emerging markets. We assume this is due to the fact that only in the recent years has the data become available. However, a few researchers did shed some light on related issues. Erb, Harvey and Viskanta (1999) stated that over the past ten years, the emerging market bonds have been characterized by high volatility, negative skewness and low, but increasing correlation with existing asset classes. Chiang, Wisen and Zhou (2007) indicated there were statistically significant diversifying benefits by adding the emerging market bonds to a mixed-asset portfolio consisting of multiple asset classes. Panchenko and Wu (2009) carried out a study on the co-movement between domestic stock and bond returns in the emerging market, and found they have been less correlated during 1995 to 2005 as emerging stock markets became more integrated with the rest of the world. This means that efforts to open up emerging stock markets provide investors with greater diversification opportunities.

In October 2007 Barclays Capital launched the Emerging Markets Government Inflation-linked Bond Index (EMGILB). This offers us for the first time consistent data of those ILBs. Our paper intends to bridge the knowledge gap by examining their behavior. It therefore serves as a further step for asset allocation decisions by both local and the US investors.

The main research question of this paper is the following: *What role do ILBs in the emerging markets play in contributing to the built up of an optimal portfolio?* The following sub-questions can be derived:

1. How did the returns of ILBs in the emerging markets behave during the past decade? As explained earlier this will be done by analyzing the returns of EMGILB.
2. What is the co-movement between the inflation and ILB returns compared to nominal bonds and equities? Which asset class has shown better performance hedging inflation (in both emerging markets and developed markets)? To find the answers, we will calculate the correlations between different asset returns and inflation. We also try to compare the inflation-hedging power of ILBs, nominal bonds and equities through analyzing their corresponding hedging matrixes.
3. How does the diversifying power of ILBs compare to traditional asset classes in emerging markets? Can we attribute those correlations to country risk or volatility of inflation? Taking the viewpoint of a cross-border investor, how do diverse assets classes in different countries correlate? To answer these questions, we first discuss the intra-market correlations between returns of ILBs, nominal bonds and equities, and then relate those results to the country risk rating and inflation volatility. Finally we test the correlations of asset returns between different countries.
4. How do the ILBs in emerging markets fit in a well-diversified portfolio with nominal bonds or equities? Can they contribute to a better efficient frontier for both local investors and the US investors? We are going to find the results both from graphic description and from econometric tests. Consequently, we aim to offer some suggestions based on a systematic discussion.

This paper is organized around the above mentioned sub-questions. In Chapter 2 we present a review of the related literature, both in emerging and developed markets. In Chapter 3 we introduce the datasets we have used for our research. In Chapter 4 we provide relevant background information of selected emerging markets and the corresponding description statistics for the different asset classes. In Chapter 5 we focus on the methodology of our research. We will elaborate on the theoretical concepts and framework. In Chapter 6 we carry out diversification analysis by testing the correlations at intra-market, time variance with inflation, country risk and cross-countries level. In Chapter 7 we provide the results and corresponding suggestions for both the local investors and the US investor, regarding several dynamic portfolio allocations of different asset classes. The conclusions of our research are presented in Chapter 8.

CHAPTER 2 Literature Review

In order to situate the topic within a relevant body of knowledge, we are going to provide a synopsis of previous literatures that related to our research. And we will try to find if the following findings still apply to our latest data in Chapter 6 and 7.

2.1 ILBs in Developed Markets

U.S. Treasury Inflation Protection Securities (TIPS) were first issued in January 1997. Through the end of 2009, 28 TIPS have been issued with maturities ranging from a few years through thirty years (U.S. Department of the Treasury, Bureau of the Public Debt, 2010). Considerable researches have been carried out regarding them.

Roll (2004) presented an empirical survey of the trading characteristics of TIPS from July 22, 1997 to August 16, 2002 and summarized their behaviors from several perspectives. First, the volatility of TIPS has been relatively low between 1999 and 2000 and considerably higher afterwards, but was still less than the volatility of nominal bonds with similar maturity. Second, the returns of TIPS were highly correlated to each other, particularly for adjacent maturities. Regarding the relation with other asset classes during the sample period, the returns of TIPS were positively correlated to returns of nominal bonds and negatively correlated to returns of equities. Third, due to the relatively low real yields of TIPS, their real durations were longer than those of the nominal bonds. However, by comparing the daily returns of TIPS to changes in mid-term nominal yields, the consequent empirical nominal durations for TIPS have been much shorter because they are not as sensitive to changes in expected inflation. In addition, given plausible assumptions about future expected returns, Roll found that the nominal bond yields already embed the expected inflation while TIPS yields do not. So by adding inflation to TIPS real yields to obtain their nominal expected returns, the greater the inflation, the more favorable TIPS appears. And the decline in TIPS real yields during 2002 could hence be explained as a result of lower inflationary expectations.

Hunter and Simon (2005) documented predictable time-variation in the real return beta of TIPS. To carry out their research, they used the bivariate GARCH model to estimate the time-varying correlations between TIPS and nominal bonds, by using the weekly data from February 5, 1997 to August 28, 2001. The results demonstrated the real rate component of nominal rates tended to increase during the sample period, which led to lower TIPS returns, as the slope of the yield curve steepened. In addition, they have found that an increase in nominal returns is related to higher TIPS returns over the next week, indicating that nominal returns lead TIPS returns. The results for the conditional correlation indicated that the correlation between returns of TIPS and those of nominal bonds is predictable. There is evidence that both the lagged slope of the yield curve and the lagged yield differential between TIPS and nominal

bonds have significant effects on the correlation. In specific, a steeper (flatter) yield curve is associated with a low (higher) conditional correlation of return at 5% confidence level. On the other hand, an increase in the yield spread between nominal Treasuries and TIPS is associated with a higher correlation between nominal and TIPS returns at the 1% level.

Campbell, Shiller and Viceira (2009) explored the history of ILBs in two developed markets, the US and the UK. With the data from two of the largest and best established ILB markets, the US TIPS market and the UK inflation-linked gilt market, they discussed the bond supplies, the levels of yields, the volatility as well as the covariances with stocks of high-frequency movements in yields. The corresponding results have shown a massive decline in long-term real interest rates from 1990 to 2008, followed by a sudden spike during the financial crisis. The breakeven inflation rates tended to stabilize until the fall of 2008, when they showed dramatic declines. The paper also elaborated on to what extent short-term real interest rates, bond risks, and liquidity explain the trends before 2008 and the unusual developments in the fall of 2008. In specific, the authors firstly reran the VAR analysis of Campbell and Shiller (1996) to test how well the expectations hypothesis of the term structure describe the 12-year history of TIPS yields during 1982 to 2008. They found that the declining yields for ILBs in the 2000's may not be particularly surprising given that short-term real interest rates have also been low in this decade. Secondly, to see how much of the yield history can be explained by changes in risk, they used the asset pricing theory by estimating a model of TIPS pricing with time-varying systematic risk, a variant of Campbell, Sunderam and Viceira (2009). They found that the covariance of TIPS and stocks only has a large effect on TIPS yields when the corresponding risk variations are persistent enough. Thirdly, they discussed the unusual market conditions that prevailed in 2008 and discovered it was the liquidity problem that created such severe financial anomalies and hence influenced ILB yields.

In a recent paper of Bekaert and Wang (2010), the authors briefly discussed the strengths and weaknesses of ILBS in developed markets. Based on a survey of the experiences on ILBs in the US, UK and Euro area, as well as references to some of the quite old theoretical literatures, they found that ILBs mainly contributed in four aspects: firstly, enhancing the market completeness and sharing the risk; secondly, providing market information of inflation expectations and real rates; thirdly, saving the debt costs for the government; and finally, reducing the government's incentives to inflate. On the other hand, they argued such theoretical benefits could not always hold in practice. For example, in the early years of the TIPS market, neither its corresponding market capitalization to absorb the demands of investors was sufficiently large, nor its market environment to allow active trading was sufficiently liquidity. Such problems potentially undermined some of the benefits of TIPS.

2.2 Diversifying Power of ILBs in Developed Markets

To find out whether TIPS provide incremental reward-to-risk benefits in a portfolio context, Hunter and Simon (2005) computed the conditional real return betas and Sharpe ratios. The results have shown that over the sample period, TIPS had superior volatility-adjusted returns relative to nominal bonds. This finding was striking in view of the absence of major inflation expectations during the sample period from February 1997 to August 2001. Again it was only loosely consistent with the possibility that TIPS elevated rather than reduced Treasury borrowing costs. Regarding the diversifying power of adding TIPS, different results have been found for diverse portfolios. During the period of relatively well-behaved inflation rates, on the one hand, when investors added TIPS to the nominal Treasury bond, the reward-to-risk ratio would significantly increase. On the other hand, if the investor owned a more diversified portfolio, for example, one already had included nominal Treasury bonds, bills and corporate bonds, the addition of TIPS to the portfolio did not provide additional reward-to-risk benefits. However, the authors suggested that the TIPS would still enhance portfolio efficiency during more inflationary periods. Similarly, Roll (2004) also suggested, to the extent that inflation was expected to increase, an investment portfolio diversified across equities and nominal bonds would be improved by the addition of TIPS.

In their paper examining how ILBs affect investors' asset allocation decisions, Kothari and Shanken (2004) used historical yields on conventional US T-bonds and an inflation-forecasting model to create a series of hypothetical ILB returns as if it had existed back to 1953. By carrying out a descriptive statistics, they found that the real returns of ILBs have been less volatile than those of other similar conventional bonds. Moreover, as a result of the inflation protection, they found the correlation with stock returns was much lower for the ILBs. This finding demonstrated ILBs could provide stronger diversifying power than conventional bonds do when composing a portfolio of stocks and bonds. Attributed to the characteristics of low volatility and correlation, the standard deviation of an equal-weighted portfolio of stocks and bonds is much lower when ILBs are used instead of conventional bonds.

Moreover, Kothari and Shanken (2004) also claimed that the decisions of investors mainly depend on expected returns and risks of the corresponding asset classes. Consequently, only if a substantial positive inflation risk premium is postulated, does a significant role for conventional bonds emerge. For the ILBs, the lack of liquidity tends to increase their yields and makes them attractive to long term investors. These conclusions are further supported by analysis regarding actual returns on TIPS from Feb 1997 to July 2003.

However, as time passed, the diversifying power of ILBs in developed markets has changed significantly. Brière and Signori (2009) studied the dynamics of conditional volatilities and correlations for daily returns of three asset classes in the US and the EU, during the sample period from 1997 to 2007. For equities, they used the S&P500 index for the US and the DJ Euro Stoxx for the EU; for ILBs, the

Barclays Global Inflation Total Return indices for the US and the French linker market[1] for the EU; for nominal bonds, the Barclays Breakeven Comparator Bond indices for both markets. They then estimated the conditional correlations and volatilities between three asset classes by means of a DCC-MVGARCH model (Engle (2002)), which has been the first time applied to ILBs. The results have showed that due to more stable inflation expectations and a more liquid ILB market, ILBs and nominal bonds in the US and the EU were practically substitutable in recent years. That is, although ILBs of developed markets once had definite diversification power, they are now highly correlated with nominal bonds and have reached similar volatility levels.

Brière and Signori (2009) also examined the monthly dynamic portfolio optimization since 1997, using their estimates of conditional correlations and volatilities. The outcomes clearly demonstrated that although diversification was a valuable reason for introducing ILBs to developed countries before 2003, this is no longer the case, as the optimal weight of ILBs in a portfolio decreased sharply in 2003 in favor of nominal bonds and equities. The corresponding ILB weighting in the EU has even actually become negligible. To sum up, they suggested that for developed markets, whether ILBs should be included in a portfolio now would only depend on investors' inflation risk aversion and their expectations for relative excess returns of both nominal and ILBs.

However, Bekaert and Wang (2010) still emphasized the potentially important role for ILBs from a different point of view, the power of hedging inflation risk. They estimated the "inflation betas" for nominal government bonds and equities over 45 countries. The sample period started between January 1970 and January 2005, varying from country to country, while most ended in January 2010. They found in half of the countries, bond returns were negatively correlated to inflation, and equities have shown poor performance in hedging the inflation risk. Such findings applied to both short and long horizons. They also expanded the assets to include real estate, foreign bonds and gold, however, only improved the results marginally. Moreover, it seemed easier to hedge inflation risk in emerging markets than in developed markets. They hence argued ILBs could be essential to hedge inflation risk by offering a better sense of the magnitude of inflation risk premium to investors.

2.3 Government Bonds in Emerging Markets

The historical behavior of emerging market bonds has been systematically studied by Erb, Harvey and Viskanta (1999) using a decade of data from J. P. Morgan Securities during 1990 to 1999. In their related paper, they tracked a number of indices including EMBI, EMBI+ and EMBI Global to offer a brief

[1] As it is mentioned in the paper of Brière and Signori (2009), this is because France has the largest ILB market in terms of outstanding amounts, number of securities, liquidity and length of sample period. It also avoids the problem of mixing bonds with different credit ratings.

exploration of the history of emerging market lending. The corresponding results indicated that the emerging market bonds have been highly volatile through time. Meanwhile, the emerging market bonds have also shown the negative skewness that needed to be compensated for in terms of higher expected returns. By operating a portfolio simulation using the JP Morgan EMBI Global universe of countries, and investigating the relation between country risk rating as well as spreads over US Treasuries, they noted that country risk plays an important role in the pricing of emerging market bonds. They also argued that for many potential investors, the combination of a relatively small market capitalization, high volatility, and negative skewness made it impractical to invest in emerging market bonds. However, with continuing capital inflows, the bond markets in emerging countries are still believed to be a preferred way of channeling capital to sovereign and quasi sovereign entities. Besides the findings we mentioned above, Erb, Harvey and Viskanta (1999) also contributed in testing the diversifying power of emerging market bonds. It is shown that in the times of crisis, the emerging bond markets were highly correlated to local equity markets.

A more systematic analysis in examining whether emerging market bonds improve the investment opportunity set for a mixed asset portfolio has been carried out by Chiang, Wisen and Zhou (2007). The dataset was composed by the monthly returns of the US dollars dominated J.P. Morgan Emerging Market Bond Index (EMBI) and mutual funds from January 1994 to December 2004. They defined the null hypothesis as the efficient frontier of benchmark assets, which included eleven different bond indices from developed markets and two international equity indices, is the same as the efficient frontier of these assets plus additional test assets, EMBI and CRSP Emerging Market Bond Fund Portfolio. And the rejected null hypothesis hereby demonstrated that both test assts expand the mean-variance efficient frontier and provide diversification benefits.

The results of Chiang, Wisen and Zhou (2007) indicated that there were statistically significant diversifying benefits by adding the emerging market bonds to a mixed-asset portfolio consisting of the US stocks, the US bonds, international stocks, and international developed market bonds. Moreover, due to the fixed-income nature of emerging market bonds, this improvement has been more evident at the lower end of a portfolio's return distribution. The results of unconstrained quadratic optimizations demonstrated that a portfolio allocation to emerging market bonds ranging from 2% to 3% was optimal for investors with moderate risk tolerances. That is to say, adding emerging market bonds to portfolios with less aggressive risk profiles appears to be beneficial.

Panchenko and Wu (2009) did a similar research in examining how the emerging stock market integration influences the relationship between stock and bond returns. The data they applied were from Thomson Datastream, for 18 emerging markets in a post-liberalization period from 1995 to 2005. In specific, it included a panel dataset of two indices, the first being the weekly local currency denominated Morgan Stanley Capital International (MSCI), and the second J.P. Morgan emerging bond market index. They

also collected weekly country-level indices from Standard & Poor's Emerging Markets Database (EMDB). To carry out the research, they estimated a conditional random effects logistic panel regression model for these market co-movements, along with time varying market integration and other relevant control variables.

They found evidence of a robust inverse relationship between stock and bond returns in emerging markets. By means of financial integration with world capital markets, as well as the restrictions on foreign ownership of assets have been gradually lifted post-financial liberalization, the segmentation risk premia of equities in emerging markets has decreased. Such stock market openings not only led to an increase in demand for equities but also created an either unchanged or reduced demand for bonds. The authors also tested if country ratings play role in the correlations of nominal bonds and stocks, however, apart from the findings of Erb, Harvey and Viskanta (1999), Panchenko and Wu (2009) found they did not have additional impacts on the same country stocks vs. bonds relation. In the corresponding correlation analysis, they found that the stock market and institutional development measures are indeed highly correlated. As such, they did not find incremental explanatory power for country ratings. Moreover, as emerging stock markets become more integrated with the rest of the world, their domestic stock and bond returns are likely to become significantly more uncorrelated, which means efforts to open up emerging stock markets could provide local investors with greater diversification opportunities.

CHAPTER 3 Data

To compare the dynamics of volatility and correlations of ILBs with other asset classes, and study the influence of these factors on the optimal allocation for indexed bonds, we compose a dataset with total return indices (TRI) for nominal bonds, ILBs and equities in emerging markets. The reason for choosing the TRI as the data instead of the Price Index is that, the TRI method is usually considered a more accurate measure of actual performance. As it is assumed all dividends and distributions for equities, as well as all coupon payments and redemptions for bonds, are reinvested, by buying more assets in the index.

In this paper, the corresponding rates of return are derived from the TRI based on the following formula:

$$R_t = \frac{P_t}{P_{t-1}} - 1 \quad (1)$$

Where R_t = the rate of return at time t

P_t =the TRI of related asset classes at time t

In finance, the rate of return (ROR) measures the ratio of gain or loss on an investment relative to the initial investment cost over a specified period. This indicator can be used to measure virtually any asset class, from real estate to bonds and stocks. Similarly, we can calculate the inflation rate for different markets using the Consumer Price Index (CPI) from the National Bureau of Statistics of corresponding country:

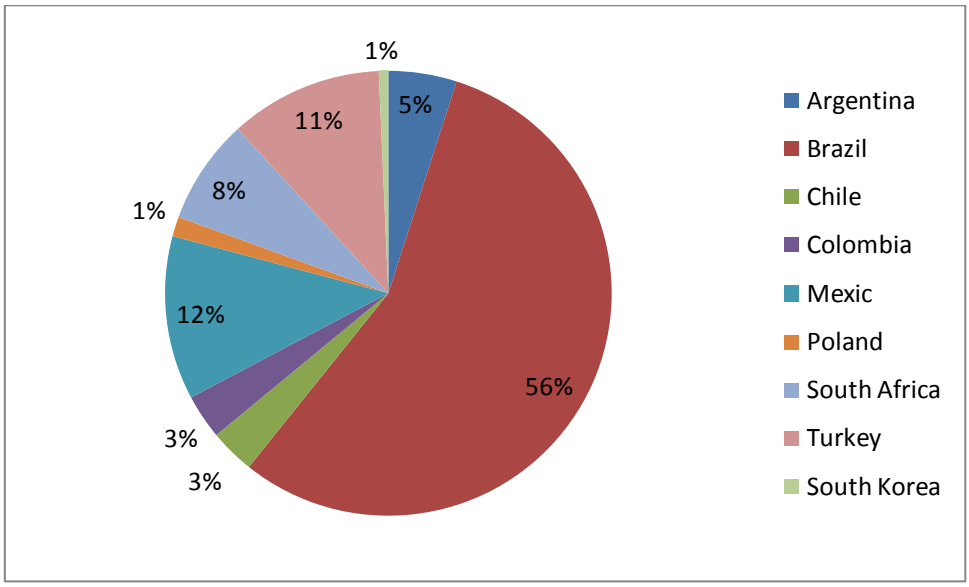
$$\pi_t = \frac{CPI_t}{CPI_{t-1}} - 1 \quad (2)$$

Where π_t = the inflation rate at time t

CPI_t =the consumer price index at time t

Data of the ILBs in emerging market is very limited during the short history of many of these instruments. The Barclays Capital Emerging Markets Government Inflation-linked Bond Index (EMGILB) provides a source of data and will be used throughout this paper. With an overall market capitalization of around US Dollar 251 billion in 2010 (Barclays Capital, 2010), the EMGILB Index measures the total return performance of 57 ILBs from 9 major emerging markets countries; Argentina, Brazil, Chile, Colombia and Mexico from Latin America (LatAm); Poland, South Africa and Turkey from Eastern Europe, Middle East, and Africa (EEMEA); and South Korea from Asia (Asia). The relative weights of the index capitalization are presented in Figure 1.

Figure 1 Weights of Market Capitalization for EM ILBs



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

The index uses daily mid-market prices from Barclays Capital market makers taken at local market close. South Africa is an exception to the rule, where ABSA Capital[2] market maker mid-closes are used. In this paper, we have used the monthly TRI as our benchmark for frequency, all the data have been published on the end of the month. The EMGILB Indices are available in local currency and foreign currency. Many emerging markets suffered due to the currency mismatch between their revenues and debt service requirements. To solve this problem and reduce the potential currency risk, using the local currency is a preferable choice considering the intra-market correlations. However, to test the cross-country correlations from an international perspective, as well as provide investment suggestions for the US investors, we refer to the foreign currencies indices, which have been measured in the US Dollars. The observations in our paper have been limited due to the difference between the sample periods, as to qualify for inclusion in a comparable group, the nominal bonds and equities must meet the same criteria as that of the ILBs.

For nominal bonds, the JPMorgan Government Bond Index-Emerging Markets Broad (GBI-EM Broad) indices are used. As a component of Emerging Markets – Local Debt Package, the GBI-EM Broad are variations of the Government Bond Index-Emerging Markets (GBI-EM), which are comprehensive emerging market debt benchmarks that track local currency bonds issued by Emerging Market governments. The difference between GBI-EM and GBI-EM Broad is the latter has a broader inclusion criterion, which includes all eligible countries regardless of capital controls and/or regulatory and tax hurdles for foreign investors. The corresponding data of nominal bonds for South Korea is not available

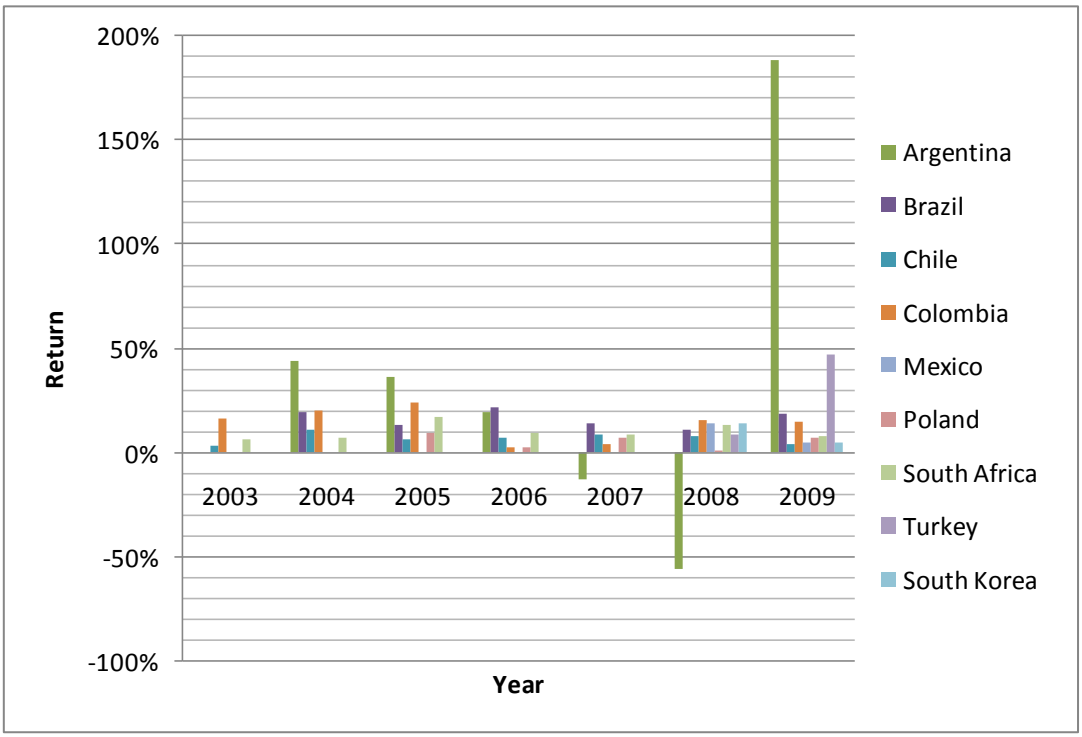
[2] Absa Capital, a division of ABSA Bank Limited, which is one of South Africa's largest financial services organizations, serving personal, commercial and corporate customers in South Africa.

as it is not categorized as an individual index in GBI-EM Broad. We hence exclude it in the further analysis, while this is acceptable as the corresponding sample period is quite short. For equities, the MSCI index for emerging market has been used. To make it comparable with the data of ILBs, both the monthly TRI for nominal bonds and equities we used have been published at the end of month.

Two pairs of asset classes from the US and the EU are used as supporting data. This way we support our understanding of the correlations of asset classes in developed markets and emerging ones, as well as test if the combination of the ILBs in these two types of markets contributes to an optimal portfolio. For nominal bonds we have used the JPMorgan Global Bond Index; for ILBs the Barclays Capital Government Inflation-Linked Index and for equities the MSCI index.

