Currency hedging strategies, strategic benchmarks and the Global and Euro Sovereign financial crises

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Abstract

This paper investigates dynamic currency hedging benefits, with a further focus on the impact of currency hedging before and during the recent financial crises originated from the subprime and the Euro sovereign bonds. We take the point of view of a Euro-based institutional investor who considers passive investment strategies in portfolios holding European, British and US assets. We analyze the impact of the model specification to improve the risk-return tradeoff when currency risk is hedged. Hedging strategies of currency risk, using exchange rates futures and driven by several multivariate GARCH models, depend on the portfolio composition and period analyzed. Dynamic covariance models provide limited evidences of a decrease in hedging rations compared to naïve hedging strategies based on linear regressions or variance smoothing. Nevertheless, those results are coupled with better performances of dynamic covariance models in terms of hedging effectiveness an improved Sharpe ratios. The empirical evidences are observed both in-sample as well as in an out-of-sample exercise.

Keywords: Multivariate GARCH, conditional correlations, currency futures, optimal hedge ratios, hedging strategies.

JEL codes: C32, C53, C58, , G01, G11, G15, G17, G23, G32.

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1. Introduction

The global financial crisis (GFC) has had a tremendous impact on global financial markets and has been particularly severe in the Euro zone. The subsequent Euro sovereign crisis (ESC) further exacerbated the effects of the GFC and led to high levels of uncertainty regarding the future of the Euro currency. Taking the point of view of a Euro-based investor, under previous circumstances, the investment in international (non-Euro) traded stocks and bonds became especially attractive for two reasons. On the one hand, international diversification resulted in lower risk than purely domestic diversification. On the other hand, there were more possibilities in taking advantage of countries with different levels of growth, and consequently, with different opportunities for successful investment. However, international investment leads to the inclusion of exchange rate volatility, and thus, currency risk in a portfolio. In this framework, investors faced the choice of maintaining exposure to currency fluctuations, or to hedge the currency risk exposure in order to further improve the returns-risk performance of their (globally) diversified portfolio. These issues have received some attention in the financial economics literature.

De Roon et al. (2011) point out that risk hedging is just one of the two motivations for internationally diversifying portfolios. They show the manner in which speculative benefits can be achieved for both bond and equity portfolios when currency positions are included as a further asset class. Overall, they also provide supporting evidence to show that currency hedging reduces risk in multi-currency portfolios. Moreover, portfolio performance improves with hedging when the comparison is made in-sample, while out-of-sample results show evidence of benefits for bond portfolios but not for equity portfolios. Campbell et al. (2010) show further evidence of hedging benefits for bond portfolios and the potential positive impact of currency investing (as opposite to hedging) in equity portfolios. Schmittmann (2010) analyses four different strategies: no hedging, half hedging, full hedging of currency risk, and the minimum-variance hedging ratio. In the cited paper, these strategies are applied to different investment horizons ranging from one-quarter to five years. Moreover, the paper examines the currency hedging benefits of single- and multi-