Figure 2 below represents the annual returns for ILBs in emerging markets. Due to the limited observations of available data in different time period, few pairs are presented in earlier years. The annual performances of most countries are relatively stable, while significant differences can still be found across countries. The result of Argentina has shown the most volatile return for -56% in 2008 and 188% in 2009. This can be attributed to a wrong action of financial reconstruction of which the details will be further discussed in Chapter 4, where we present the background information of emerging markets.

Figure 2 Yearly Performances of EM ILBs



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

CHAPTER 4 Descriptive Statistics

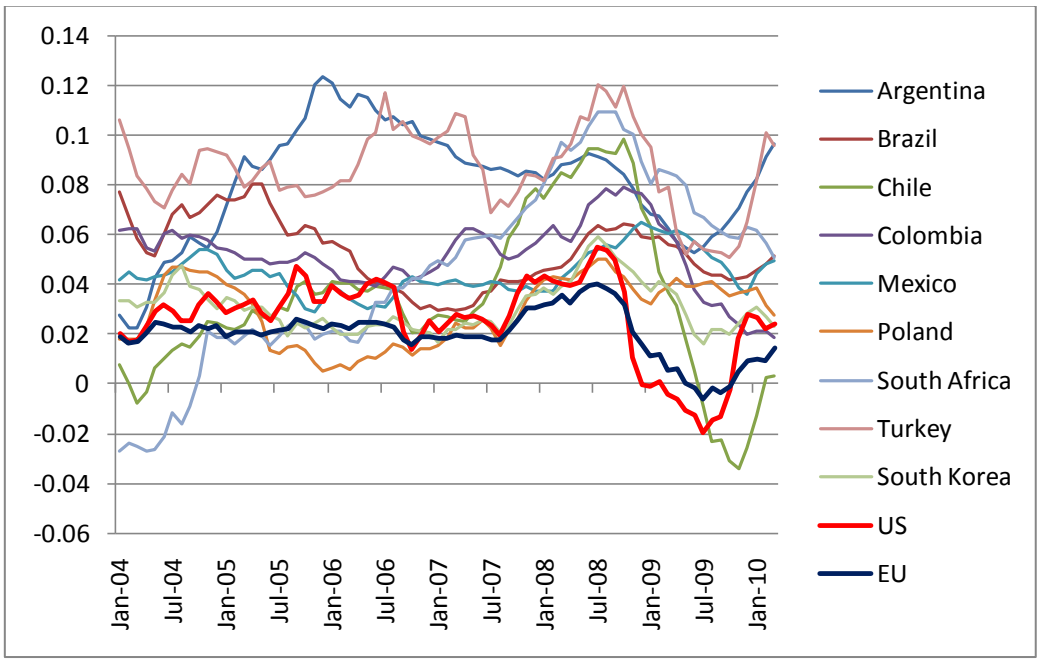
In this section, we will first provide some general information regarding the emerging markets and their corresponding inflation situations. Based on a descriptive statistics of three asset classes, we then compare the differences in behavior between the classes from returns, volatilities and distribution characteristics aspects. Finally we conclude some general explanations regarding the corresponding performances.

4.1 Background Information for Emerging Markets

Over the past several years, output growth in emerging market economies has outpaced that in industrial nations. For a long time this growth was accompanied by relatively low inflation, but the situation has changed in the recent years. Currently, we are in a situation where global growth is slowing, but inflationary pressure remains strong. As it is shown in Figure 3, inflation in the developed world, such as the US or the EU, has been relatively stable despite a sharp decrease during the financial crisis in 2008, and is expected to remain moderate because of slowing growth. On the other hand, inflation in emerging markets has fluctuated a lot during the decade and on average, is much higher than that of developed countries. In those countries inflation is still expected to continue to grow at a relatively fast path, positively influencing the performances of ILBs.

Figure 3 Inflation in Different Countries

January 2004 to March 2010



Source: Author's calculations based on DataStream

Numerous factors have acted simultaneously to push inflation upwards in emerging countries. Over the last five years, soaring oil prices, instability in the financial markets, and deteriorating housing market conditions have made the US lower the federal funds rate, which has spurred a depreciation of the dollar. Many emerging and oil export countries had adopted monetary policy that entailed maintaining a constant exchange rate towards the US dollar, or at least managing a floating regime imposing considerable limitations on appreciation. The rapid reduction of interest rates in the US undermines monetary policy restraint in these countries at a time when a tighter stance is necessary. Meanwhile, there is little margin to increase the short-term supply of commodities, and demand in emerging market economies is growing by leaps and bounds, especially for food commodities, which constitute a much higher proportion of local consumption. Price inflation of certain commodities hence can quickly evolve into overall inflation pressure in emerging nations. Furthermore, inflation expectations are less securely anchored than they are in developed countries with experience of price stability, and this precipitates general inflationary effects and makes them more persistent than they would otherwise be. As a result, strong domestic demand, rising commodity and food prices and a relative inflexible monetary policy have pushed inflation in the emerging markets sharply upwards over the past years.

Besides this common trend of inflation in emerging markets, two countries experienced special circumstances which had a profound impact on the performance of their markets. We now take a closer look to developments in Argentina and Turkey.

Argentina

The economy of Argentina is characterized by turbulent development over the last ten years[3]. After five years of unprecedented economic and political crisis and government policies favoring consumption against exports, the economic growth of Argentina decelerated heavily in 2002. With rising demand, capacity constraints, monetary policy centered round a fixed nominal exchange rate, and growing wage pressure appearing, the inflation in Argentina accelerated at the end of 2005. From 2006 onwards, the Economy Ministry implemented a price control policy aimed at maintaining a low inflation level. Although it did bring the inflation rate down in 2007, the instrument itself is being considered to be harmful in the medium and long-term. One year later, the financial crisis heavily impacted the local economy, which caused a recession in the bond market. In an effort to protect retirees' savings, in the fourth quarter of 2008, President Cristina Kirchner announced a plan to nationalize the country's 30 billion dollars in private pension funds. However, rather than stabilizing Argentina's economy, this action resulted in greater uncertainty and tremendous economic and social turmoil. Argentina's stock market subsequently lost more than half of its value, the bond market plummeted and the value of the Argentine

[3] For a consise overview please refer to http://en.wikipedia.org/wiki/Economy_of_Argentina

peso dropped dramatically. The Argentinean government publicly blamed the markets' performance on the ten companies in charge of the pension funds, but much of the losses were attributable to declines in the value of government bonds. In June 2009, President Cristina Kirchner suffered a defeat in the mid-term elections, which ended her control of congress and reflected widespread dissatisfaction with her governing style and policies. However, according to a recent report of Citigroup Inc., Argentina's banking sector has good prospects due to increased lending and the possibility of a change in government in 2011, with the stocks of financial conglomerate Grupo Financiero Galicia (GGAL, GGAL.BA) showing the best potential. In addition, Argentine banks showed explosive loan growth during the second quarter in 2010 (Romig, 2010).

Turkey

As we have read from the website of Turkish Statistical Institute[4], with the highest inflation rate on average over our sample period, Turkey has a long history of high inflation. In the past decade, Turkey overall experienced a remarkable fall in inflation as well as a marked decline in its volatility. This can be attributed to tight fiscal and prudent monetary policies. Inflation has declined to single digit in 2004 for the first time in the last 35 years, greatly facilitating the reduction in interest rates. To further strengthen the reforms and erase the vestiges of an unstable economy, a new currency, the "New Turkish lira", was launched on January 1 of 2005. Inflation continued to decelerate in 2005 at 8.2%, but reached 9.6% because of soaring oil prices. Although like other economies, the Turkish economy has been affected by the global financial crisis in 2008, the Turkish Government introduced various economic stimulus measures to reduce the corresponding effects such as temporary tax cuts on automobiles, home appliances and housing. This resulted at the end of 2009, in the lowest inflation rate over three decades. Meanwhile, share prices in Turkey nearly doubled over the course of 2009. According to The Economist, in the period between December 2008 to December 2009 the Turkish stock market rose the most in the world after Argentina's stock market. On 8 January 2010, International credit rating agency Moody's upgraded Turkey's rating with a notch. Turkey is one of the few countries that upgraded its rating with two notches.

4.2 Returns, Volatility and Distribution Characteristics

Table 1 below displays the summary statistics of three asset classes in nine emerging markets and two developed ones, the corresponding inflation rates have been derived from the monthly CPI. As we have mentioned above, the data for nominal bonds in South Korea lacks. We hence only present the data of ILBs and equities, and they will also be excluded in our further analysis.

[4] For a consise overview please refer to http://en.wikipedia.org/wiki/Economy_of_Turkey and http://www.turkstat.gov.tr/

Table 1 Descriptive Statistics

(CPI Inflation Rate and Monthly return in local currencies)

Area	Sample	Item	Mean	Median	Min	Max	Std Dev	Skewness	Kurtosis
Latin America	**Argentina**	Inflation	0.67%	0.64%	0.3%	1.2%	0.26%	0.48	-0.68
	Jul/07	Nominal Bonds	2.68%	1.73%	-53.3%	53.0%	16.75%	-0.27	5.04
	Mar/10	ILBs	1.97%	2.32%	-58.1%	44.3%	17.17%	-0.81	4.21
	Obs. 33	Equities	0.34%	2.17%	-37.0%	25.1%	11.74%	-1.00	2.44
	Brazil	Inflation	0.43%	0.44%	-0.2%	0.9%	0.21%	0.00	0.24
	Oct/03	Nominal Bonds	1.24%	1.34%	-4.2%	9.7%	1.64%	1.14	9.46
	Mar/10	ILBs	1.36%	1.21%	-3.3%	6.4%	1.65%	0.14	1.65
	Obs. 78	Equities	2.29%	3.32%	-25.1%	18.6%	7.30%	-0.71	1.68
	Chile	Inflation	0.25%	0.27%	-1.3%	1.5%	0.53%	-0.12	0.21
	Nov/02	Nominal Bonds	0.34%	0.28%	-4.4%	4.6%	1.30%	-0.36	3.40
	Mar/10	ILBs	0.56%	0.62%	-3.4%	3.0%	1.19%	-0.79	1.37
	Obs. 89	Equities	1.77%	1.82%	-9.5%	15.8%	4.66%	0.33	0.58
	Colombia	Inflation	0.43%	0.38%	-0.2%	1.5%	0.40%	0.54	-0.46
	Jan/03	Nominal Bonds	1.03%	1.20%	-3.5%	6.5%	2.07%	0.01	0.06
	Mar/10	ILBs	1.10%	1.23%	-4.1%	6.6%	1.94%	-0.27	0.82
	Obs. 87	Equities	3.05%	2.94%	-21.4%	20.5%	7.56%	-0.21	0.94
	Mexico	Inflation	0.37%	0.39%	-0.5%	1.1%	0.32%	-0.33	0.49
	Feb/03	Nominal Bonds	0.84%	0.97%	-4.1%	6.3%	1.69%	0.15	1.64
	Mar/10	ILBs	0.93%	1.06%	-5.4%	6.7%	1.92%	-0.21	1.39
	Obs. 86	Equities	2.13%	3.16%	-20.0%	12.8%	5.67%	-0.95	1.80
Eastern Europe, Middle East, and Africa	**Poland**	Inflation	0.23%	0.27%	-0.4%	0.9%	0.32%	-0.09	-0.66
	Sep/04	Nominal Bonds	0.59%	0.53%	-2.6%	3.9%	1.18%	-0.01	0.72
	Mar/10	ILBs	0.61%	0.53%	-6.7%	9.8%	1.90%	0.88	10.76
	Obs. 67	Equities	1.10%	2.82%	-23.9%	19.6%	7.91%	-0.50	0.88
	South Africa	Inflation	0.42%	0.38%	-1.3%	1.7%	0.53%	-0.07	1.07
	Feb/02	Nominal Bonds	0.91%	0.86%	-3.7%	8.3%	1.99%	0.78	2.44
	Mar/10	ILBs	0.93%	0.79%	-2.1%	4.6%	1.21%	0.73	1.29
	Obs. 98	Equities	1.31%	1.33%	-16.3%	14.1%	5.38%	-0.27	0.36
	Turkey	Inflation	0.72%	0.58%	-0.7%	2.6%	0.83%	0.38	-0.43
	Mar/07	Nominal Bonds	1.70%	1.37%	-6.4%	8.1%	2.51%	-0.04	3.25
	Mar/10	ILBs	2.07%	2.19%	-16.9%	13.3%	4.37%	-1.79	10.21
	Obs. 37	Equities	1.43%	2.37%	-23.5%	23.5%	10.88%	-0.12	-0.17
Asia	**South Korea**	Inflation	0.28%	0.35%	-0.3%	0.9%	0.31%	0.19	-0.56
	Apr/07	Nominal Bonds	X	X	X	X	X	X	X
	Mar/10	ILBs	0.62%	0.35%	-7.9%	11.2%	3.06%	0.59	4.44
	Obs. 36	Equities	0.91%	1.38%	-21.0%	14.4%	7.76%	-0.56	0.56
Developed Markets	**US**	Inflation	0.21%	0.22%	-1.8%	1.4%	0.36%	-1.63	9.08
	Feb/00	Nominal Bonds	0.52%	0.63%	-4.7%	5.6%	1.53%	-0.28	1.28
	Mar/10	ILBs	0.63%	0.76%	-8.3%	5.9%	1.93%	-0.95	3.90
	Obs. 122	Equities	0.09%	0.75%	-17.1%	10.0%	4.67%	-0.59	0.98
	EU	Inflation	0.17%	0.24%	-0.8%	1.0%	0.36%	-0.59	0.61
	Oct/03	Nominal Bonds	0.40%	0.56%	-1.6%	4.0%	1.03%	0.18	0.72
	Mar/10	ILBs	0.40%	0.63%	-5.6%	4.9%	1.38%	-0.76	4.48
	Obs. 78	Equities	0.65%	1.55%	-14.1%	15.5%	4.69%	-0.62	2.30

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

As can be derived from Table 1, equity contributes the highest average return among the three asset classes, with the exception of Argentina, Turkey and the US, where equity has performed the worst. Turkey contributed both the highest inflation rate and average return of ILBs during the period, which is in accordance with the background information we mentioned above. Nominal bonds should include compensation for the risk of unexpected future inflation and theoretically their returns should therefore be slightly higher than those of ILBs with similar maturities. However, the average returns on ILBs in emerging markets are higher than those on nominal bonds except for Argentina. This may be due to the data we used are from different maturities. We will further discuss it in Chapter 5.

One thing that has grabbed our attention is that Argentina contributed an extremely high and low return for both ILBs and nominal bonds across countries. In specific, in October 2008, the return of ILBs in Argentina plummeted to -58%. Meanwhile, the nominal bonds have also suffered a sharp slide with a return of -53%. As we have mentioned above, such findings were consistent with the frustration of the markets due to the financial reconstruction of Argentina in the fourth quarter of 2008. For the president Cristina Kirchner raided private pension plans, nationalizing them and seizing their $25 billion in assets to keep Argentina's economy afloat. In June 2009, both the returns of nominal bonds and ILBs rebounded to the highest level over the sample period, about 53% and 44% respectively. This can be attributed to Argentina stopping the wrong action of financial reconstruction, and with a help of a second highest and climbing inflation rate, the bonds market quickly recovered. Such unique trend of returns has been illustrated in the Figure I-1 of Appendix I, where the cumulative monthly returns have been plotted. Another finding from Appendix I is that all the returns of equities across countries have suffered from sharp drops between 2008 and 2009. However interestingly the downturn effects of financial crisis is not reflected in the returns of the ILBs and nominal bonds as we only see small declines during that period.

Volatility has been a hallmark of emerging market asset classes throughout time. As a cost of the return advantage, equities generally show the highest average volatility compare to other asset classes. Our result has demonstrated this inference except for Argentina, where the volatility of equity is the lowest, but still at a high level compared to other countries. Being different from the finding of Kothari and Shanken (2004), ILBs seemed to lose their attractive property regarding volatility, for seven out of ten[5] countries have shown higher average volatilities of ILBs than those of nominal bonds. However, the differences of volatility are very small, only in Turkey did we find the volatility of ILBs exceeded that of nominal bonds by nearly 2%. To take a deep look into the volatility trend, we have plotted the monthly standard deviations of returns for three asset classes within a moving one-year window (Appendix II). Consistent with what we have found in Table 1, despite Argentina, the equities still show the highest volatilities across different asset classes. During the crisis, all the returns have been more volatile, while the volatilities of equities have shown higher increases compared to those of ILBs and nominal bonds.

[5] South Korea has been excluded since there's no corresponding data for local nominal bonds.

For most of the countries, the volatilities of nominal bonds and ILBs have behaved in a similar trend within the market, and on average they have converged recently. This might be due to the fact that the volatilities of ILB yields have been very similar to those of nominal yields as breakeven inflation rates have stabilized. Alternatively it could be caused by the duration effect; we will discuss the mechanism of ILBs volatility later in Chapter 5.

Research into the distribution characteristics of ILBs shows that, seven out of eleven countries have negative skewness, among which five are emerging countries. The skewness for a normal distribution is zero, and any symmetric data should have a skewness near zero. Negative skewness indicates data that are skewed left as the left tail is long relative to the right tail; and positive skewness indicates data that are skewed right as the right tail is long relative to the left tail. Behavioral finance studies have found that, in general, investors prefer assets with positive skewness, as sometimes the investors are willing to accept low (or even negative) expected returns for these assets (Swedroe, 2003). A classic example is the lottery ticket, where the odds of winning the jackpot are extremely low, but the few times it does occur, the winnings are extremely high. To take on negative skewness, investors demand a higher expected return. Regarding the ILBs in emerging markets, the negative skewness is consistent with the higher expected return. Positive excess kurtosis[6] can be found in the ILBs of Argentina, Poland, Turkey and South Korea, which means it is more likely that their future returns will be either extremely high or extremely low.

Regarding the difference between the emerging markets and developed ones, the emerging markets have shown higher inflation, which is on average more volatile over the sample period. Generally, many emerging market governments maintain certain disinflationary policies. When the markets distrust such policies, issuing ILBs can reduce the funding costs since the initial assumptions of breakeven inflation rate will be too high, and will subsequently decline as inflation undershoots forecasts (Bekaert & Wang, 2010). In that context, the volatility of inflation trends in emerging markets can be a sizeable fiscal boon for the investor compared to the developed markets. Moreover, most of the ILBs in emerging markets have contributed superior returns, accompanied by slightly higher volatilities, which make the ILBs in emerging markets more attractive compared to those in the developed countries. For the equities, consistent with the general knowledge, the equities are more volatile than bonds in both emerging and developed markets —particularly in the former one where local liquidity can be limited or where the free float is restricted.

[6] The excess kurtosis can be calculated by subtracting 3 from the real kurtosis; the "minus 3" is often explained as a correction to make the kurtosis of the normal distribution equal to zero. For more information, please refer to http://en.wikipedia.org/wiki/Kurtosis

CHAPTER 5 Methodology

5.1 Fisher Equation

The Fisher equation, which was named after Irving Fisher, famous for his works on the theory of interest, states that the yield on a nominal bond would be the sum of three components: the inflationary expectations, a required real yield that is equal to the expected average inflation rate over the bond's life, and a risk premium, which reflects the compensation for the risk of future inflation which is higher than expectation. Since the ILBs are free of inflation risk, it allows the substitution of actual real yields for required real yields, in the formula, to give:

$$(1+n) = (1+i)\,(1+f)\,(1+prem) \qquad (3)$$

Where n = the yield on nominal bond

i = the real yield of ILB

f = the inflationary expectations

$prem$ = the inflation risk premium

If inflation and interest rates are relatively low then this can be approximated with an additive form:

$$n = i + f + prem \qquad (4)$$

Although the ILBs are directly backed by the governments of different countries, and hence provide the practical proxy for a positive, "risk free" yield that an investor can hope for, they are still not perfectly risk-free asset. Any government could default on its debt or fudge the CPI numbers. Especially in emerging markets, where the political and economic situation is not as stable as in the developed countries, this might be a risk. Take Argentina for example; with the highest credit risk in the world, Argentina's central government is still severely restricted in its access to international credit markets after its historic debt default in 2001 of about $95 billion (Farzad, 2010). So the real yield for ILBs in Argentina is indeed a combination of risk free rate plus a significant premium for credit risk.

5.2 Breakeven Inflation Rate

By rewriting the Equation 4 another representation of nominal bond yield can be achieved:

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

Where $beir$ = breakeven inflation rate

As can be seen from Equation 5, in principle, the breakeven inflation rate is the difference between the returns of an ILB and a comparable nominal bond issued at the same term. In theory, calculating it by simply subtracting a real yield from a nominal yield is a bit crude since there will be certain biases, such as the reinvestment risk, the term mismatch between the ILB and nominal bond, and deviations from real yield caused by the indexation lag (James, 2004). In some markets, it is even hard to find a proper nominal bond as the comparator. The real theoretical measurement of breakeven inflation rate only comes

into existence when there is no lag of the identical term, and both the ILB and nominal bond are zero-coupon.

We should also pay attention to the fact that it is not easy to disaggregate the breakeven inflation rate into inflationary expectations and the risk premium as these two components are either very difficult to find or even not observable (James, 2004). Moreover, in the early stages of the development for many ILBs markets, the breakeven inflation rates were below what was commonly perceived to be expected future inflation. Besides the reason that the liquidity of market may skew preferences towards nominal debt, government would like to pay a premium and accept a relatively cheaper issuance in the early stage of a program because of the future diversification benefit from the ILBs (Shen, 2006). However, due to the higher supply in the short term than the investors thought, the market clearing breakeven level may still be lower than consensus inflation expectations. Although from this point of view considering the breakeven inflation rates as the representative of the expectations and risk premium is a bit simplistic, it has often been used as the starting point for academic studies.

5.3 The Duration of Inflation-linked Bonds

Mechanically, two variables drive the volatility of ILB returns (Campbell, Shiller, Viceira, 2009). One is the volatility of the yields, since the returns of ILBs depend on the correlation between real yield changes and break-even-inflation changes on whether the volatility is higher or lower of ILBs. The other is the duration, which equals the elasticity of a bond's price with respect to its gross yield. Coupon bonds have a longer maturity than their duration, and their duration increases as yields fall. As the yields of ILBs are lower than those of the nominal bonds, their durations are longer compared to the nominal bonds durations for the same maturity. And hence ILBs tend to have a greater return volatility for the same yield volatility. In this paper, we can hardly avoid such effect as the data we used are for 'all maturities[7]', which means the maturities, as well as the durations of different asset classes cannot be the same. For example, the maturity of ILBs in a country which has only one or two ILBs issued (such as maturity for 5 years and 10 years), can hardly be the same as that of nominal bonds in the same country, where more than five kinds of assets have been issued (such as maturity for 5, 10, 20, 30 years etc.).

However, it is very difficult to match the duration of ILBs with nominal ones. Although it is easy to calculate a modified duration for ILBs, the number itself is incomparable to the duration of nominal bonds. In order to achieve equivalency with the duration of a nominal bond, we need to calculate the sensitivity to expected inflation and the covariance between the real yield and inflationary components. By taking the variance of the both sides of Equation 5, we can get the following equation:

[7] The 'all maturities' index includes all assets issued in the corresponding country with diverse maturities.

$$Var(n) = Var(i)+Var(beir)+\{2Cov(i,beir)\} \quad (6)$$

Where $Var(n)$ = variance of nominal yield

$Var(i)$ = variance of real yield

$Var(beir)$ = variance of breakeven inflation rate

$Cov(i,beir)$ = covariance between real yield and breakeven inflation

Provided the covariance between the real yield and breakeven inflation rate is not sharply negative, nominal yields will be more volatile than real yields. In other words, the yield sensitivity of ILBs to a change in the equivalent nominal yield will usually be less than one (James, 2004). If such sensitivity could always be a stable number then it would be easy to calculate the equivalent duration. Nevertheless, it fluctuates a lot in the practice, as there have always been phases where it is significantly positive and others where it is reasonable negative.

5.4 Pearson's Correlation and Rolling Windows Method

One of the main purposes of this paper is to investigate how the returns of ILBs are correlated to those of other asset classes. To answer this question statistically, the most familiar measure of linear dependence between two quantities- the Pearson product-moment correlation coefficient, has been applied. Also referred to as the Pearson's correlation it was developed by Karl Pearson elaborating a similar but slightly different idea introduced by Francis Galton in the 1880s (Rodgers and Nicewander, 1988; Stigler, 1989). The Pearson's correlation is obtained by dividing the covariance of the two variables by the product of their standard deviations. In formula, the historical correlations of maturity m are computed as following:

$$\rho_T = \frac{\sum_{t=T-m}^{t=T-1} x_t y_t}{\sqrt{\sum_{t=T-m}^{t=T-1} x_t^2 \sum_{t=T-m}^{t=T-1} y_t^2}} \quad (7)$$

Where $x_t = X_t - \bar{X}, y_t = Y_t - \bar{Y}$

Where X_t and Y_t represent two return series, of which the mean is $\bar{X}$ and $\bar{Y}$, respectively. The Pearson correlation ranges from −1 to 1. A value of +1 denotes a perfect positive (increasing) linear relationship, with all data points lying on a line for which Y_t increases as X_t increases. A value of −1 denotes a perfect negative (decreasing) linear relationship, with all data points lay on a line for which Y_t decreases as X_t increases (Dowdy and Wearden, 1983). A value of 0 implies that the variables are independent with each other, that is to say, there is no linear correlation between the variables. And the values between −1 and +1 represent the degree of linear dependence between the variables. The closer the coefficient is to either −1 or +1, the stronger the correlation between the variables. When it approaches 0 the relationship is weak.

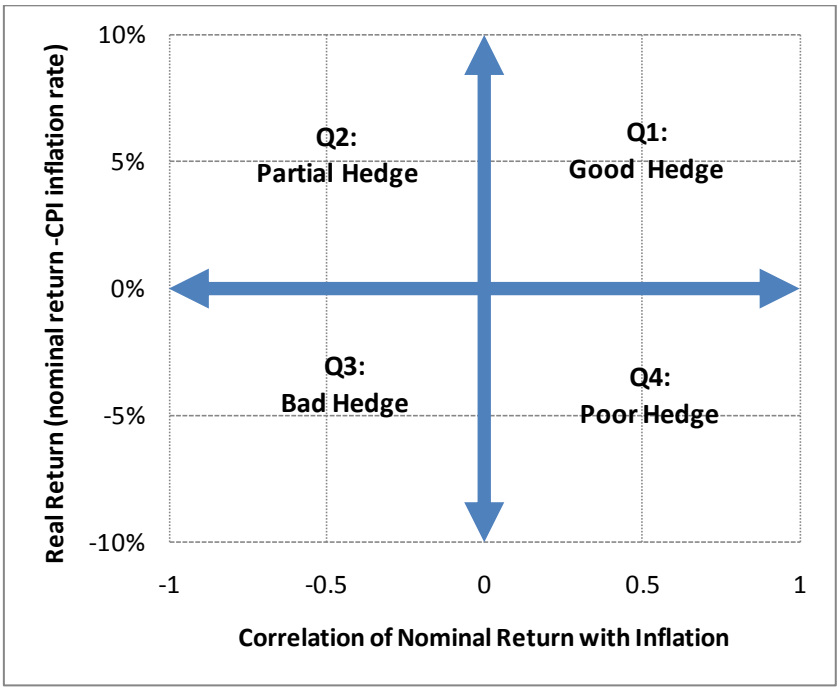
To investigate the time-variance of the correlations, the rolling windows approach has been chosen as the basic method. In specific, to determine the smoothness of the temporal movements of the data, the width of the window has to been decided firstly. In general, a shorter window will produce more erratic time series of sample correlations but will give a better representation of the contemporaneous correlation (Jia & Adland, 2002). Due to the limited amount of the available data in this paper, the width of the window has been set as 12 months. Then the correlations between returns of ILBs and those of other asset classes have been calculated over the window. And by adding a more recent monthly data on the bottom of the series and meanwhile deleting one oldest data from the beginning, the correlation window starts to "roll". However, there are some shortcomings in using the historical correlations. Firstly, they cannot explain the dynamic characteristics of the returns for asset classes, such as the time varying conditional variance. Secondly, the resulting time series of correlations from the sequential overlapping samples would tend to exhibit so-called "ghost features" (Alexander, 1996). As the impact of major market movements are reflected in the correlations up to the width of the window-here, 12 months-after they occurred. Last but not least, the chief drawback of the application of rolling windows is that the resulting time series are heavily auto-correlated and hence tricky for further econometric analysis. Nevertheless, it is still the most straight forward approach to preliminary historical analysis of time-varying correlation, which is the object of this paper.

5.5 Inflation Hedging Matrix

According to a latest research of Colonial First State Global Asset Management[8] (Hartigan, 2010), to value the inflation hedging properties of assets, two different but complementary criteria should be considered: real return and correlation with inflation. The real return equals to the total return minus the inflation rate. Hence a positive real return means the overall total return from an asset is in excess of price inflation, that is to say, the asset provides an investor with a return that outpaces inflation. The correlation with inflation measure how an asset's return moves in line with price growth. If the return from an asset is positively correlated with inflation, it will rise as inflation starts to accelerate. Hence the strength of the protection against inflation can be measured by the correlation coefficient: the closer to +1.0 it is, the better the hedge it offers.

[8] Colonial First State Global Asset Management is the consolidated asset management division of the Commonwealth Bank of Australia group and Australia's largest manager of Australian sourced funds. http://www.cfsgam.com.au/Home.aspx

Figure 4 Hedging Matrix



Source: CFS GAM Research

There are four possible outcomes for the hedging performance for any particular asset based on the above two criteria, Figure 4 provides us a summary of the outcomes in the form of a hedging matrix. As we can see in Quadrant 1, an asset can be a good hedge if it has a positive real return and is positively correlated with inflation. In Quadrant 2 states a partial hedge when the asset provided only positive real returns with negative correlation. A poor hedge can be found in Quadrant 3, where the asset's return has a positive correlation with inflation but its real returns are negative. Finally, Quadrant 4 illustrates a bad hedge when the asset does not offer either a positive return or any link to movements in inflation. By counting the spots of different quadrants and studying the position they lay, we can have an overview on the strength of assets in hedging inflation. One important remark is that short selling is forbidden in this matrix, otherwise the investors can still benefit from shorting certain assets with negative correlations, which in turn make both Quadrants 3 and 4 a nice hedging. Furthermore, since the results could heavily depend on the time-varying effect, which means a shock during the period may significantly affect the outcome of the matrix, it would be more accurate to use rolling-window method instead of simple average.

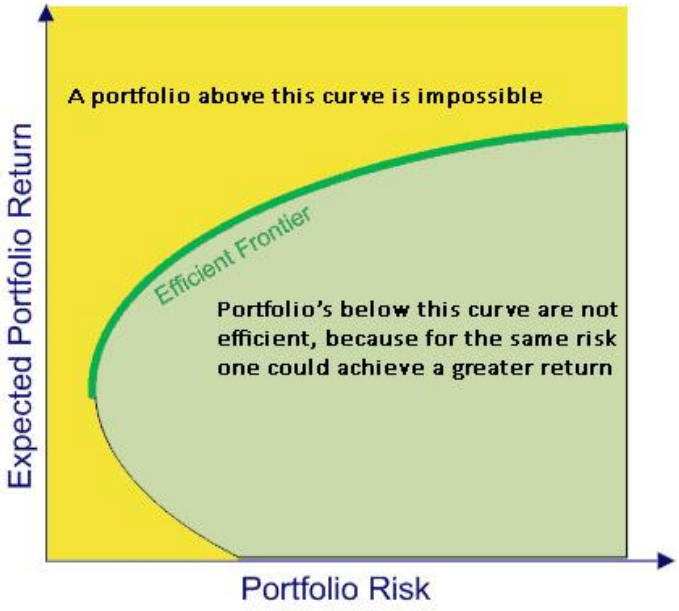
5.6 Efficient Frontier

The efficient frontier was first defined by Harry Markowitz (1952) in his revolutionary paper that launched portfolio theory. That theory considers a universe of risky investments and explores what might be an optimal portfolio based upon those possible investments. The so-called "optimal portfolio" can be defined in one of two ways:

1. For a given amount of portfolio risk, the portfolio which can maximize the expected return
2. For a given level of expected return, the portfolio which has the lowest volatility

Each definition produces a set of optimal portfolios. The first definition produces an optimal portfolio for each possible level of risk, while the second produces an optimal portfolio for each expected return. Actually, the two definitions are equivalent. The set of optimal portfolios obtained using one definition is exactly the same set which is obtained from the other. That set of optimal portfolios is called the efficient frontier. This is illustrated in Figure 5:

Figure 5 Efficient Frontier



Source: Author's adjustment based on the figure from web[9]

The green region in Figure 5 represents the achievable risk-return space. For every point in that region, there will be at least one portfolio that can be constructed and has the risk and return corresponding to that point. The yellow region is the unachievable risk-return space. No portfolios can be constructed corresponding to the points in this region. The efficient frontier is the dark green bold curve that runs along the top of the achievable region. Portfolios on the efficient frontier are optimal in both the definitions we mentioned above. Typically, the portfolios which comprise the efficient frontier are the ones which are most highly diversified. Less diversified portfolios tend to be closer to the middle of the achievable region.

[9] http://thismatter.com/money/investments/modern-portfolio-theory.htm

5.7 Mean-variance Spanning Tests

Investors are often interested in whether the addition of new asset classes (test assets) can improve the efficient frontier of the existing set of asset classes (benchmark assets). This question was first formally addressed by Huberman and Kandel (1987). The null hypothesis is that the efficient frontier of a set of K benchmark assets is the same as the efficient frontier of the K benchmark assets plus a set of N additional test assets, where N has the value of one or more. If the null hypothesis is rejected, the implication supports the notion that the test assets expand the mean-variance efficient frontier and provide diversification benefits. A complete survey of mean-variance spanning tests can be found in Kan and Zhou (2008).

We hereby briefly describe the statistical framework for mean-variance spanning tests:

The K-vector returns on the K benchmark assets are denoted as R_{1t}, similarly, the N-vector returns on the N test assts are denoted as R_{2t}. Where $R_t \equiv [R_{1t}' \; R_{2t}']'$, $E[R_t] \equiv \mu$, $Var[R_t] \equiv V$.

Ordinary least squares (OLS) are used to estimate the following specification:

$$R_{2t} = \alpha + \beta R_{1t} + \varepsilon_t, \; t = 1, 2, \ldots, T \qquad (8)$$

$$(R = XB + E \text{ in matrix form})$$

Where ε_t is independently and identically distributed as a multivariate normal with mean zero and variance $\sum$. Define $\delta = 1_N - \beta 1_K$, where 1_N is an N-vector of ones. The null hypothesis is that:

$$H_0: \alpha = 0_N, \; \delta = 0_N$$

The logic of the test is that, if the tangency portfolio and the global minimum-variance portfolio have zero weights in the test assets, the two-fund separation theorem guarantees that every portfolio on the efficient frontier of the $N+K$ assets will have zero weights in the test assets. When we are unable to reject the null hypothesis, the efficient frontier of $N+K$ assets is as same as that of K assets, which means investors can not improve the efficient frontier by adding N assets into the portfolio. Vice versa, if the null hypothesis has been rejected, which means investors can benefit from adding N test assets into the portfolio.

CHAPTER 6 Diversification Analysis

Before turning to the analysis of asset allocation, we will study the diversifying power of ILBs through several factors. In the following section we start to get an impression of the inflation-hedging properties of ILBs. We will calculate the correlations between the returns of different assets classes and inflation, and also compare their corresponding hedging matrixes. After that, we examine the intra-market correlations between three asset classes and try to find a relationship between these correlations and country risk rating. We also elaborate on inflation volatilities. Finally, taking the view point of a cross-border investor, we test the correlation at a cross-countries level by using the data in foreign currency.

6.1 Correlations with Inflation

Since the ILBs have their principals indexed to inflation, their returns are expected to maintain a higher positive correlation with the domestic inflation rate than other asset classes (Bekaert & Wang, 2010). However, the results of corresponding research in emerging markets seem to be much more complex than we imagined. Table 2 below shows the correlations of return on domestic ILBs to local inflation, derived from both the monthly and quarterly frequency.

Table 2 Correlations with Inflation for Different Asset Classes

CPI Inflation Rate and Monthly return in local currencies

Country	Asset Class	Monthly		Quarterly		Yearly	
		Inflation	Delta Inflation	Inflation	Delta Inflation	Inflation	Delta Inflation
Argentina	Nominal Bonds	(0.11)	0.03	(0.07)	0.27	0.20	0.83
	IL Bonds	(0.06)	0.04	(0.09)	0.25	0.29	0.83
	Equities	0.16	0.06	0.22	0.18	0.53	0.85
Brazil	Nominal Bonds	(0.13)	(0.20)	(0.07)	(0.03)	(0.42)	(0.46)
	IL Bonds	0.08	0.03	0.12	0.20	(0.45)	0.00
	Equities	(0.06)	0.09	(0.00)	0.26	(0.17)	0.18
Chile	Nominal Bonds	(0.20)	0.13	(0.36)	0.11	(0.27)	(0.10)
	IL Bonds	(0.01)	(0.07)	0.07	(0.13)	0.40	(0.21)
	Equities	(0.12)	0.14	(0.24)	0.27	(0.55)	0.43
Colombia	Nominal Bonds	(0.13)	(0.05)	(0.17)	(0.07)	(0.45)	(0.49)
	IL Bonds	(0.05)	0.08	(0.18)	0.07	(0.10)	(0.40)
	Equities	(0.17)	(0.15)	(0.19)	(0.08)	(0.37)	(0.16)
Mexico	Nominal Bonds	0.10	(0.11)	0.17	(0.00)	(0.45)	(0.30)
	IL Bonds	0.18	(0.04)	0.29	0.20	(0.49)	(0.13)
	Equities	(0.06)	(0.04)	(0.20)	(0.11)	(0.72)	(0.11)
Poland	Nominal Bonds	(0.17)	0.00	(0.29)	(0.09)	(0.31)	(0.36)
	IL Bonds	(0.08)	(0.22)	(0.05)	(0.36)	(0.17)	(0.23)
	Equities	(0.19)	(0.09)	(0.26)	(0.27)	(0.68)	(0.02)
South Africa	Nominal Bonds	(0.04)	(0.10)	(0.17)	(0.36)	(0.15)	(0.57)
	IL Bonds	0.26	0.07	0.44	(0.17)	0.55	(0.15)
	Equities	(0.19)	(0.06)	(0.35)	0.12	(0.58)	0.38

Turkey	Nominal Bonds	(0.02)	(0.00)	0.12	(0.09)	(0.46)	(0.49)
	IL Bonds	(0.43)	(0.43)	(0.38)	(0.42)	(0.57)	0.28
	Equities	(0.23)	(0.05)	(0.35)	(0.03)	(0.36)	0.48
US	Nominal Bonds	(0.25)	(0.15)	(0.33)	(0.26)	(0.07)	(0.24)
	IL Bonds	0.09	0.11	0.26	0.24	0.31	0.26
	Equities	0.04	0.01	0.24	0.10	0.29	0.29
EU	Nominal Bonds	(0.27)	0.00	(0.50)	(0.05)	(0.46)	(0.21)
	IL Bonds	(0.06)	0.04	(0.18)	(0.07)	(0.11)	0.26
	Equities	0.11	(0.02)	0.18	0.05	0.00	0.45

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

As can be seen from Table 2, most countries have shown negative correlations between the inflation and returns of corresponding asset classes. This is especially true for nominal bonds, which are negatively affected by unanticipated inflation. Such finding is consistent to the paper of Bekaert and Wang (2010), where half of the test countries have shown negative correlations between bond returns and inflation. As a result, it is likely that there will be periods where the real return of corresponding asset classes will be negative, thereby weakening their hedging ability as well as introducing greater uncertainty in relation to returns. At the same time, it is evident that equities are on average not particularly good inflation hedges, as we found positive correlations only in Argentina and two developed countries. However, the correlation of equity returns and inflation in US was positive, which has been different from the finding of Bekaert and Wang (2010). They demonstrated the nominal returns of stocks in the US and inflation was mostly negatively correlated. We attribute such difference to the dissimilar data and sample periods.

On the one hand, at monthly level, only four out of ten countries have shown positive correlations between the ILB returns and inflation, and ILBs in Brazil, Mexico, South Africa and the US have outperformed other asset classes. With the highest positive correlation is South Africa, at about 0.26. At the same time in Chile the correlation is almost zero, which means the return of ILBs there has hardly any relation to local inflation. Regarding the correlations to the change of the inflation rate, we have found more positive results across countries. However, only the ILBs in Colombia, South Africa and the US did outperform other asset classes.

On the other hand, at quarterly level, although only returns of ILBs in five countries are positively correlated to inflation, the absolute values substantially increased. Strikingly is the result for South Africa, where the corresponding correlation jumped to 0.44. However, for the correlations with delta inflation, some countries behaved in an opposite direction. For example, in contrast to the negative results we found with absolute inflation, Argentina has turned to relatively high positive correlations for all three asset classes. Meanwhile the correlation of ILBs in South Africa has been negative. Measured at both monthly and quarterly level, returns of ILBs in Turkey showed high negative correlations (around -0.40) no matter for absolute inflation or the change. This means that the ILBs didn't co-move with the inflation.

One interesting finding is that, Bekaert and Wang (2010) demonstrated that the inflation hedging capability of equity returns is more apparent at longer horizons, however, it only applied to our conditions

in Argentina and the US. Actually, when we expanded the time horizon, the correlation did not simply increase; instead the changes in yearly result are different from country to country. In specific, Argentina and the US have been the only two countries where the corresponding correlations with inflation have increased for all three assets. The correlations in Brazil, Mexico, Poland and Turkey tended to decrease. Regarding the other countries, there was no uniform outcome as the correlations for different assets changed in various directions. In Chile, Colombia, South Africa and the EU, the correlation of equities and inflation decreased while those of other asset classes and inflation increased. In Colombia, the corresponding correlation for ILBs increased and correlation for nominal bonds as well as equities decreased.

There are three main reasons explaining the deviation from the paper of Bekaert and Wang (2010) as well as our intuitive starting point: Firstly, past performance is not a guarantee of future results. As we have mentioned above in the methodology part, the ILBs will probably do well relative to nominal bonds, though yields are driven by inflation expectations, and not necessarily by actual inflation, especially in the short run. Secondly, our inflation rates are derived from the monthly CPI, which are normally published with one month lag. In other words, the returns of asset classes are calculated at the end of each month, but the actual inflation rates may lag by several months. This can also explain why we get better result when using a longer period, such as within a quarter. Thirdly, the duration of ILBs also affects the correlation of inflation. That is, the shorter the term of the ILB, the higher the correlation to inflation of the bond. This is because shorter-term ILBs are affected less by interest rate movements and investors' interest or inflation sentiments. Therefore, a change in inflation is more clearly reflected by the shorter-term ILB.

6.2 Inflation Hedging Properties

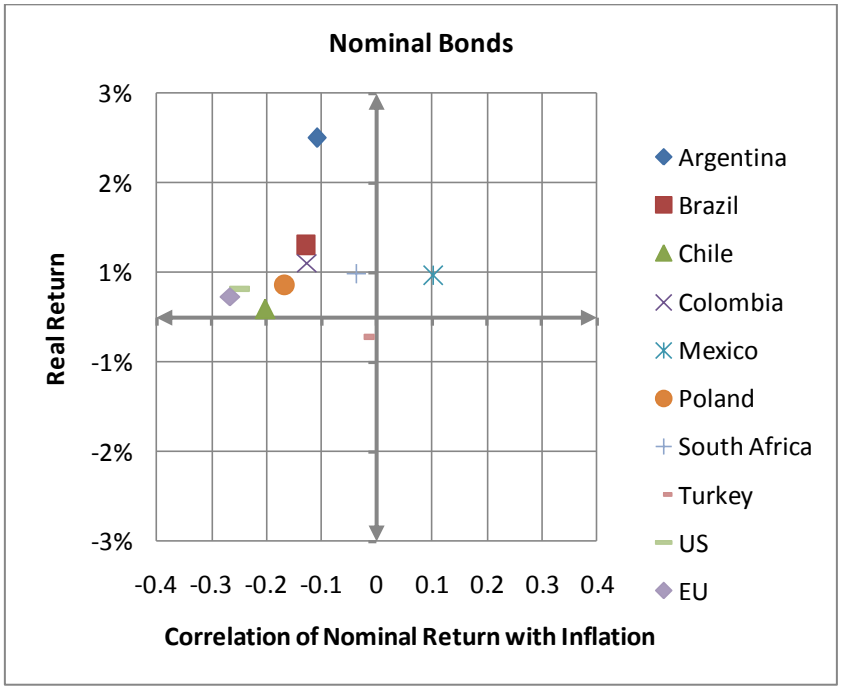
As we have introduced in Chapter 5 we can get an overview of the inflation hedging properties of assets, by relating the real return to the correlation of nominal return and inflation in a matrix. Figure 6 below illustrates the hedging matrixes of different asset classes over the sample period.

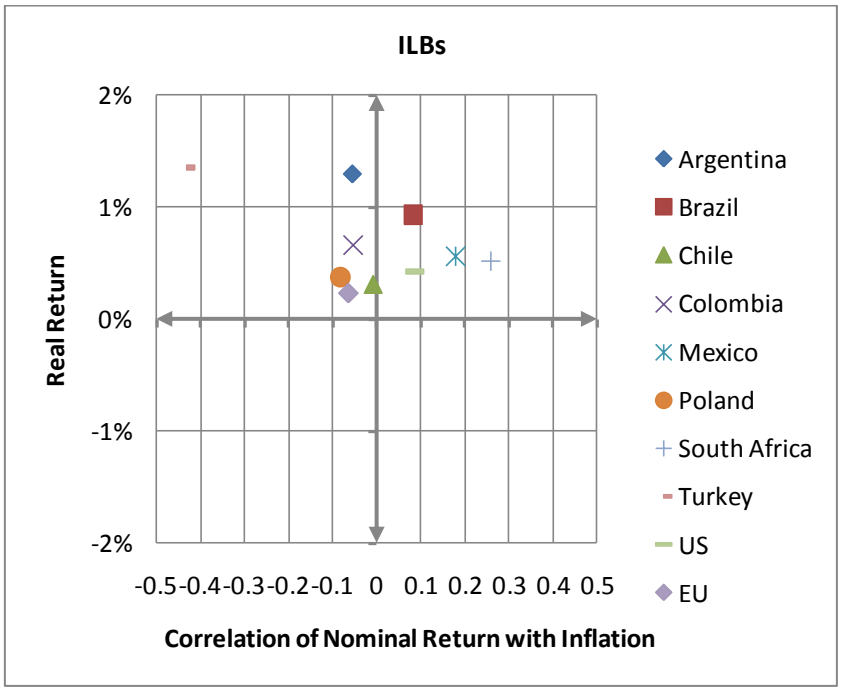
Taking all three asset classes into consideration, most assets have provided either a partial hedge or a good hedge against inflation. When compared to nominal bonds and equities, ILBs have performed the best in hedging the inflation risk, as all corresponding dots for different countries have been found laying in the good or partial hedge quadrants. For nominal bonds, we found Turkey in the bad hedge quadrant, for equities, Argentina and the US laid in the poor hedge quadrant.

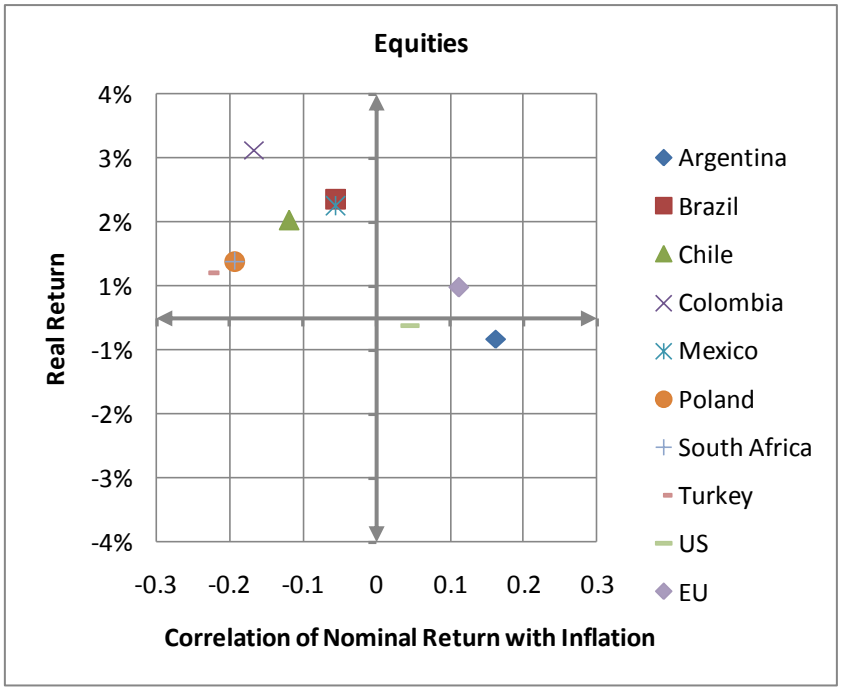
Considering the different countries respectively, ILBs in Brazil, Mexico, South Africa and the US have shown stronger power in hedging the inflation compared to nominal bonds and equities. For Argentina, nominal bonds have contributed the highest real return among three asset classes, while the correlation between nominal return and inflation is less than that of ILBs. For Chile, ILBs have been more tightly

correlated to inflation compared to other assets, meanwhile contributing the second largest real return behind equities. As were Colombia and Poland. The nominal bonds in Turkey were the only assets which laid in the bad hedge quadrant. Regarding the EU, equities performed the best. However, it is difficult to say that it would be easier to hedge inflation risk in emerging markets than in developed markets, which has been demonstrated by Bekaert and Wang (2010).

Figure 6 Hedging Matrix for Different Asset Classes (based on average data)







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

However, the above findings are mainly derived from the calculation based on the average data, which seems to be rather rough as certain shocks during the period may significantly affect the result. Hence we apply the same study for each country by using the moving 1 year window (see Appendix III for the hedging matrixes). Table 3 below summarizes the result of Appendix III by counting the number of plots in the different quadrants. The location of each plot is decided by the corresponding real return and correlation of nominal return with inflation over 1 year moving window.

Table 3 Summary of the Inflation Hedging Matrix (based on moving 1 year window)

Country	Asset Class	Obs.	Good Hedge	Partial Hedge	Bad Hedge	Poor Hedge
Argentina	Nominal Bonds	22	2	12	5	3
	ILBs	22	3	12	5	2
	Equities	22	9	3	2	8
Brazil	Nominal Bonds	67	13	38	12	4
	ILBs	67	36	16	6	9
	Equities	67	23	22	12	10
Chile	Nominal Bonds	78	9	30	36	3
	ILBs	78	23	22	23	10
	Equities	78	22	21	14	21
Colombia	Nominal Bonds	76	22	26	20	8
	ILBs	76	12	37	22	5
	Equities	76	13	38	20	5
Mexico	Nominal Bonds	75	28	18	10	19
	ILBs	75	34	14	4	23
	Equities	75	28	20	18	9
Poland	Nominal Bonds	56	12	24	11	9
	ILBs	56	14	22	11	9
	Equities	56	5	28	17	6

South Africa	Nominal Bonds	87	14	40	24	9
	ILBs	87	29	30	10	18
	Equities	87	17	33	26	11
Turkey	Nominal Bonds	26	2	7	11	6
	ILBs	26	3	15	8	0
	Equities	26	1	12	10	3
US	Nominal Bonds	111	20	48	31	12
	ILBs	111	51	19	15	26
	Equities	111	20	44	26	21
EU	Nominal Bonds	67	4	36	24	3
	ILBs	67	7	33	20	7
	Equities	67	16	25	7	19

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

As can be seen from Table 3, within the First Quadrant-"the good hedge", seven out of ten countries have been found where the ILBs are dominant. Especially ILBs in Brazil, South Africa and the US show obvious advantages, by contributing over 10 spots more than those of the nominal bonds and equities in this Quadrant. This can be seen as good evidence of the stronger hedging power of ILBs against inflation. In Argentina and the EU, equities have occupied the most. Colombia is the only country where nominal bonds ranked first. On the bottom-right of the matrix, the poor hedge quadrant, the different assets classes performed more or less the same. That is, four countries have shown equities dominated, another four have shown ILBs dominated, while three have shown nominal bonds dominated (Poland has been taken account twice as the corresponding spots of ILBs and nominal bonds are the same). One interesting finding is that different asset classes sometime can perform the best in both opposite directions. Such as the nominal bonds in Colombia are dominant in both the First and Fourth Quadrants; the same thing holds for the ILBs in Mexico, South Africa and the US; as well as equities in Argentina and the EU. The reason behind this might be the unexpected inflation shocks which make the asset class deviate from its general pattern.

6.3 Intra-Market Correlations

To hedge the risk of investment, people generally prefer to diversify the portfolio with different asset classes, of which the returns are historically weakly or non-correlated. Since the chosen asset classes perform independently of one another, if one financial instrument makes neutral or negative returns, investors can still gain from an asset class which makes positive returns. According to the literature, the ILBs in developed markets have contributed a lot in showing a strong diversifying power during their first years in existence. (Roll (2004), Kothari and Shanken (2004)). However, one of the studies of Brière and Signori (2009) has suggested that in more recent years, with a relatively high correlation with other asset classes, the ILBs in developed markets have gradually lost their attractiveness as strong diversifying instruments. Did the same thing happen to the emerging markets? To answer this question, the correlation

matrixes calculated for both emerging countries and developed ones over the available sample periods are illustrated in Table 4. We also consider two factors that might have certain impact or co-move with the correlations: standard deviation of the inflation rate and country risk rating, the latter of which is derived from the Institutional Investor Country Credit Rating (IICCR). Since 1979, Institutional Investor has been asking senior economists and risk analysts to rate individual country credit worthiness, and then compiled their responses to determine country credit ratings (Institutional Investor, Inc., 2010). Due to the limitation to the access of latest data, the 2007 IICCR has been applied in this paper (Institutional Investor, Inc., 2007). Regarding the ranking of the EU, arithmetic average has been calculated through dividing the sum of the rankings from the EU countries by number of the corresponding members. We will discuss both factors further in Chapter 6.4.

Table 4 Correlations of Monthly Return for Different Asset Classes (local currency)

Country	Correlations			Co-moving Factors	
	Nominal Bonds vs. ILBs	Nominal Bonds vs. Equities	ILBs vs. Equities	Inflation Volatilities	Country Risk Rating
Argentina	0.82	0.48	0.64	0.26%	44.4
Brazil	0.69	0.35	0.39	0.21%	61.2
Chile	0.80	0.01	(0.12)	0.53%	77.6
Colombia	0.66	0.46	0.44	0.53%	56.6
Mexico	0.78	0.37	0.36	0.32%	70
Poland	0.23	0.43	0.38	0.32%	71.2
South Africa	(0.03)	0.08	(0.10)	0.53%	66.7
Turkey	0.21	0.00	0.51	0.83%	51.7
US	0.71	(0.27)	0.05	0.36%	94.1
EU	0.59	(0.24)	0.22	0.36%	82.0

Source: Author's calculations based on Barclays Capital and DataStream)

One often cited source of diversification provided by ILBs is the fact that they exhibit negative correlation with other asset classes, especially equities and moderate correlation with nominal bonds. However, in our sample, the negative correlation with ILBs and equities can be found only in Chile and South Africa, which means the ILBs in these countries can be used as perfect substitutes for equities. Overall the correlations of ILBs and nominal bonds are relatively high, except for Poland, South Africa and Turkey, where the results are lower than 0.50.

Since nominal bonds and equities are negatively affected by unanticipated inflation, they are expected to correlate positively because of their similar sensitivity to inflation. In contrast ILB returns are positively affected by inflation through the negative relationship between inflation and real interest rates. Consequently the returns of ILBs and equities might co-move less strongly than those of nominal bonds and equities do (Kothari and Shanken 2004; Brière and Signori, 2009). Our results for emerging countries are partly consistent with such judgment, for five out of eight countries have shown lower correlations of

ILBs between equities compared to those of nominal bonds between equities. This finding suggests that ILBs of emerging markets still provide stronger diversifying power when compared to nominal bonds, attributing to their market properties such as more volatile inflation expectations and less liquidity market condition.

For the developed countries, the correlations of ILBs and equities are higher than those of nominal bonds and equities, although they are relatively low compared to those in emerging countries, regarding intra-market correlation. Such result is different from the finding of Brière and Signori (2009), where they have found that since 2003, there has been a strong analogy between the equities vs. nominal bonds correlations and equities vs. ILBs correlations. As it has been shown in Chapter 2, this might due to the differences of the dataset and sample period between their paper and ours. However, we still arrive at the same conclusion as Brière and Signori (2009) that the ILBs in developed countries have less diversifying strength.

Since correlations are very unstable, the covariance matrix calculated above on the whole period may partly conceal the real-world situation. To solve this problem, we have portrayed the time-varying correlations by applying the rolling window approach. Appendix IV plots the correlations of monthly returns between three asset classes over a moving one-year window.

In accordance with what we have found in the above covariance matrixes, the time-varying correlations of ILBs and nominal bonds remain at a high level compared to other correlations. Meanwhile, most countries have contributed some negative correlations of ILBs and equities during the sample period. Across all emerging markets- with the exception of Turkey- the ILB returns and equity returns co-moved less strongly compared to nominal bonds and equities. This indicates that investors can benefit more from the diversifying power of ILBs than when adding nominal bonds. Furthermore, the correlations in most of the countries have shown a tendency of decreases during the financial crisis. For the developed countries, such difference is almost unnoticeable in the years before 2008 as the equities vs. nominal bonds correlations and equities vs. ILBs correlations have almost coincided with each other.

Regarding developed countries, we have found similar trends for the behavior of the correlations between ILBs and nominal bonds. Fluctuating and relative volatile before 2003, the correlations approached a high level about 90% and were extremely stable until the financial crisis. According to some earlier studies (Lucas and Quek (1998), Lamm (1998)), the correlation between ILBs and nominal bonds mainly depend on whether nominal interest rate movements are more reflective of changes in real interest rates or changes in inflation expectations. That is, when real rates are moving the market, ILBs and nominal bonds tend to be more correlated, while when inflation expectation drives the nominal interest rate, a lower correlation may be expected.

To sum up, both the tables of correlation matrix and the time-varying figures have told us a similar story. Although the correlations of ILBs with other asset classes have fluctuated during the sample period, and

there have been differences regarding the performances across countries, the diversifying power of ILBs in emerging markets has not diminished as that of developed markets.

6.4 Country Risk Ratings, Inflation Volatilities and Correlation

As with all types of debt, investors in the emerging markets need to take into account country risk, which arises from the changes of the financial environment and which could negatively affect the operating profits or the assets values. The countries which belong to the emerging market category cover not only a wide geographic area, but are also characterized by diverse ranges of macroeconomic situations. For example, due to the difference in financial factors and stability factors, investors would recognize that the issues facing Mexico are quite different from those facing South Korea. Accordingly researchers have paid much attention to explain the relationship between the country risk and correlations of different asset classes, which is exceedingly meaningful for inflation-related product, such as the ILBs. In a paper of Kelly, Martins and Carlson (1998), the authors revealed that there are greater degrees of co-movement in emerging markets than in developed markets, as the lower a country's perceived creditworthiness, the higher the intra-market correlations of domestic bond or equity returns. Erb, Harvey, & Viskanta (1999) proved such finding by demonstrating the asset classes in emerging markets have higher intra-market correlations than those in the developed markets. In a more recent paper, Panchenko and Wu (2009) also approved this while did not find incremental explanatory power for country ratings.

The second factor that we took into account has been the stability of inflation expectations. As we discussed before, inflation expectations could drive the nominal interest rate and thus affect the correlation between the returns of ILBs and those of other assets. Especially when the inflation of market is believed to be more volatile, the use of ILBs to compose portfolios seems to be more attractive: this is not only due to their relative strong hedging power against inflation but also because of the low correlations between other asset classes. Our hypothesis is hence that the more stable expectations of inflation are, the higher the correlation between the returns of ILBs and those of other asset classes is. However, since it is difficult to get data of inflation expectation, we have used the volatility of historical inflation as substitutes.

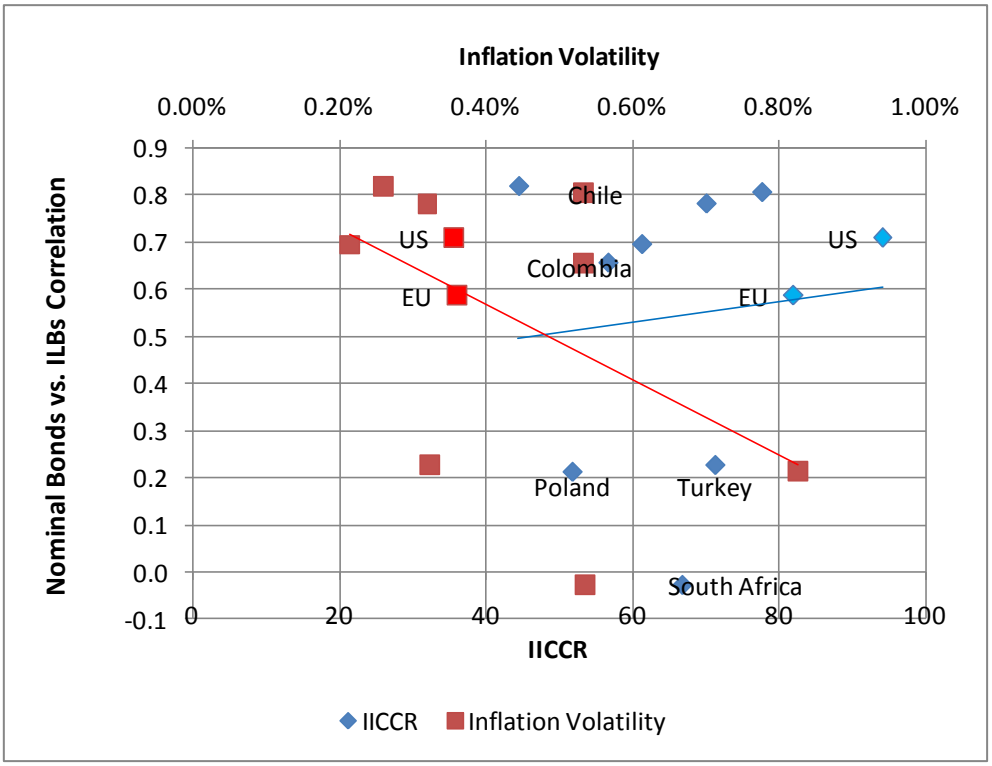
Figure 7, 8 and 9 below illustrated the relation between the correlation and the two factors we have introduced in Table 4. The blue and red lines are the linear regression lines showing the co-movement trends between correlations and IICCR, correlations and volatility of inflation respectively. The finding of Kelly, Martins and Carlson (1998) has been partly demonstrated by the downward blue lines in both Figure 8 and 9. As with the increase of the IICCR, both the correlations of the ILBs vs. equities and nominal bonds vs. equities decrease. However, we have found a different picture regarding the correlations between returns of nominal bonds and returns of ILBs, which increase as IICCR rise. Meanwhile, we have found that the intra-market correlations for the developed and emerging markets are

substantially different between diverse asset classes. The intuition that asset classes in emerging markets tend to have higher correlations than developed markets hence doesn't apply to all the samples we used.

On the other hand, our intuition regarding the negative relation between the correlations and volatility of inflation has been fully demonstrated by the downward red lines in all three figures. That is, a more volatile inflation always accompanies with a lower correlation between the returns of ILBs and those of other asset classes. Interestingly, such finding also holds for the correlation between returns of nominal bonds and those of equities. Another interesting finding is that, in Figure 7, the spots of the US and the EU lie in the top-right corner, which means the nominal bonds vs. ILBs correlations in developed countries are relatively high considering their high credit rating. Being consistent with our intuition, in Figure 8 and 9, the spots which represent the correlations in developed countries mainly concentrate in the lower right corner.

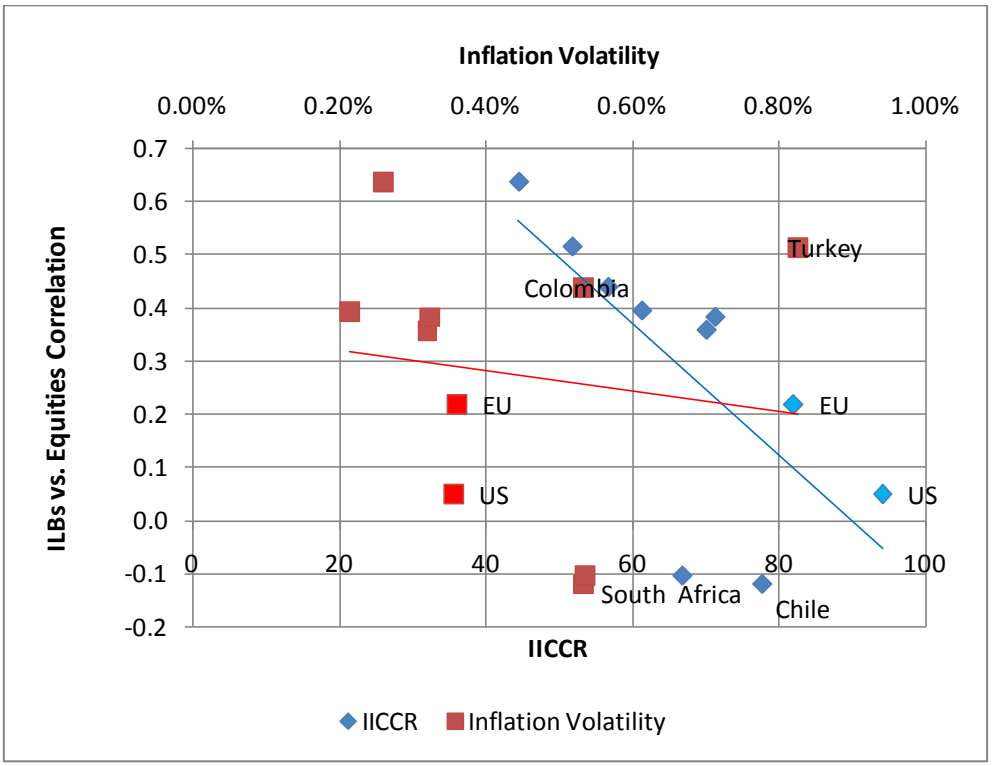
Some unique behaviors of correlations in specific countries also caught our eyes. For country risk rating, we have found a common behavior regarding three types of correlations in South Africa, which are much lower compared to those in the US and the EU, especially when considering its corresponding IICCR is not as high as those of developed countries. Same finding applies to Poland (Figure 7), Turkey (Figure 7&9) and Chile (Figure 8&9). For volatility of inflation, Colombia has shown high correlations under relatively volatile inflation in all three figures. Same finding applies to Chile (Figure 7) and Turkey (Figure 8).

Figure 7 Nominal Bonds vs. ILBs Correlations regarding Country Risk



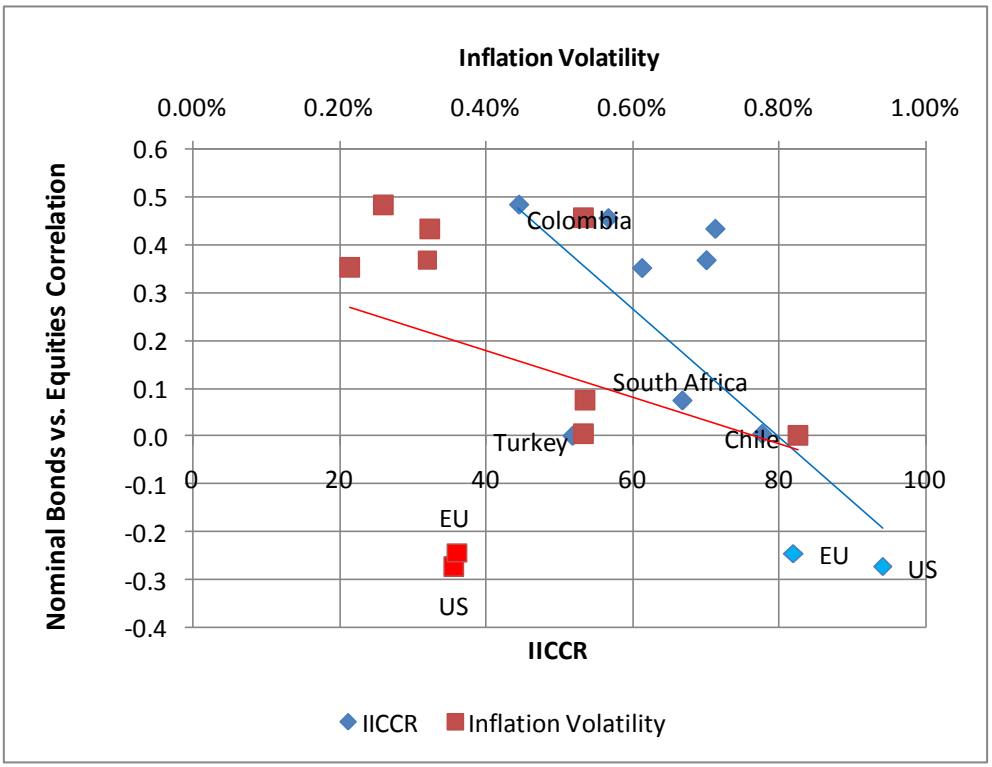
Source: Author's calculations based on Barclays Capital, DataStream and Institutional Investor

Figure 8 Equities vs. ILBs Correlations regarding Country Risk



Source: Author's calculations based on Barclays Capital, DataStream and Institutional Investor

Figure 9 Nominal Bonds vs. Equities Correlations regarding Country Risk



Source: Author's calculations based on Barclays Capital, DataStream and Institutional Investor

6.5 Cross-Country Correlations

As we have found in the previous sections, to protect a portfolio against inflation, ILBs in emerging markets are still of strong diversifying power compared to those in developed ones. However, little is often made of the fixed income portion as investors typically have a bias for ILBs in their home market. Instead, investors may better look globally in getting the best value of money hedge against inflation. By using a mix of the cheapest possible markets, investors can benefit from the wider opportunity set and improve the diversification benefit. Table 5 to Table 7 below show the cross-country correlations of different asset classes returns, using the monthly return data in foreign currency[10] (USD) of eight emerging markets and two developed ones.

Table 5 Cross-country Correlations of Nominal Bond Returns

July 2007 - March 2010, Monthly Return, USD

	Argentina	Brazil	Chile	Colombia	Mexico	Poland	South Africa	Turkey	US	EU
Argentina	1.00									
Brazil	0.56	1.00								
Chile	0.47	0.44	1.00							
Colombia	0.42	0.70	0.39	1.00						
Mexico	0.33	0.64	0.47	0.53	1.00					
Poland	0.29	0.60	0.35	0.62	0.68	1.00				
South Africa	0.24	0.56	0.36	0.69	0.50	0.62	1.00			
Turkey	0.48	0.69	0.43	0.71	0.59	0.64	0.78	1.00		
US	(0.07)	(0.17)	0.15	0.06	0.07	0.18	0.05	0.08	1.00	
EU	0.34	0.55	0.50	0.55	0.53	0.75	0.56	0.53	0.56	1.00

Source: Author's calculations based on Barclays Capital

Regarding the correlations of nominal bond returns, we have found moderate results throughout countries, ranging from -0.17 of the US vs. Brazil to 0.78 of South Africa vs. Turkey. The US has contributed the lowest correlations with other countries, among which two negative results have been found with Argentina and Brazil. Such negative correlations suggest the returns of ILBs in these emerging countries hardly have any common trends as those in the US, and hence could fully substitute with each other within one portfolio. In other words, investors could benefit from a portfolio composed of nominal bonds from the US and other countries.

[10] For the cross-country investment, a portfolio should be composed under same currency unit, where EURO or USD has been frequently used.

Table 6 Cross-country Correlations of ILB Returns

March 2007 - March 2010, Monthly Return, USD

	Argentina	Brazil	Chile	Colombia	Mexico	Poland	South Africa	Turkey	US	EU
Argentina	1.00									
Brazil	0.53	1.00								
Chile	0.60	0.37	1.00							
Colombia	0.42	0.66	0.29	1.00						
Mexico	0.40	0.61	0.38	0.48	1.00					
Poland	0.38	0.46	0.24	0.47	0.64	1.00				
South Africa	0.41	0.57	0.29	0.52	0.57	0.64	1.00			
Turkey	0.65	0.67	0.40	0.67	0.62	0.47	0.72	1.00		
US	0.45	0.41	0.51	0.26	0.60	0.37	0.31	0.52	1.00	
EU	0.48	0.52	0.48	0.47	0.58	0.62	0.63	0.62	0.77	1.00

Source: Author's calculations based on Barclays Capital

Similar patterns can be found for ILBs in Table 6, despite on average higher results in the US compared to the correlations of nominal bonds. Returns of ILBs in Chile and Poland contribute the lowest correlation (0.24), however, no significant advantage has been found throughout countries, as all correlations are positive. Chile is characterized by relatively low correlations compared to other countries, as considering the corresponding results between other countries, 5 out of 9 are lower than 0.40. On the other hand, the highest result attributes to the correlation within developed countries (0.77), among which the EU seems to more tightly correlate to the emerging markets compared to the US. Another interesting finding is that there is no obvious evidence supporting the correlations between countries within the same area are higher than those in the different areas. For example, the correlation of Colombia vs. Mexico is lower than that of Colombia vs. South Africa and Turkey.

Table 7 Cross-country Correlations of Equity Returns

April 2004 - March 2010, Monthly Return, USD

	Argentina	Brazil	Chile	Colombia	Mexico	Poland	South Africa	Turkey	US	EU
Argentina	1.00									
Brazil	0.55	1.00								
Chile	0.47	0.65	1.00							
Colombia	0.35	0.44	0.46	1.00						
Mexico	0.54	0.69	0.64	0.58	1.00					
Poland	0.40	0.61	0.52	0.46	0.67	1.00				
South Africa	0.39	0.68	0.57	0.54	0.68	0.67	1.00			
Turkey	0.42	0.50	0.53	0.45	0.57	0.53	0.51	1.00		
US	0.40	0.71	0.64	0.50	0.82	0.66	0.66	0.65	1.00	
EU	0.47	0.77	0.67	0.53	0.78	0.74	0.73	0.63	0.89	1.00

Source: Author's calculations based on Barclays Capital

Compared to the corresponding results of nominal bonds and ILBs, equities have been found to show on average higher correlations. Such stronger connections suggest that the potential benefit of cross-country

integration is not obvious considering equities. This holds especially for the correlation of the US vs. the EU, which is extremely high with about 0.89. It might due to the fact that, as the equity markets of developed countries are more integrated to the world market, the returns of equities there could be more driven by the same factors. Such trend of globalization hence increases the commonality in returns and has a positive effect on cross-country correlations. Consequently, people who aim at diversifying domestic risk by investing in a portfolio of equities both from developed countries may not benefit as much as they expected.

CHAPTER 7 Asset Allocation

Upon the appearance of any new asset, investors are anxious to know how it fits into a well-diversified portfolio. ILBs in emerging markets provided no exception to this rule. In this section, the primary results for the analysis of asset allocation will be presented, using the same three classes of assets as earlier discussed in the paper: ILBs, nominal bonds, and equities. Although investment portfolio in the real world would not be restricted to such broad asset classes, and the results may differ between countries, some insights about how ILBs fit in to an overall investment strategy can be gained.

7.1 Portfolio Efficiency

To give an overall feel of the benefits of diversification by using ILBs instead of nominal bonds, the return characteristics of portfolios constructed with various percentages of bonds and equities are presented in Table 8. However, since it is rather difficult to find the corresponding risk free rates in the emerging markets, we hereby only apply the Sharp ratio related research on South Africa, where the risk free rate is derived from the long-term annual interest rate from OECD.Stat[11] during the sample period from February 2002 to March 2010 (OECD, 2010).

Table 8 Characteristics of Equity-Bond Portfolios in South Africa

	Percent Bond Allocation						
Portfolio	0	20	40	50	60	80	100
A. Nominal bonds used							
Return	1,31%	1,23%	1,15%	1,11%	1,07%	0,99%	0,91%
Standard Deviation	5,35%	4,33%	3,37%	2,92%	2,53%	1,98%	1,98%
Sharpe ratio	10,44%	11,04%	11,80%	12,20%	12,51%	11,89%	7,78%
B. Inflation linked bonds used							
Return	1,31%	1,24%	1,16%	1,12%	1,08%	1,01%	0,93%
Standard Deviation	5,35%	4,26%	3,20%	2,68%	2,19%	1,36%	1,20%
Sharpe ratio	10,44%	11,33%	12,74%	13,77%	15,15%	18,74%	14,92%

Source: Author's calculations

For the given weights, investing in ILBs seems to contribute more in risk reduction when compared to nominal bonds. The standard deviations of the panel A, where the portfolios are composed of nominal bonds and equities, are continuously higher than those of the panel B, where the ILBs have used as the

[11] As it is indicated in the website of OECD.Stat, the long term (in most cases 10 year) government bonds are the instrument whose yield is used as the representative 'interest rate' for this area. Generally the yield is calculated at the pre-tax level and before deductions for brokerage costs and commissions and is derived from the relationship between the present market value of the bond and that at maturity, taking into account also interest payments paid through to maturity.

substitutes for nominal bonds. To be more specific, within an equal-weighted portfolio of equities and bonds, the standard deviation is about 0.24% lower when ILBs are used instead of nominal bonds. And the difference is even higher at a level of 0.78% when the portfolio weight on bonds is 100%, which means leaving out equities.

Moreover, the Sharpe ratio in Table 8 gives some insights for portfolios with various weights taking return into consideration. As a common measurement of the excess return to risk, the Sharpe ratio is maximized by the mean–variance optimal portfolio. In this case, the optimal asset allocation in panel A is an investment of nominal bonds/equities for 60/40. In panel B, where the ILBs are considered, the optimal allocation to bonds is 80% of the portfolio. Generally, both the expected return and risk of the overall portfolio can be lowered by investing in bonds. Comparing the two optimal conditions, the return of portfolio with nominal bonds slightly exceeds that of portfolio with ILBs by 0.06%, while the risk of the former is much higher for 1.17%. That is, in this case, the opportunity for diversification by adding nominal bonds barely improves the Sharpe ratio in comparison to ILBs.

7.2 Efficient Frontier

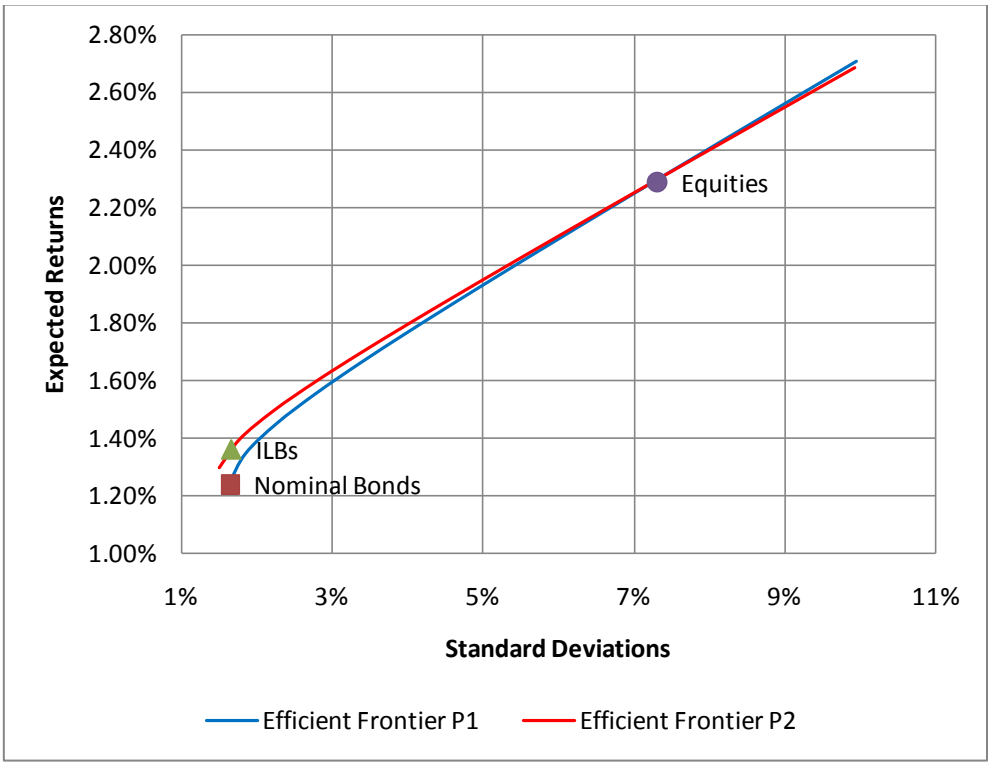
To test what role ILBs do play in asset allocation, we address whether they can provide additional diversification benefits to investors who hold an optimal portfolio of nominal bonds and equities. Specifically, we form the first portfolio (P1) with a set of spanning assets, containing benchmark asset *K*: nominal bonds and equities, and spot the corresponding efficient frontier in the graph. Then we create the second portfolio (P2) by adding a test asset *N*: the ILBs, to the first portfolio, and draw the efficient frontier in the same graph. Short sales are not allowed for both portfolios. Intuitively, the resulting frontier for P2 will lie above the original frontier only if the second portfolio with ILBs is more efficient in a mean-variance sense than the spanning assets. That is, the frontier will shift upwards if the investor's reward-risk ratio is improved by adding the test assets. In the following analysis, we have simply divided the corresponding results into two groups: efficient frontier with change and without change.

Group 1: efficient frontiers with change by adding ILBs

Brazil, Chile, Colombia, Poland and South Africa belong to Group 1, as their efficient frontiers for all the second portfolios have shifted upwards to different extents, which means the investor's reward-risk ratio is improved by adding the ILBs in these countries. The most obvious improvement can be attributed to South Africa, where by adding the ILBs to the portfolio, the corresponding standard deviation decreases with nearly 1%. It is also in accordance with the results we found in the previous chapter, as the negative correlations between ILBs and other asset classes demonstrated the strong diversifying power of ILBs.

Similarly, in Poland, where the correlation between ILBs and equities (0.38) is lower than that between nominal bonds and equities (0.43), equities have hence been fully substituted by ILBs in composing the optimal portfolio with lowest risk. The optimal asset allocation with highest returns is a 100% equities portfolio for all these countries. However, as compensation to such high returns, only the equities in Chile and South Africa have added value in composing the optimal portfolio with lowest risk. In addition, we have noticed that all the spots for equities have lie in the upper right of the graphs as well as on the corresponding efficient frontiers. This indicates that when ignoring the risk, the equities have contributed the highest expected return in composing the optimal portfolio. This is also true for Table 1, as equities have been found offering the highest returns and being the most volatile among three asset classes within these countries. The following graph gives an example for the countries in Group 1, regarding the performances for other countries which also belong to Group 1, please refer to Figure V-1 in Appendix V.

Figure 10 Efficient Frontiers for two Portfolios in Brazil

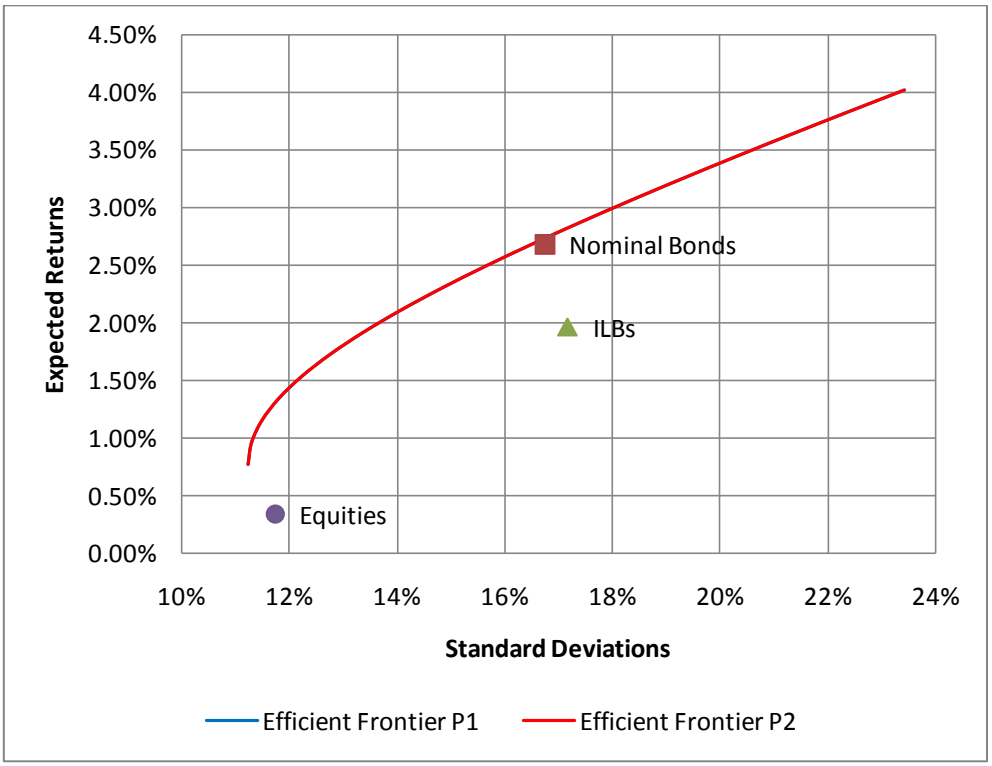


Source: Author's calculations

Group 2: efficient frontiers without change by adding ILBs

Argentina, Mexico, Turkey, the US and the EU belong to Group 2, as there are no improvements in their corresponding efficient frontiers when adding ILBs.

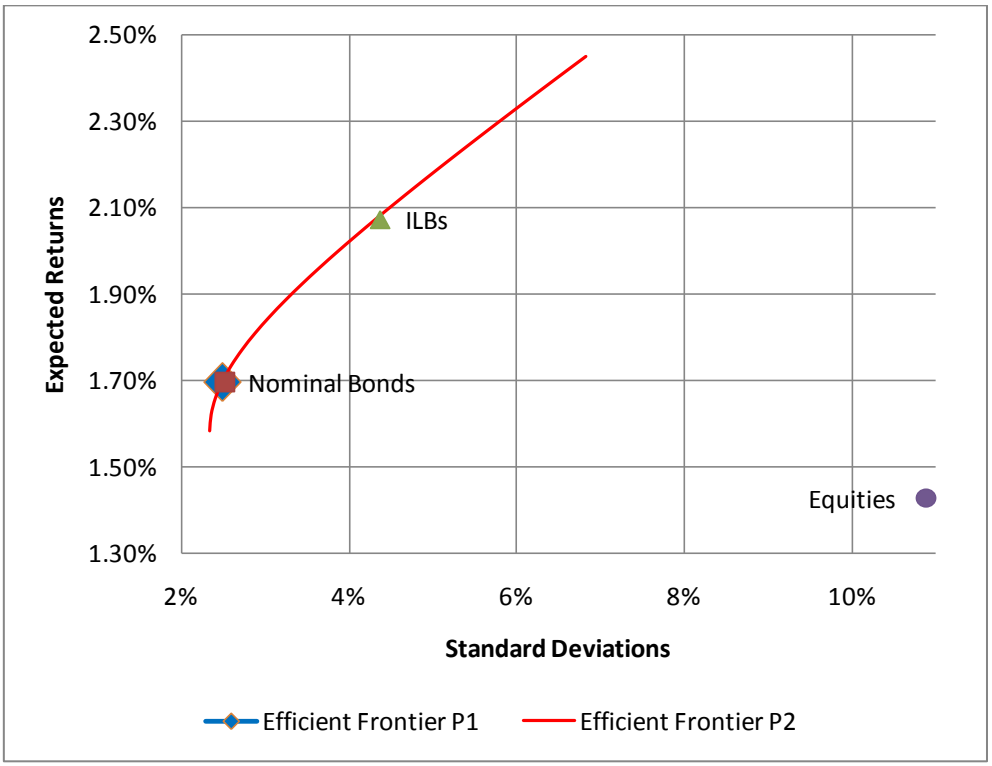
Figure 11 Efficient Frontiers for two Portfolios in Argentina



Source: Author's calculations

The result in Argentina has shown that the efficient frontiers for both portfolios are exactly the same since when composing the second portfolio, the optimal weight for ILBs is 0%. That is to say, the ILBs in Argentina do not add any value to asset allocation. Moreover, the green triangle, which represents a portfolio of 100% ILBs, lies in the right lower of the red square, which represents a portfolio of 100% nominal bonds. Such position indicates that in comparison to nominal bonds, ILBs provide higher risk but lower expected returns. The purple circle for equities lies in the left-bottom of the graph, providing a relatively low return for only 0.34% with a standard deviation of 11.74%. The above mentioned results are in accordance with the findings we discovered in previous chapters, for all three asset classes in Argentina have shown relatively high average volatilities in comparison to those in other countries. Within the country itself, the ILBs have been the most volatile over the period. And the relatively high intra-market correlations of ILBs also demonstrate they might not be good substitutes for other asset classes. The optimal allocation with the minimum risk attributes to the corresponding weights of nominal bonds for 19% and equities for 81%. A similar pattern can be found in Figure V-2 of Appendix regarding Mexico.

Figure 12 Efficient Frontiers for two Portfolios in Turkey



Source: Author's calculations

The figure for Turkey is quite unique, as when only nominal bonds and equities are available, a weight of 100% nominal bonds contributes to both the optimal portfolios of minimum risk and the highest average return. Thus we are unable to draw the corresponding curve; instead, the efficient frontier for P1 is represented as a dot. It may be due to the descriptive statistics we got in Table 1, as the average return of nominal bonds in Turkey is higher than that of equities, while the average standard deviation is lower. Furthermore, in the previous chapter, we have found that ILBs in Turkey have been positively correlated to other local asset classes, while such correlation between nominal bonds and equities was almost zero. From this point of view, it seems that we should not include ILBs in a portfolio of Turkish assets as their diversifying power is rather weak. However, 100% of ILBs do contribute the highest average return for P2, which could be very attractive for a return-oriented investor. This can also be seen from the graph, as the closer the dots on the efficient frontier P2 to the green triangle are, the higher the return of the portfolio is.

Regarding the developed countries, ILBs hardly add value in increasing the return of the portfolio or decrease the corresponding risk. In the US, since the negative correlation between nominal bonds and equities become better substitutes with each other, ILBs are even excluded when forming the optimal portfolio with lowest standard deviation. However, they have contributed to the optimal portfolio with highest returns for second portfolio. Due to the terrible performance of the equities (the purple circle for equities lies in the right-bottom of the figure), such optimal allocation attributes to 100% of nominal

bonds before including ILBs. In the EU, with a relative high returns, equities alone still construct the optimal portfolios with the highest returns no matter if ILBs have been included or not. The corresponding figures of these two developed countries can be found in Figure V-2 in Appendix.

7.3 Test for Mean-Variance Spanning

In the previous section, we have illustrated the performances of efficient frontiers in different countries when adding ILBs to their corresponding portfolios. However, for some countries, the movements are too small to be visualized by simple graphs. To offer a clearer view and more robust evidence regarding the diversifying power of ILBs, we demonstrate the result from an econometric method, by applying the mean-variance spanning test we have introduced in Chapter 5.

We hence derive the equation as following:

$$R_{ILBs} = \alpha + \beta_1 * R_{nominal\ bonds} + \beta_2 * R_{equities} + \varepsilon \quad (9)$$

$$H_0 : \alpha = 0 \text{ and } \beta_1 + \beta_2 = 1$$

The test asset is ILBs, benchmark assets are nominal bonds and equities. The null hypothesis is that the efficient frontier of a set of nominal bonds and equities is the same as the efficient frontier of these two assets plus ILBs. If the null hypothesis is rejected, the implication supports the notion that ILBs expand the mean-variance efficient frontier and provide diversification benefits. Vice versa, if we are unable to reject the null hypothesis, the efficient frontier of three assets is as same as that of two traditional assets, which means investors can not improve the efficient frontier by adding ILBs into the portfolio.

Table 9 Mean-variance Spanning Test

Country	Argentina	Brazil	Chile	Colombia	Mexico	Poland	South Africa	Turkey	US	EU
Wald Test	1.03	15.93	34.01	28.84	2.54	16.75	255.39	3.69	2.86	0.07
P-value	0.60	0.00	0.00	0.00	0.28	0.00	0.00	0.16	0.24	0.96

Source: Author's calculations

Table 9 presents the test results, which have been consistent with what we have found in the previous figures of efficient frontiers. The values in Brazil, Chile, Colombia, Poland and South Africa are statistically significant at the 1% level. This suggests that adding the ILBs of these countries enhances the mean-variance efficient frontier of a mixed-asset portfolio. In other words, the ILBs in these five emerging countries provide diversification benefits and they improve the investment opportunity set for portfolio managers. On the other hand, the Wald test results in Argentina, Mexico, Turkey and two developed countries are insignificant at both 1% and 5% level. This means we cannot reject the null hypothesis for these countries, especially for Argentina and the EU, where the p-values are even higher

than 0.5. It is robustly evident that the diversification benefits from investing in ILBs of these countries are quite weak and hence investors can not benefit by adding them into a mixed-asset portfolio.

7.4 Suggestions for the US Investors

In section 7.3 we have investigated if ILBs in different countries benefit the efficient frontiers of their corresponding mixed-asset portfolios from the viewpoint of local investors. What is the situation for the cross-border investors? Since the US market has been considered as the most mature market across different asset classes, we are going to apply the mean-variance spanning test under a situation that the US investors aim to improve their efficient frontiers by adding assets in emerging markets to their exciting portfolio, which includes traditional assets and ILBs.

Based on the similar mechanism of Equation 9, we derive the equation as following:

$$R_{EM\ asset\ classes} = \alpha + \beta_1 * R_{US\ nominal\ bonds} + \beta_2 * R_{US\ ILBs} + \beta_3 * R_{US\ equities} + \varepsilon \quad (10)$$

$$H_0 : \alpha = 0 \text{ and } \beta_1 + \beta_2 + \beta_3 = 1$$

The test assets are different asset classes in emerging markets, where the related return indices of the US dollars have been used. The benchmark assets are nominal bonds, ILBs and equities in the US markets. The null hypothesis is that the efficient frontier of a set of benchmark assets is the same as the efficient frontier of these US assets plus a set of assets in emerging markets. If the null hypothesis is rejected, the implication supports the notion that test assets expand the mean-variance efficient frontier and provide diversification benefits for the US investors. We can hence compare the diversifying power of ILBs to the traditional assets in emerging markets regarding composing a portfolio of various asset classes in the US.

Table 10 Mean-Variance Spanning Test for US Investors

Benchmark assets= US nominal bonds, US ILBs, US equities

Panel A: Test asset= EM nominal bonds									
Country	**Argentina**	**Brazil**	**Chile**	**Colombia**	**Mexico**	**Poland**	**South Africa**	**Turkey**	**Equally Weighted EM**
Wald Test	0.50	14.74	4.79	6.61	0.51	4.20	4.08	3.79	2.32
P-value	0.78	0.00	0.09	0.04	0.77	0.12	0.13	0.15	0.31
Panel B: Test asset= EM ILBs									
Wald Test	1.42	18.13	3.97	6.19	0.97	2.55	3.07	4.85	3.02
P-value	0.49	0.00	0.14	0.05[12]	0.62	0.28	0.22	0.09	0.22
Panel C: Test asset= EM equities									
Wald Test	0.08	10.62	12.11	14.30	14.60	5.04	7.82	2.48	3.10
P-value	0.96	0.00	0.00	0.00	0.00	0.08	0.02	0.29	0.21

Source: Author's calculations

[12] 0.0453

As can be seen from Table 10, in panel A, the test assets are the nominal bonds in emerging markets. The Wald test statistics in Brazil and Colombia have a value of 14.74 and 6.61, respectively, which are significant at the 5% level. Chile has shown a significant p-value at 10% level. The results suggests that adding the nominal bonds in these two countries could improve the efficient frontier of a portfolio composed by nominal bonds, ILBs and equities in the US. Panel B shows the test results using the ILBs in emerging markets as the test assets. Similar to the results in panel A, Brazil and Colombia again both contribute significant results at 5% level, while Turkey is significant at 10% level. We have found much more significant results in panel C, where equities in emerging markets have been used as test assets. In specific, only in Argentina and Turkey, the corresponding results are not statistically significant at 10% level. The test statistics for Brazil, Chile, Colombia, Mexico and South Africa are significant at 5% level, among which the results of first four countries are even significant at 1% level. It is evident that the diversification benefits from investing in emerging market equities are quite strong and robust for the US investors compared to emerging market nominal bonds and ILBs.

Moreover, to test if these eight emerging markets as a whole contribute the US investors, we include another column, where return of each country is equally weighted. None of the corresponding results in three panels show a significant value. However, the equally weighted results still perform better in comparison to some countries when being considered individually. For example, in panel B, the p-value for equally weighted ILBs is much lower than those in Argentina, Mexico and Poland. Hence we believe by changing the related weights of emerging countries, the US investors can still benefit especially when a test asset with a high p-value has already been included in the portfolio.

Based on the above results, the suggestion for the US investors could be to overweight their investments in emerging market equities, since they have on average shown benefits in more countries than nominal bonds and ILBs did. However, it would be still interesting to test how the latter two asset classes perform under the situation that equities of emerging markets have been already included in the existing portfolio.

We hence achieve the equation 11 and corresponding results in Table 11:

$$R_{EM\ asset\ classes} = \alpha + \beta_1 * R_{US\ nominal\ bonds} + \beta_2 * R_{US\ ILBs} + \beta_3 * R_{US\ equities} + \beta_4 * R_{EM\ equities} + \varepsilon \quad (11)$$

$$H_0 : \alpha = 0 \text{ and } \beta_1 + \beta_2 + \beta_3 + \beta_4 = 1$$

Compared to panel C in Table 10, we have found both progress and regress regarding the test statistics. When adding emerging market ILBs into the existing portfolio with local equities, the p-value of Argentina decreases from 0.96 to 0.81, but is still insignificant at 10% level. The most meaningful progress can be found in Turkey, where the related p-value has decreased from 0.29 to 0.06. It is now significant at 10% and hence could reject the null hypothesis. We also find this result is even lower than that in panel B of Table 10 (0.09), when emerging market ILBs is considered individually. This is strong evidence supporting the US investors to include ILBs into the existing portfolio. By contrast, compared to

panel C in Table 10, all other six countries have shown increases in their p-values, among which Brazil and South Africa are the only two countries remain significant at 5%. The statistics in Chile, Colombia, Mexico and Poland are no longer significant at 10%. Regarding the performance of the equally weighted asset in emerging markets, the corresponding result is statistically insignificant with a high p-value about 0.73. Similar patterns apply to panel A in Table 11, where nominal bonds in emerging markets have been used as test asset.

Table 11 Mean-Variance Spanning Test for the US Investors

(Incl. equities in emerging markets)

Benchmark assets= US nominal bonds, US ILBs, US equities, EM equities

Panel A: Test asset= EM nominal bonds									
Country	**Argentina**	**Brazil**	**Chile**	**Colombia**	**Mexico**	**Poland**	**South Africa**	**Turkey**	**Equally Weighted EM**
Wald Test	0.48	5.76	0.77	0.38	1.77	0.28	0.22	5.25	0.09
P-value	0.79	0.06	0.68	0.83	0.41	0.87	0.90	0.07	0.96
Panel B: Test asset= EM ILBs									
Wald Test	0.42	9.71	0.66	0.11	1.18	0.29	6.61	5.58	0.64
P-value	0.81	0.01	0.72	0.95	0.55	0.87	0.04	0.06	0.73

Source: Author's calculations

To sum up, in the viewpoint of the US investors, equities in emerging markets on average is the most attractive diversifying tool compared to other two asset classes. However, by adding ILBs in Turkey, the US investors can get benefits which they cannot get by including local equities alone.

CHAPTER 8 Conclusions

In our study we examined whether ILBs in emerging market improve the investment opportunity set for a mixed-asset portfolio. We based our finding on monthly data for three asset classes from eight emerging countries and two developed ones.

During the past decade, the average annual returns of ILBs in the emerging markets fluctuated a lot. Due to continuous turbulent conditions in economic and political environment, the lowest return of -55.90% in 2008 and the highest 187.81% in 2009 both attributed to Argentina. Also the monthly returns varied from one country to another. The ILBs in Turkey yielded the highest average monthly return and inflation rate. Our results have also shown that the corresponding average monthly returns of ILBs in emerging markets are higher than those of nominal bonds (except for the case of Argentina). This contrasts to the theory which states that the returns of nominal bonds should be slightly higher than those of ILBs with similar maturities as they include the compensation for the risk of unexpected future inflation. We attribute this to the duration deviations caused by our data from different maturities. With Regard to the volatility, ILBs lost their attractiveness as their corresponding results in eight out of eleven[13] countries were higher than those of nominal bonds. Equities generally represented the highest average volatility compare to other asset classes (except for Argentina). Research into the distribution characteristics of ILBs showed seven out of eleven countries have negative skewness, among which five belonged to emerging markets.

Since the ILBs have their principals indexed to inflation, their returns are expected to more tightly correlate to inflation compared to other asset classes. However, we found the results of corresponding correlations of inflation deviate from our expectations. Only four out of ten countries have shown positive correlations at monthly level, and expanding the time horizon did not positively influence all results. We attribute this to the following reasons. Firstly, the prices of ILBs are driven by inflation expectations instead of actual inflation from a theoretical viewpoint. Secondly, the calculated inflation rates have a one-month lag. Thirdly, for ILBs, there is a reverse relation between the duration and correlation of inflation. Although ILBs have not shown obvious advantages in higher correlations of inflation compare to those of nominal bonds and equities, we demonstrated their stronger power in hedging inflation. Using the hedging matrix, ILBs of all countries were found to be laying in the good or partial hedge quadrants.

Regarding the diversifying power of ILBs, the results of intra-market correlations have shown that the power is still strong in emerging markets, while it has almost diminished in developed markets. To further investigate the mechanism behind the correlations, we related them to volatility of inflation and country risk rating. The first factor fully demonstrated an inverse relation with the correlations. That is, a more volatile inflation is always accompanied with a lower correlation between the returns of ILBs and those of other asset classes. Considering the country risk factor, our results have been only partly consistent with

[13] We still take South Korea into consideration at this level.

the finding of Kelly, Martins and Carlson (1998), which indicated a negative relation with correlations. We have found a different outcome regarding the correlations between returns of nominal bonds and those of ILBs, which increased as country risk rating grew. This can be attributed to the different methods and data we used.

We also investigated the cross-country correlations of ILB returns taking the viewpoint of a cross-border investor. Only the returns of ILBs in Chile and Poland contributed to relatively low correlations, and no significant advantage has been found throughout countries with negative results. However, the cross-county correlations of ILBs still remained at a low level compared to equities. This make ILBs more attractive compared to stocks. We also found that there has been no geographic impact on cross-country correlation. No obvious evidence could support the correlations between countries within the same area are higher than those in the different areas.

Based on the above diversifying analysis, we examined asset allocation among nominal bonds, ILBs and equities. We took South Africa as an example, representing their return characteristics of portfolios constructed with various percentages of bonds and equities. The results showed that investing in ILBs contributed more in risk reduction compared to nominal bonds did. And hence substantial weight should be given to ILBs of emerging markets in an efficient portfolio.

To analyze how ILBs of emerging markets fit into well-diversified portfolios, we have applied mean-variance spanning tests. The result is mixed. For local investors, it has been demonstrated- both from graphs and econometric tests- that in most emerging markets, ILBs improve the mean-variance efficient frontier of a mixed-asset portfolio consisting of local nominal bonds and equities. For the US investors, ILBs in emerging markets have no additional advantages compared to local equities as a diversifying tool. However, by adding ILBs in Turkey, the US investors can get benefits which they cannot get by including local equities alone.

Our study shed new light on the subject of asset allocation regarding ILBs in emerging markets, adding to the earlier literature, which mainly highlighted the corresponding situation in developed markets. Still, it is preliminary because we restricted ourselves to mean–variance analysis with ILBs, stocks and bonds only. The analysis should be extended to more asset classes. Exploring inflation expectations based on survey data might also be add to deeper insight. As we only carried out our research based on the CPI inflation rates. The implication of this study for practitioners is straightforward. Adding ILBs of emerging market to portfolios with less aggressive risk profiles appears to be beneficial. However, we do not recommend that an investor's actual asset allocation will be based solely on observations of this study, as no one can predict the future based on a historical analysis. But the results certainly have affected our belief about the potential benefits of ILBs in emerging markets.

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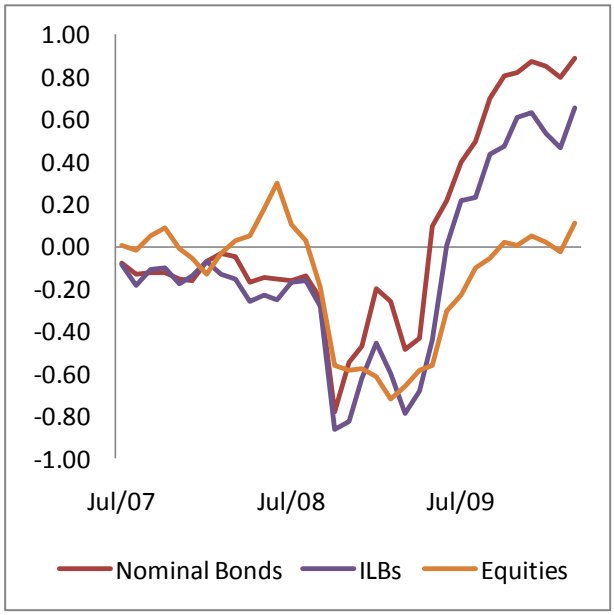
Appendix I

Figure I-1 Cumulative Monthly Returns

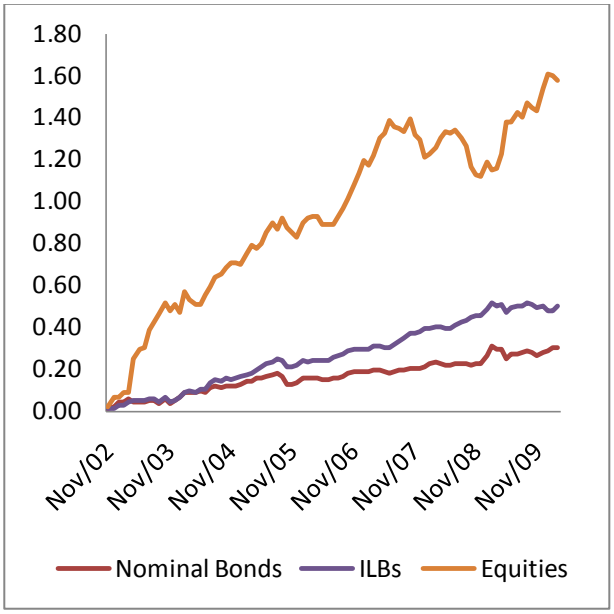
Argentina，2007-2010



Source: Author's calculations

Figure I-2 Cumulative Monthly Returns

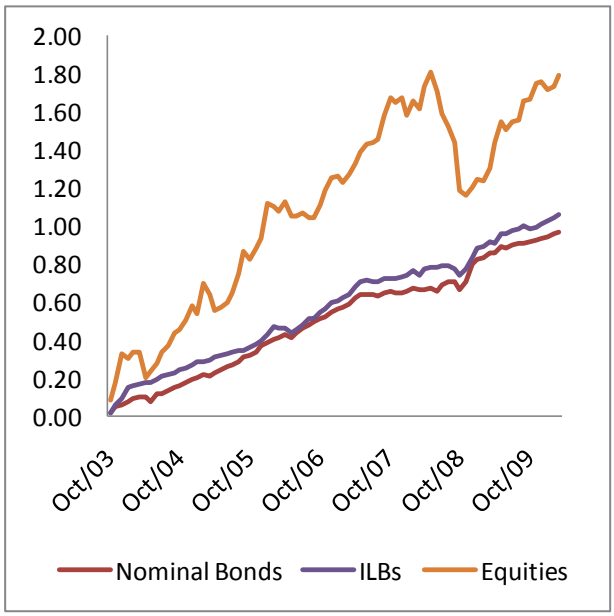
Chile，2002-2010



Source: Author's calculations

Figure I-3 Cumulative Monthly Returns

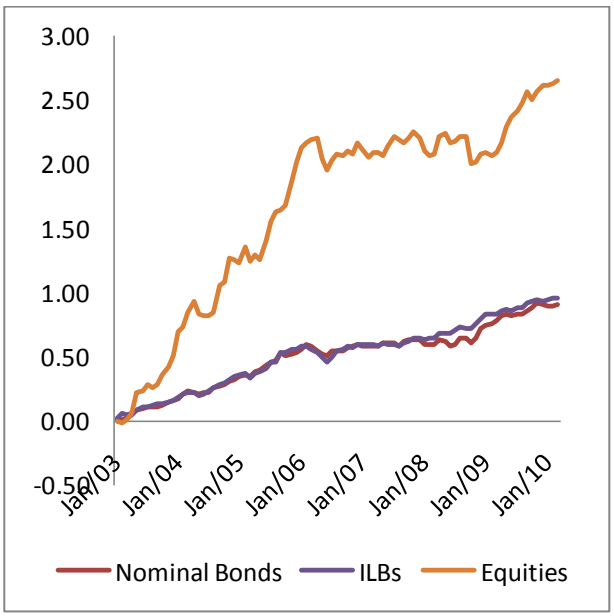
Brazil，2003-2010



Source: Author's calculations

Figure I-4 Cumulative Monthly Returns

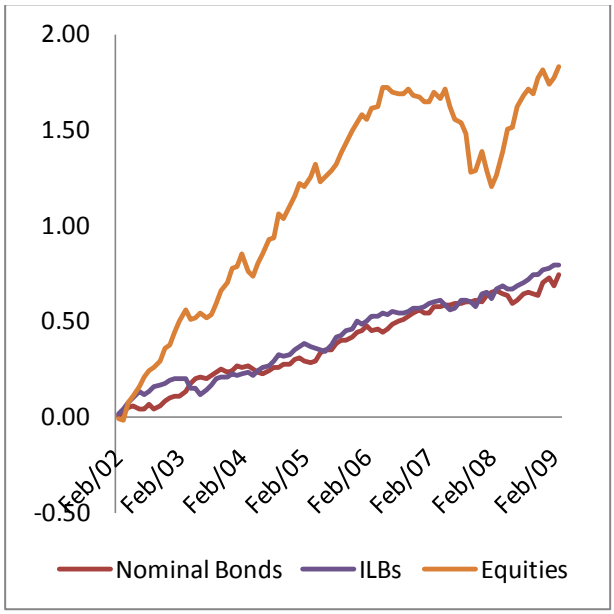
Colombia，2003-2010



Source: Author's calculations

Figure I-5 Cumulative Monthly Returns

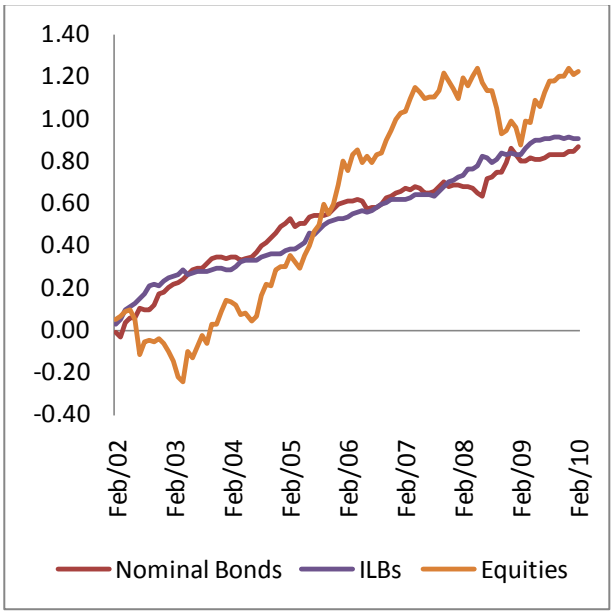
Mexico，2003-2010



Source: Author's calculations

Figure I-6 Cumulative Monthly Returns

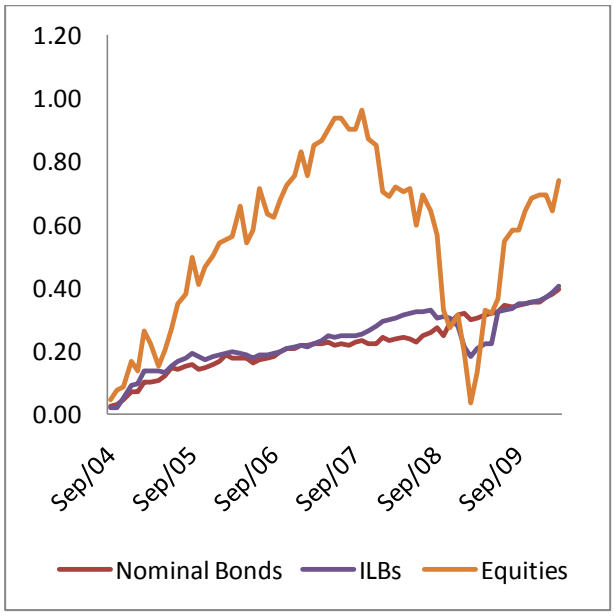
South Africa，2002-2010



Source: Author's calculations

Figure I-7 Cumulative Monthly Returns

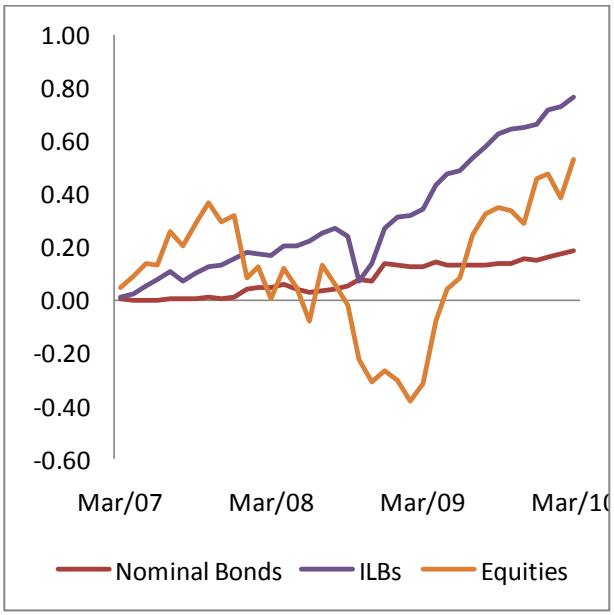
Poland，2004-2010



Source: Author's calculations

Figure I-8 Cumulative Monthly Returns

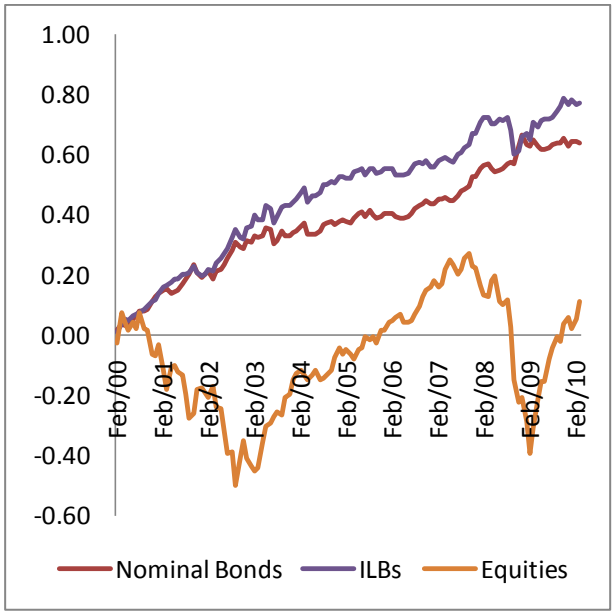
Turkey，2007-2010



Source: Author's calculations

Figure I-9 Cumulative Monthly Returns

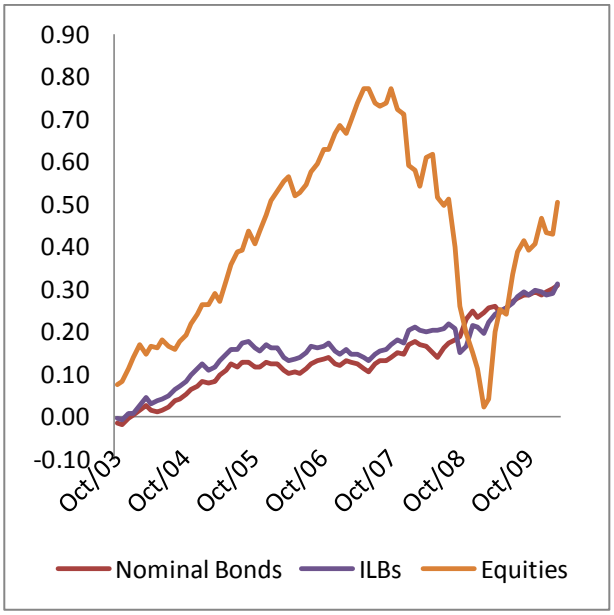
US，2000-2010



Source: Author's calculations

Figure I-10 Cumulative Monthly Returns

EU，2003-2010

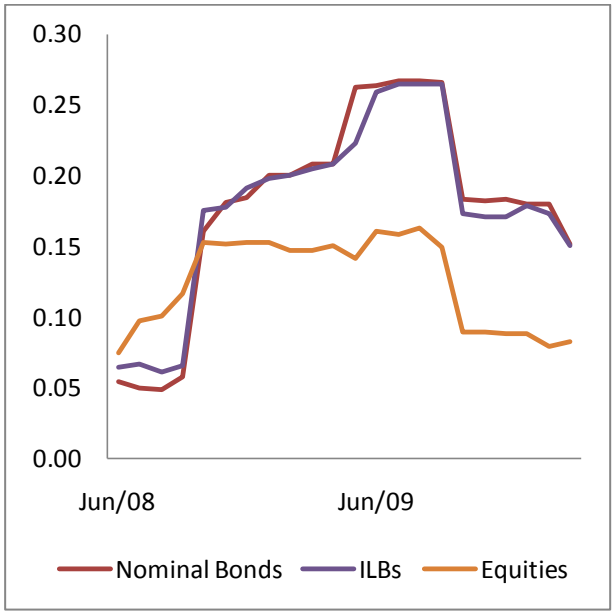


Source: Author's calculations

Appendix II

Figure II-1 Volatility over 1-Year Moving Window

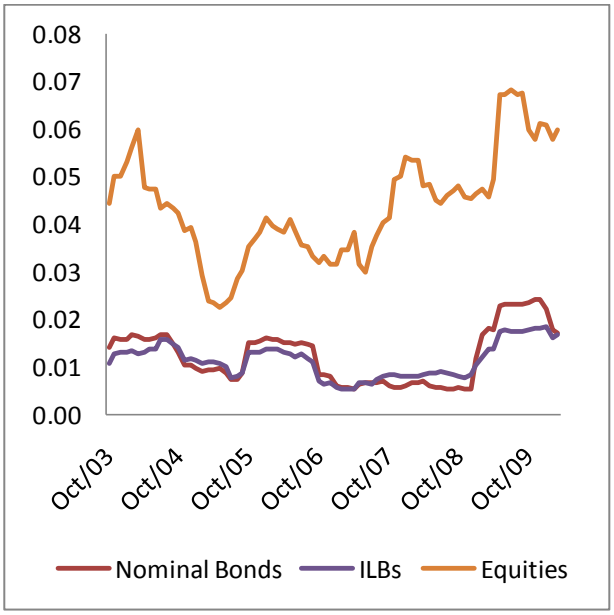
Argentina，2007-2010



Source: Author's calculations

Figure II-2 Volatility over 1-Year Moving Window

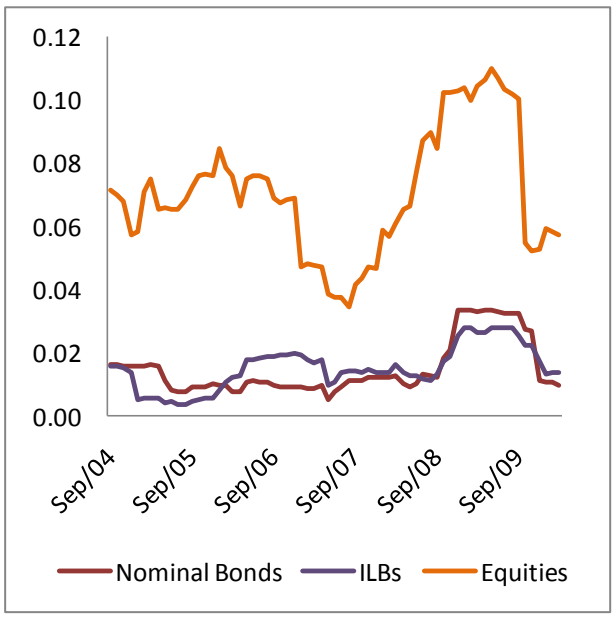
Chile，2002-2010



Source: Author's calculations

Figure II-3 Volatility over 1-Year Moving Window

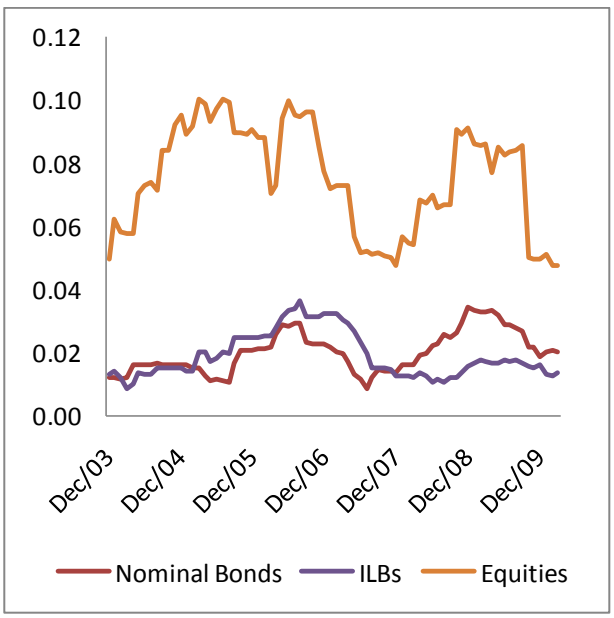
Brazil，2003-2010



Source: Author's calculations

Figure II-4 Volatility over 1-Year Moving Window

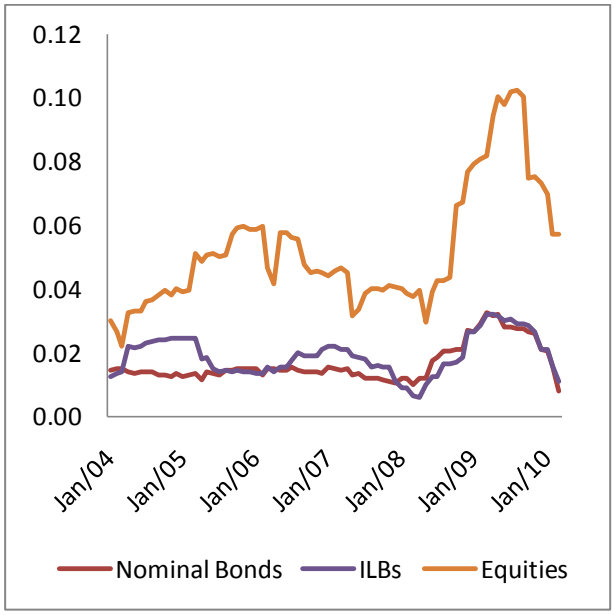
Colombia，2003-2010



Source: Author's calculations

Figure II-5 Volatility over 1-Year Moving Window

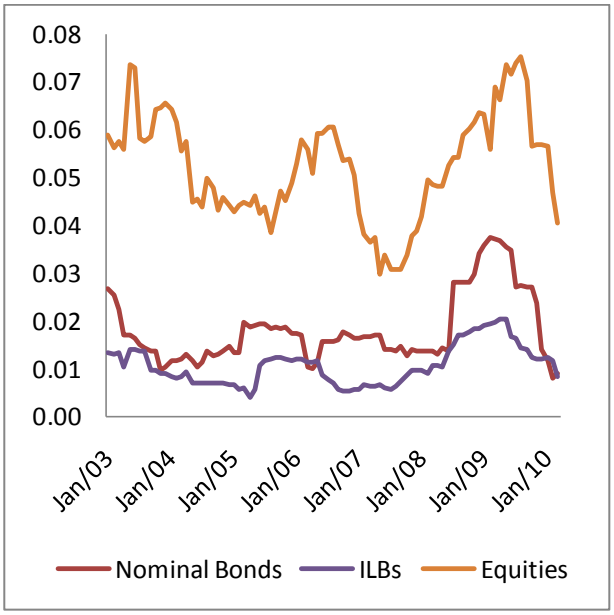
Mexico，2003-2010



Source: Author's calculations

Figure II-6 Volatility over 1-Year Moving Window

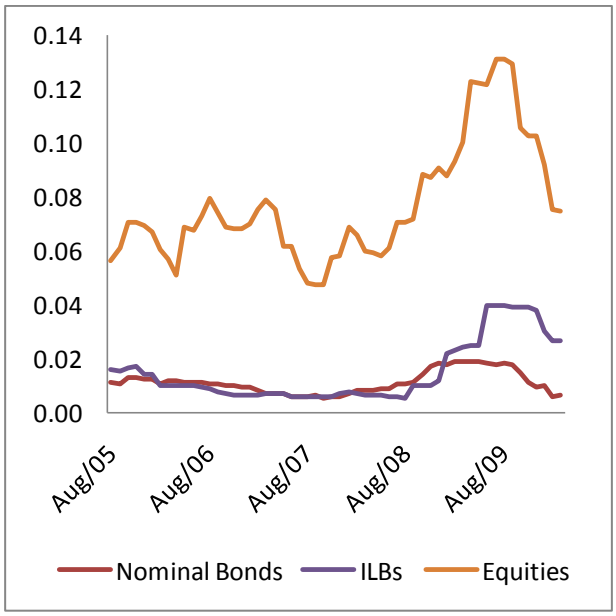
South Africa，2002-2010



Source: Author's calculations

Figure II-7 Volatility over 1-Year Moving Window

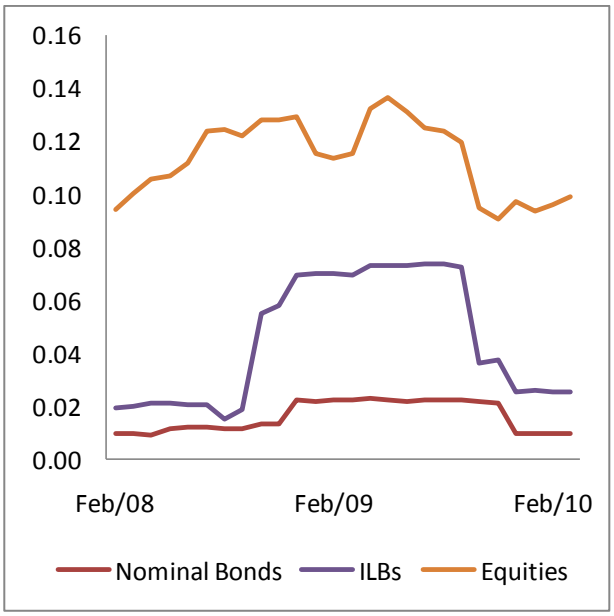
Poland，2004-2010



Source: Author's calculations

Figure II-8 Volatility over 1-Year Moving Window

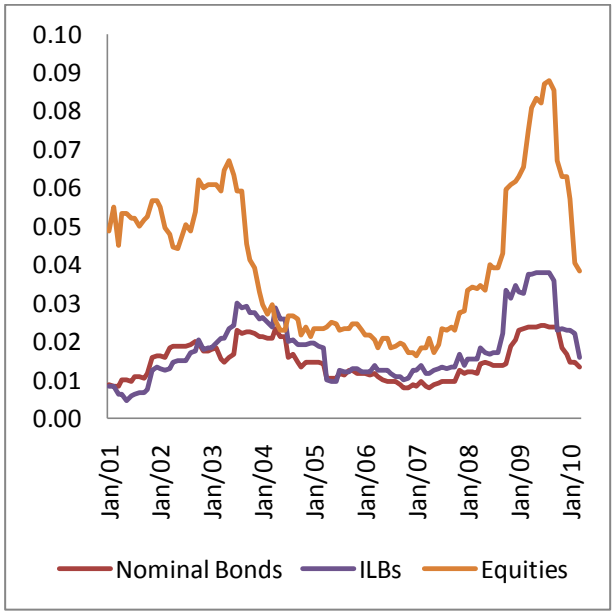
Turkey，2007-2010



Source: Author's calculations

Figure II-9 Volatility over 1-Year Moving Window

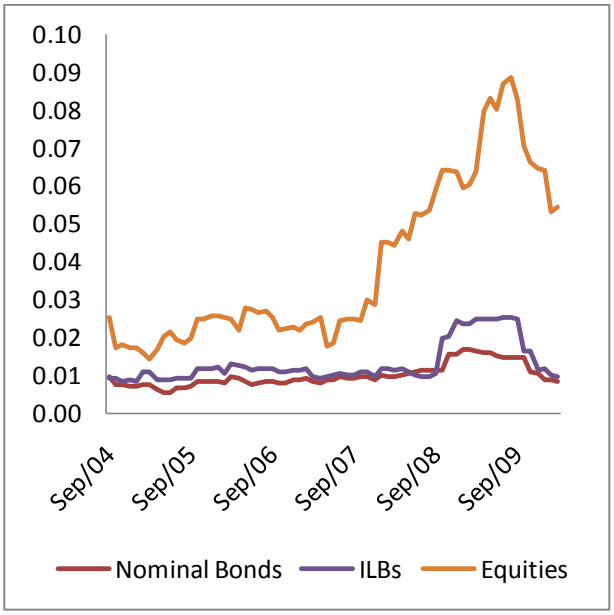
US，2000-2010



Source: Author's calculations

Figure II-10 Volatility over 1-Year Moving Window

EU，2003-2010

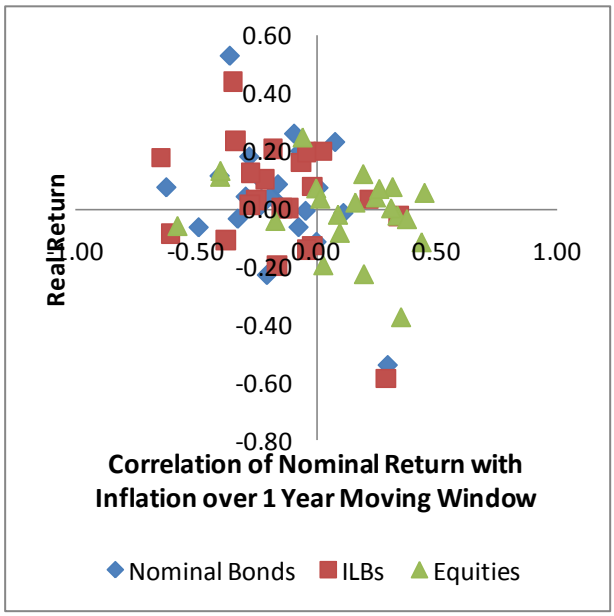


Source: Author's calculations

Appendix III

Figure III-1 Hedging Matrix

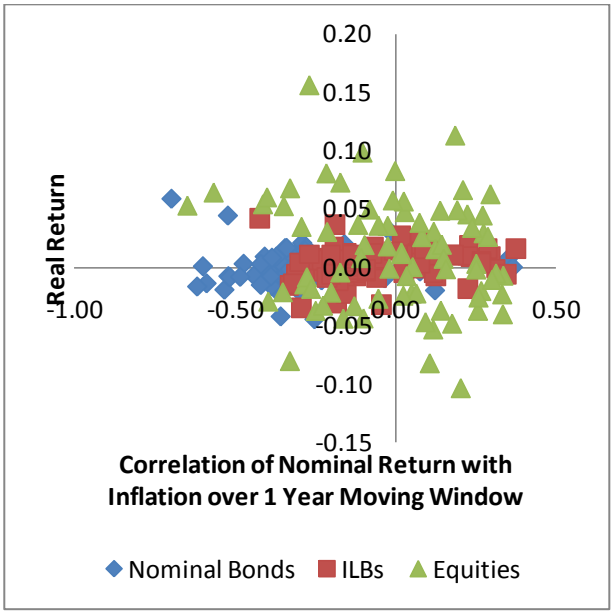
Argentina，June 2008 – Mar 2010



Source: Author's calculations

Figure III-2 Hedging Matrix

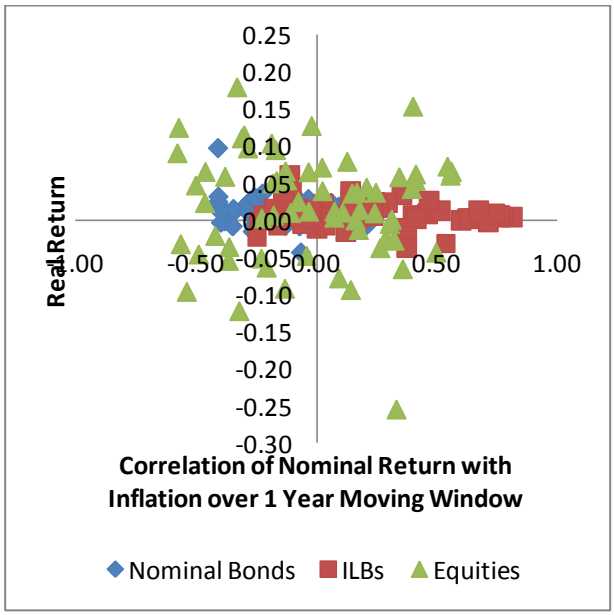
Chile，Oct 2003 –Mar 2010



Source: Author's calculations

Figure III-3 Hedging Matrix

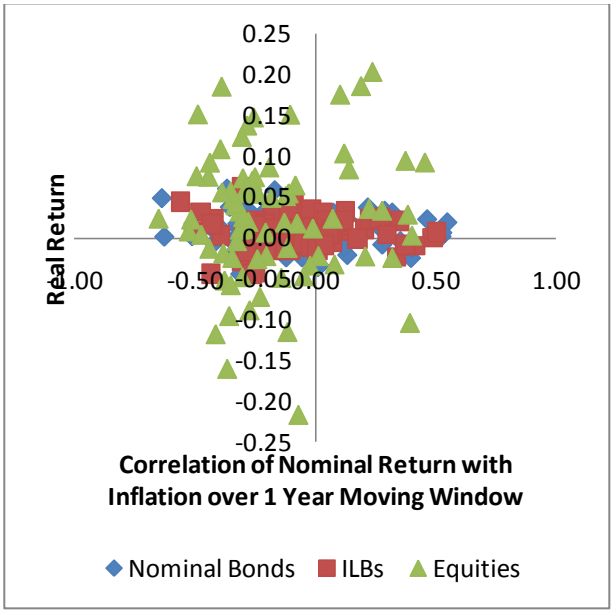
Brazil，Sep 2004 –Mar 2010



Source: Author's calculations

Figure III-4 Hedging Matrix

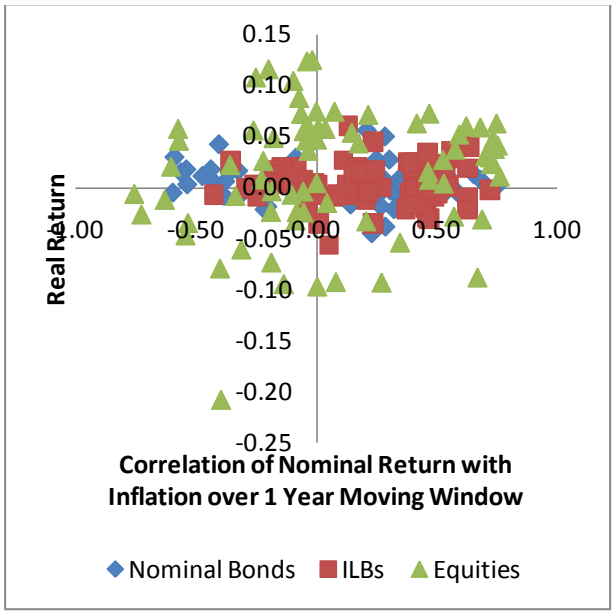
Colombia，Dec 2003 –Mar 2010



Source: Author's calculations

Figure III-5 Hedging Matrix

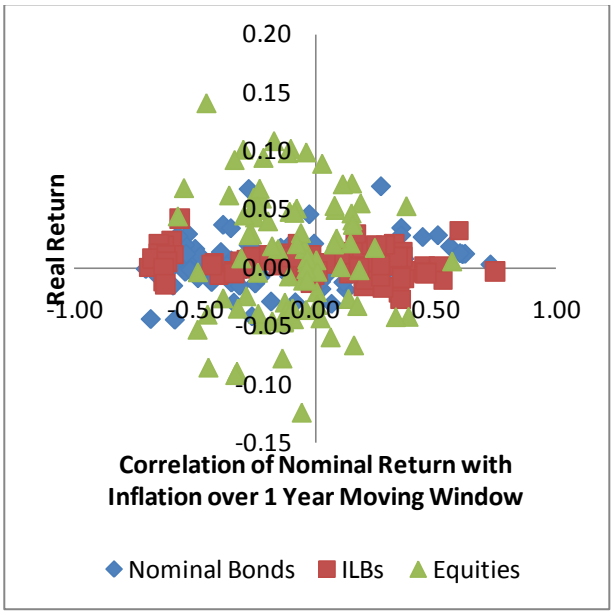
Mexico, Jan 2004 –Mar 2010



Source: Author's calculations

Figure III-6 Hedging Matrix

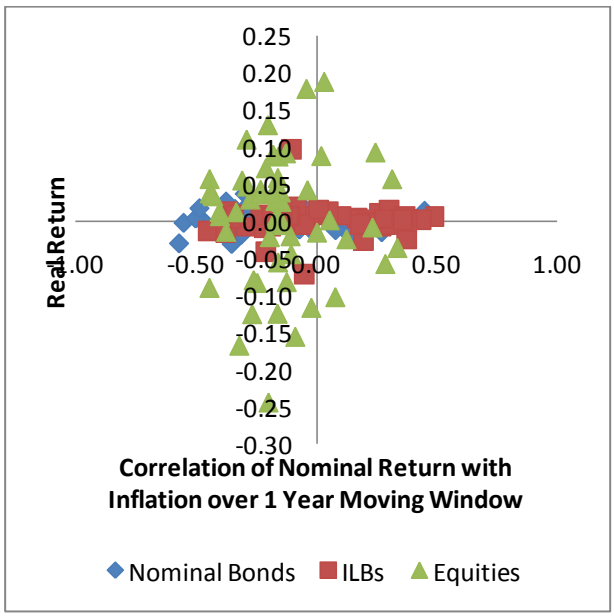
South Africa, Jan 2003 –Mar 2010



Source: Author's calculations

Figure III-7 Hedging Matrix

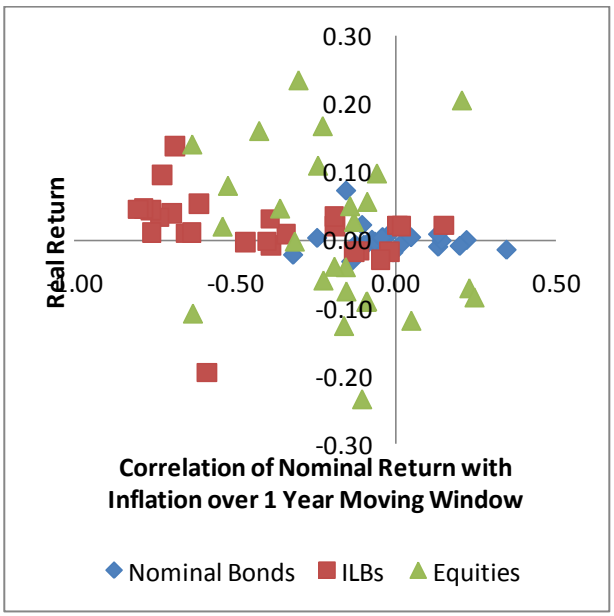
Poland, Aug 2005 –Mar 2010



Source: Author's calculations

Figure III-8 Hedging Matrix

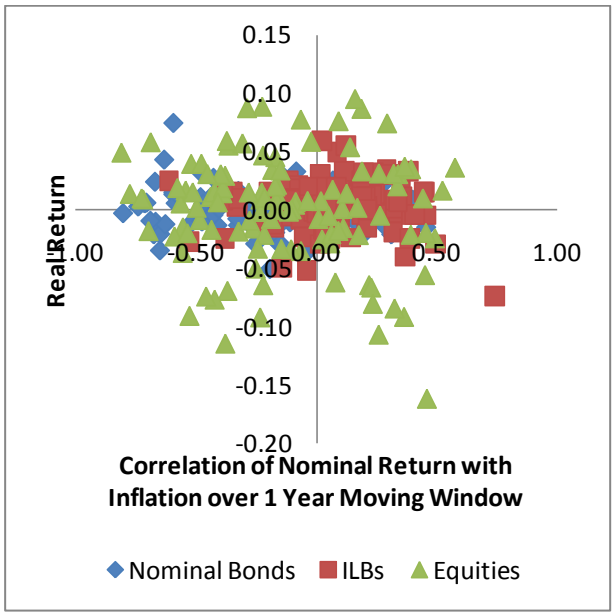
Turkey, Feb 2008 –Mar 2010



Source: Author's calculations

Figure III-9 Hedging Matrix

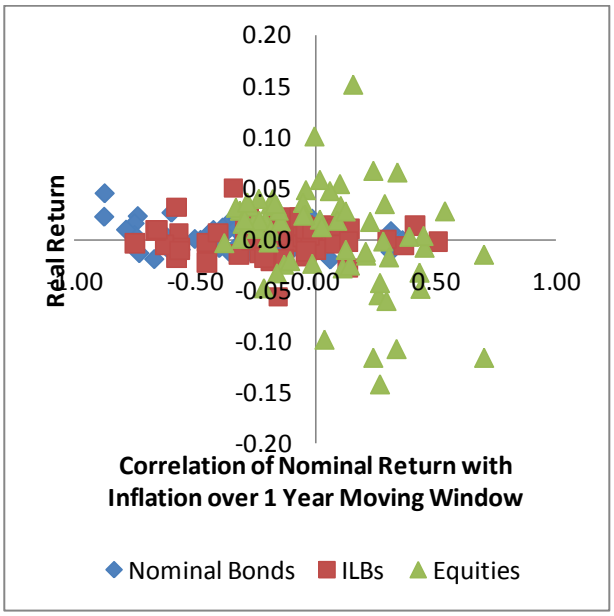
US，Jan 2001 –Mar 2010



Source: Author's calculations

Figure III-10 Hedging Matrix

EU，Sep 2004 –Mar 2010

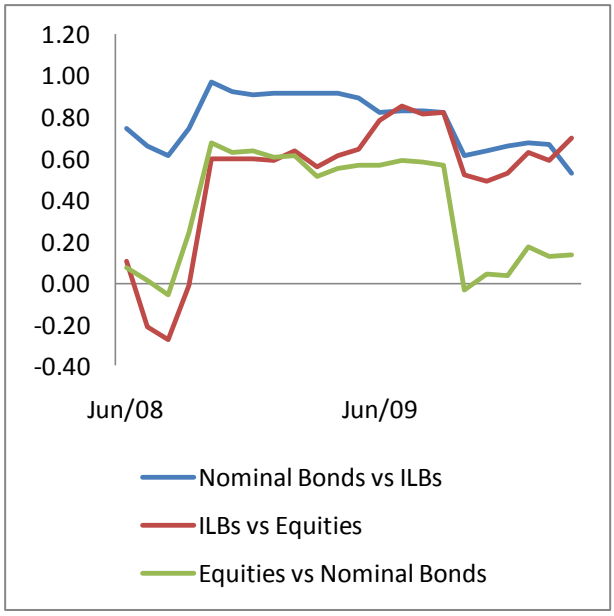


Source: Author's calculations

Appendix IV

Figure IV-1 Correlations of Monthly Returns with Major Asset Classes over 1-Year Moving Window

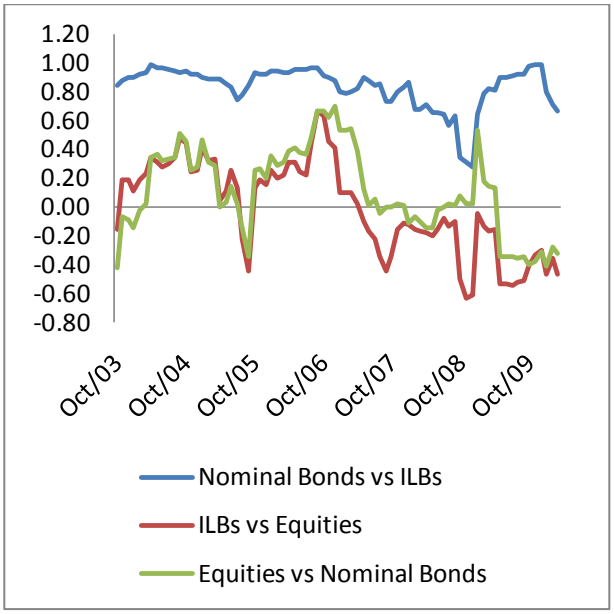
Argentina，2007-2010



Source: Author's calculations

Figure IV-2 Correlations of Monthly Returns with Major Asset Classes over 1-Year Moving Window

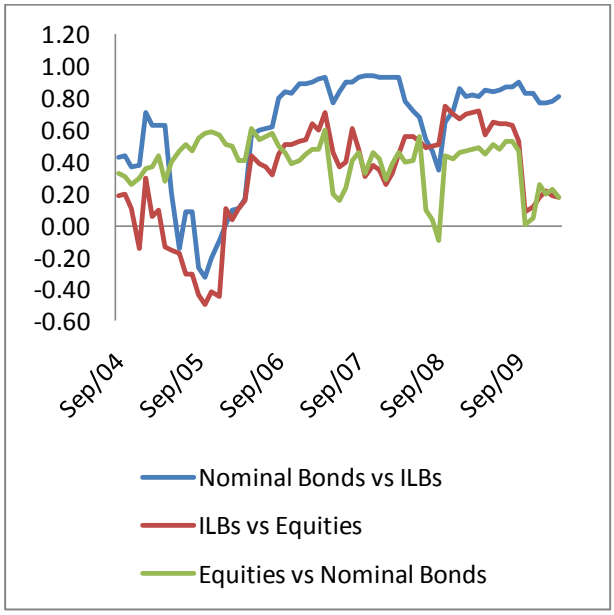
Chile，2002-2010



Source: Author's calculations

Figure IV-3 Correlations of Monthly Returns with Major Asset Classes over 1-Year Moving Window

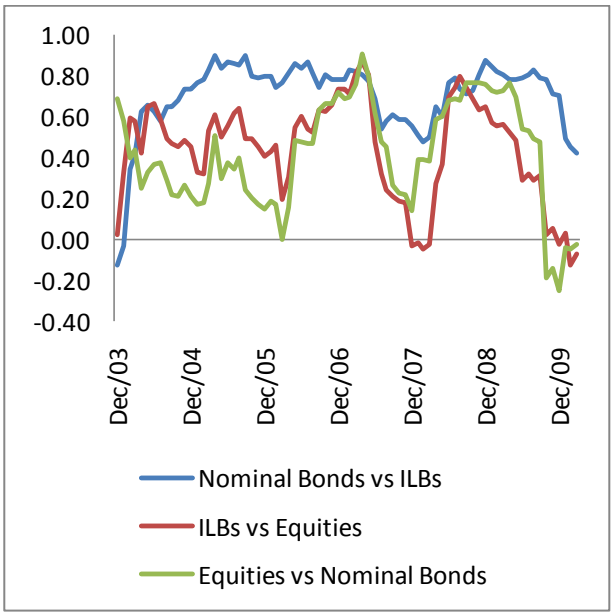
Brazil，2003-2010



Source: Author's calculations

Figure IV-4 Correlations of Monthly Returns with Major Asset Classes over 1-Year Moving Window

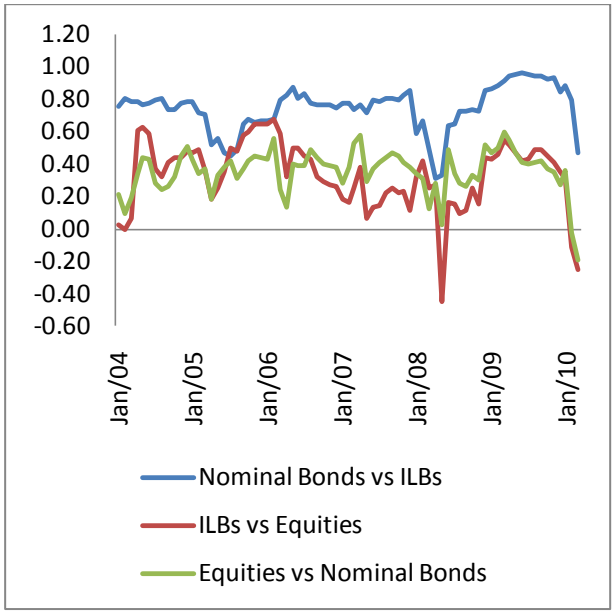
Colombia，2003-2010



Source: Author's calculations

Figure IV-5 Correlations of Monthly Returns with Major Asset Classes over 1-Year Moving Window

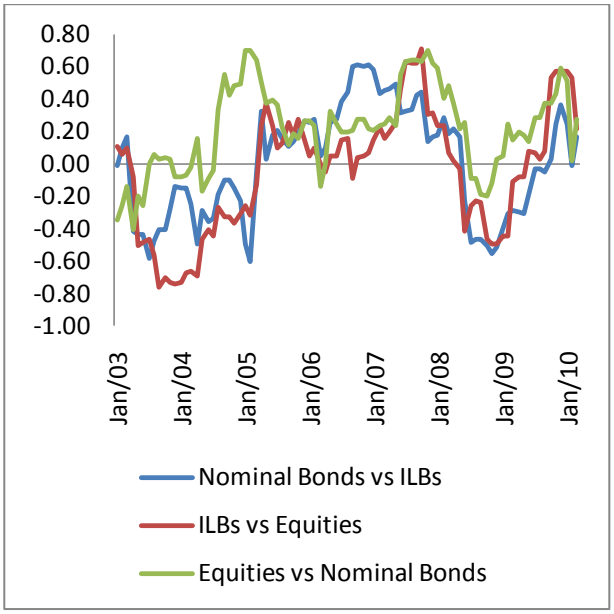
Mexico，2003-2010



Source: Author's calculations

Figure IV-6 Correlations of Monthly Returns with Major Asset Classes over 1-Year Moving Window

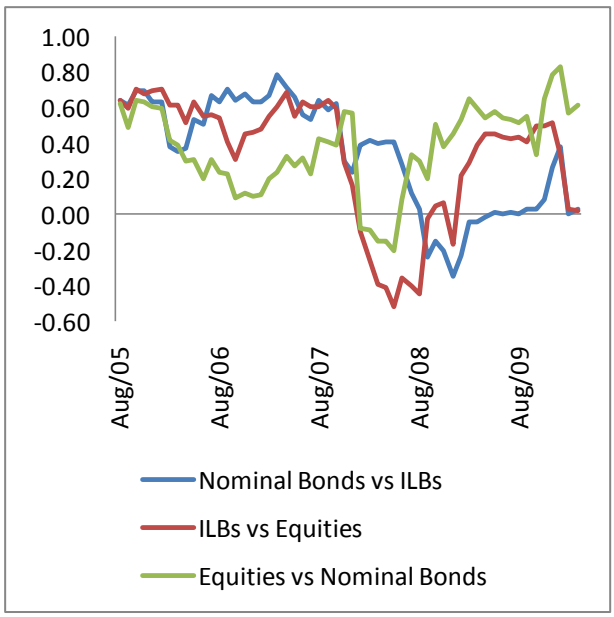
South Africa，2002-2010



Source: Author's calculations

Figure IV-7 Correlations of Monthly Returns with Major Asset Classes over 1-Year Moving Window

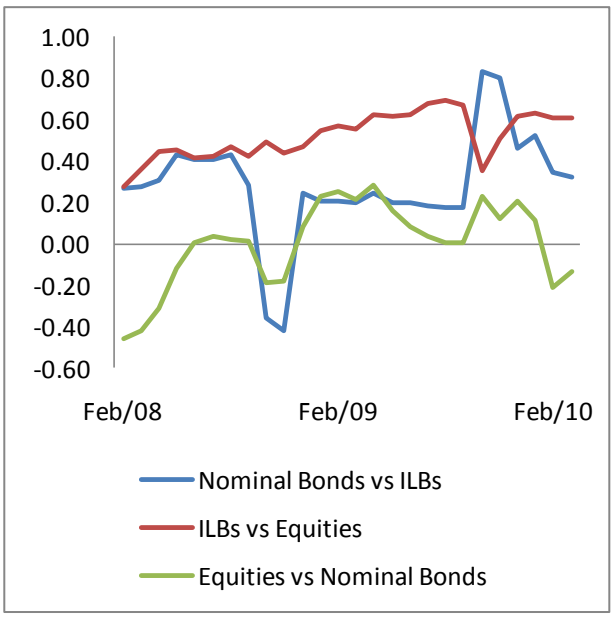
Poland，2004-2010



Source: Author's calculations

Figure IV-8 Correlations of Monthly Returns with Major Asset Classes over 1-Year Moving Window

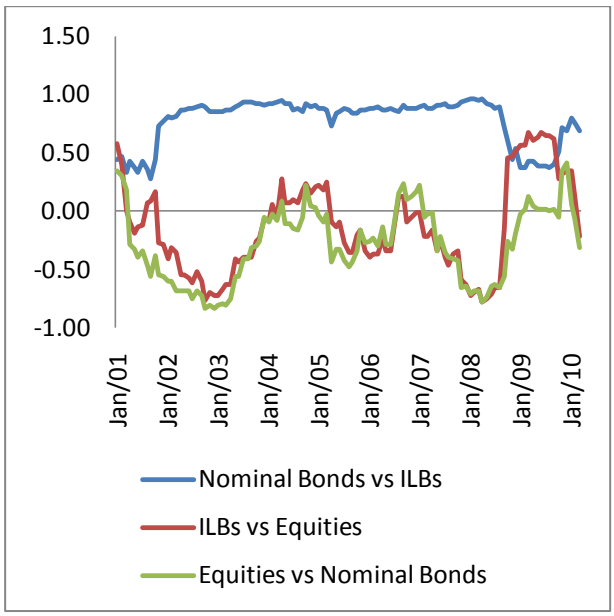
Turkey，2007-2010



Source: Author's calculations

Figure IV-9 Correlations of Monthly Returns with Major Asset Classes over 1-Year Moving Window

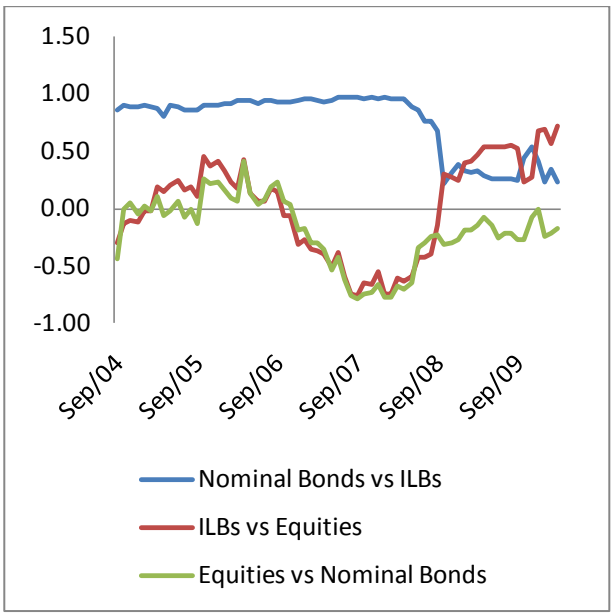
US，2000-2010



Source: Author's calculations

Figure IV-10 Correlations of Monthly Returns with Major Asset Classes over 1-Year Moving Window

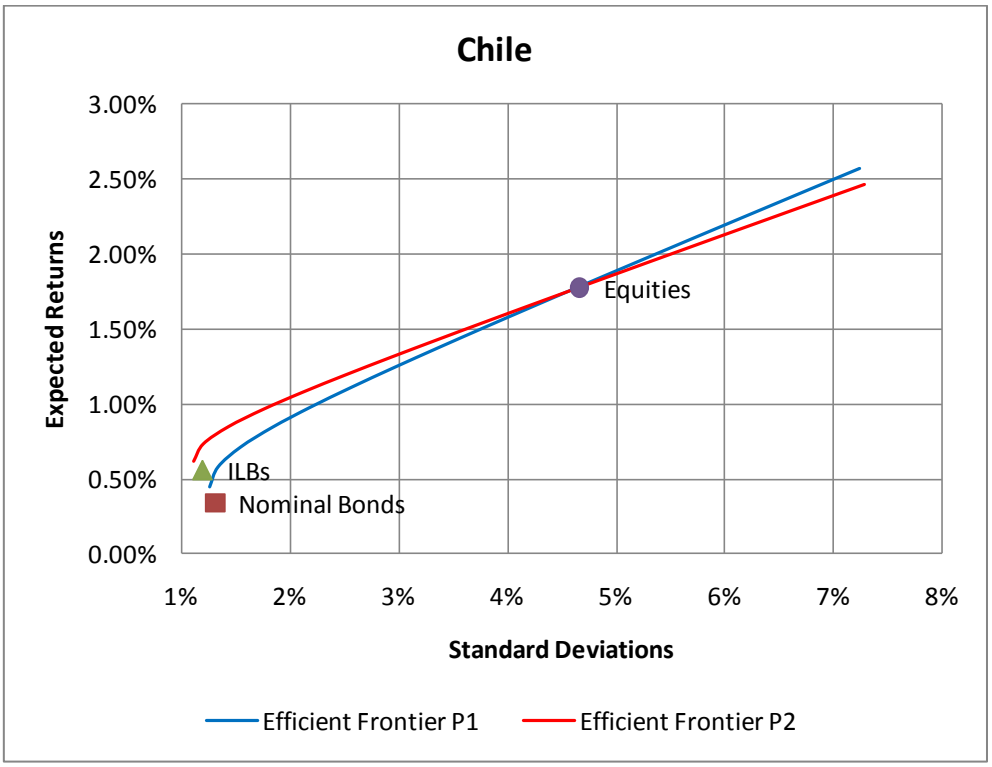
EU，2003-2010

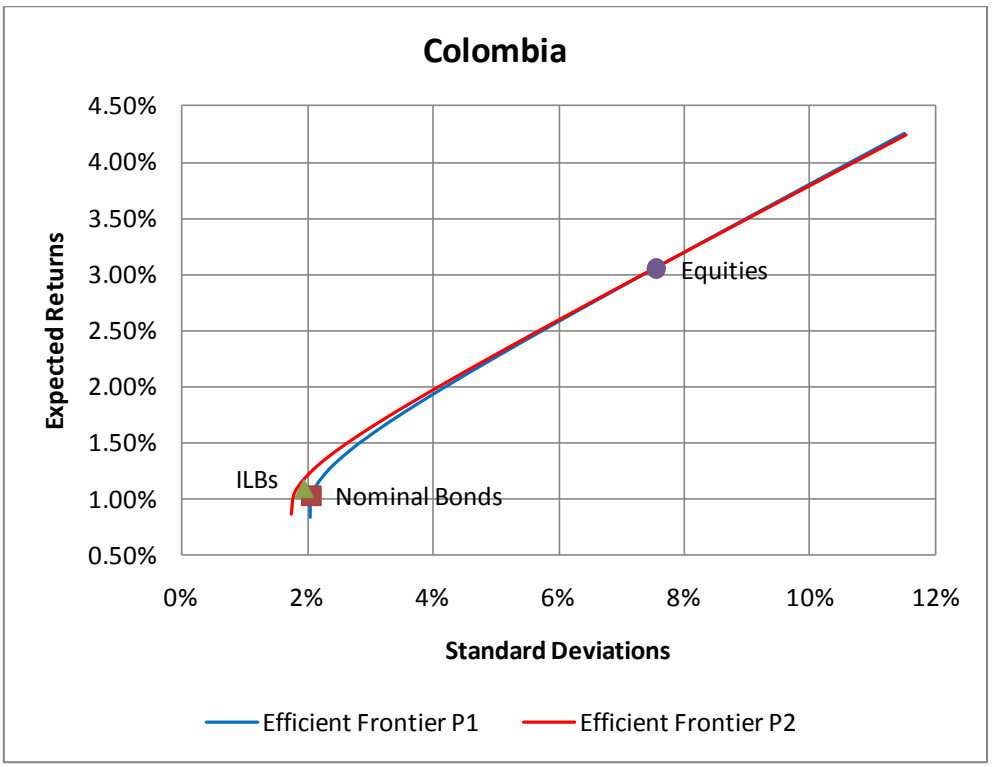


Source: Author's calculations

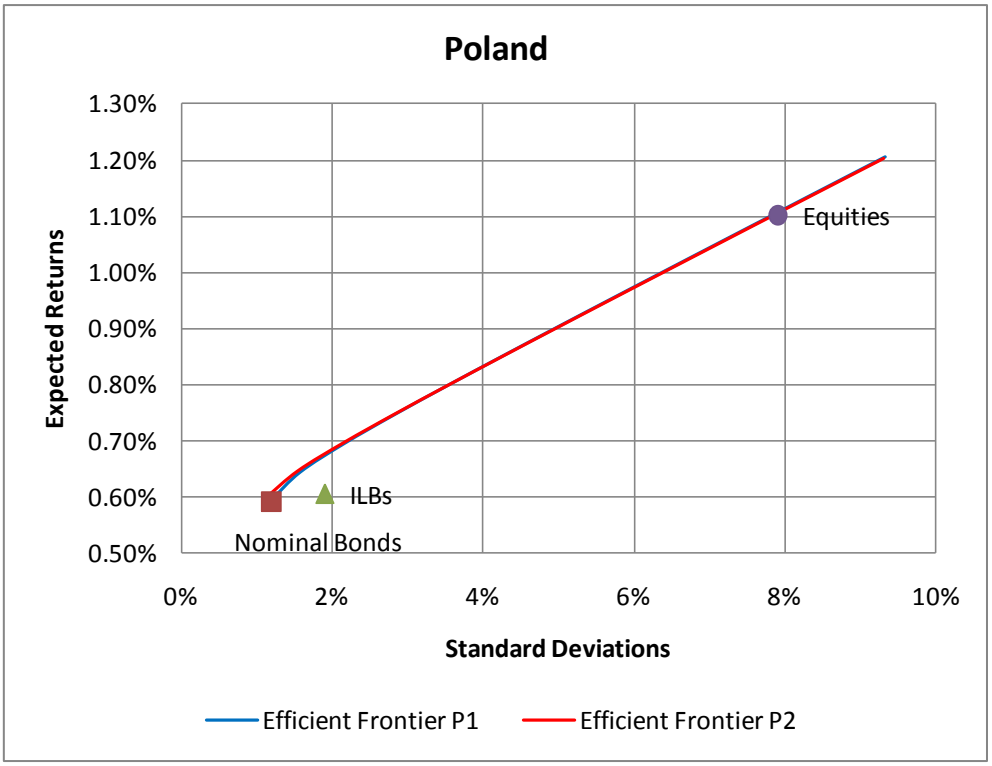
Appendix V

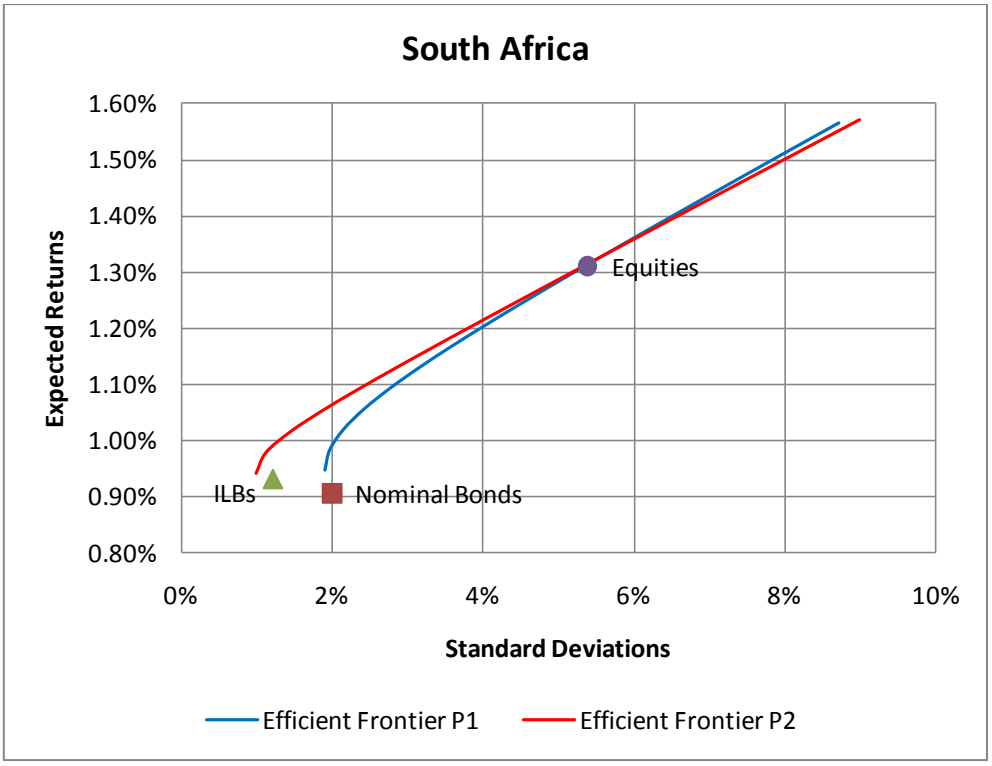
Figure V-1 Efficient Frontiers for Group 1 [14]





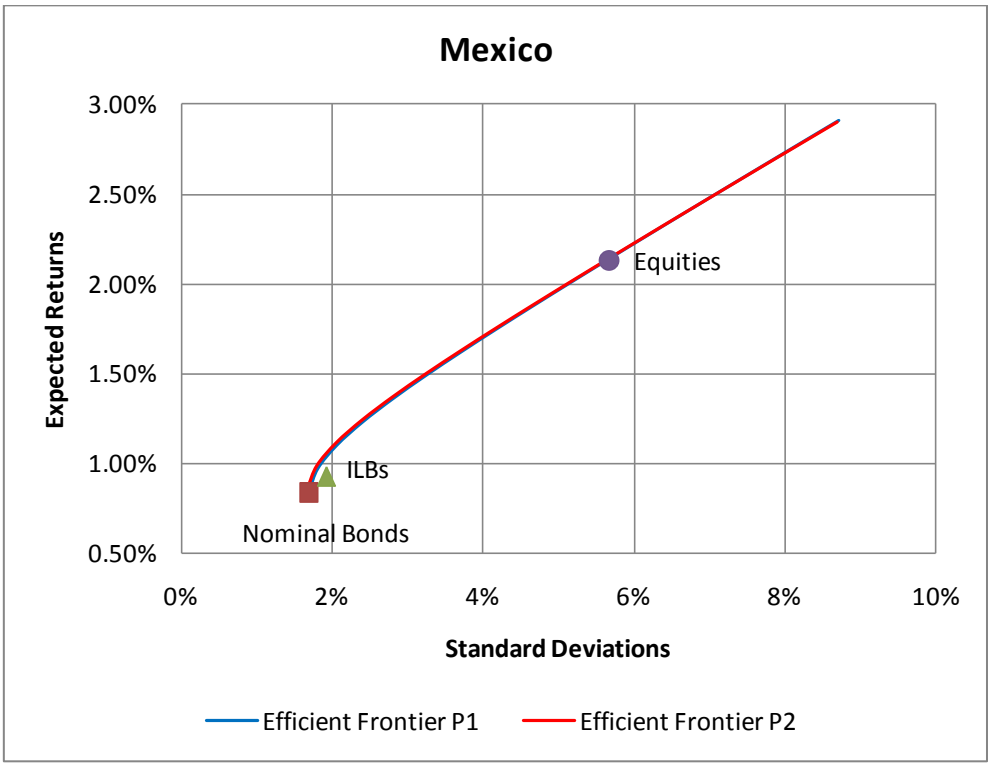
[14] Group 1 includes countries where the efficient frontiers have changed by adding ILBs.

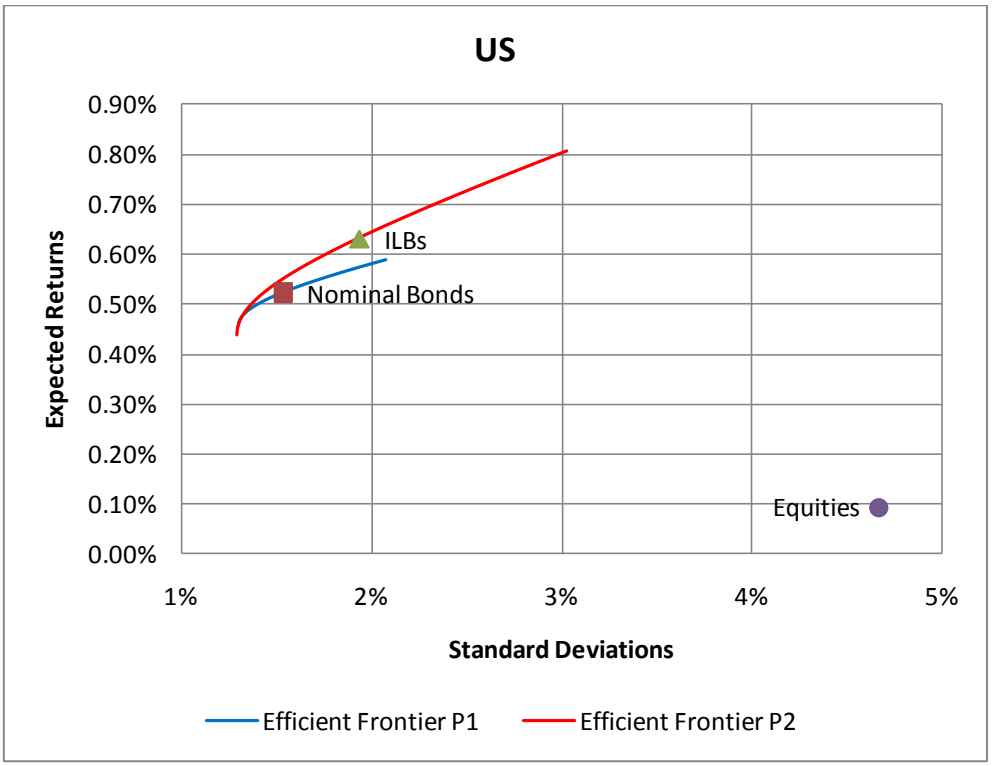




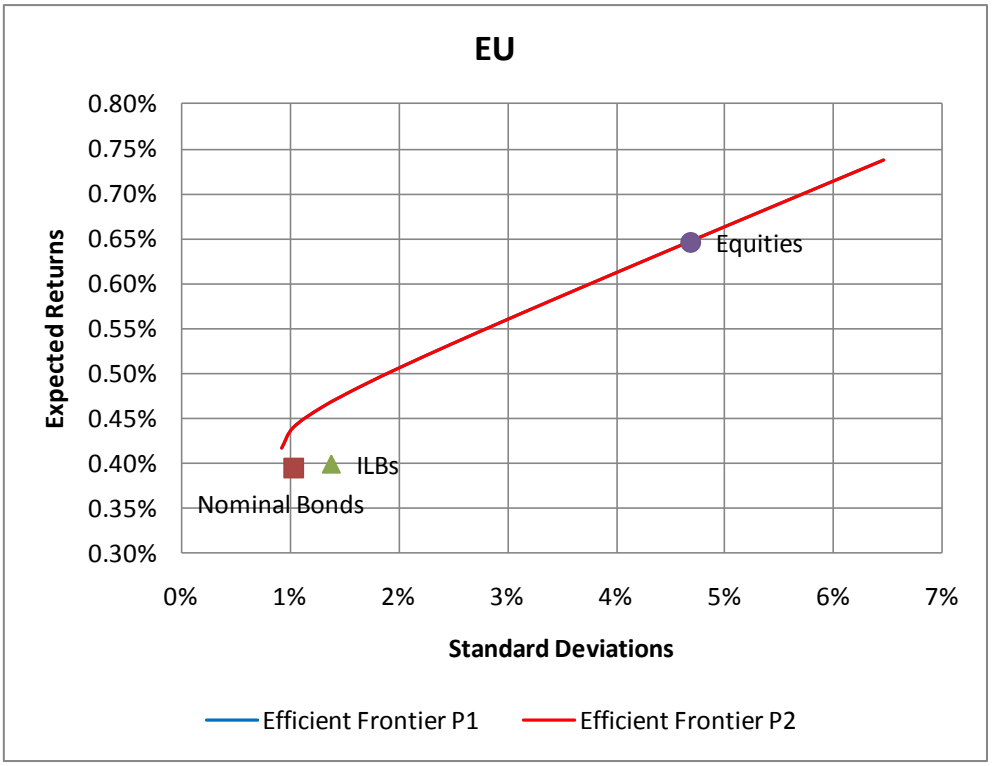
Source: Author's calculations

Figure V-2 Efficient Frontiers for Group 2 [15]





[15] Group 2 includes countries where the efficient frontiers have not changed by adding ILBs.



Source: Author's calculations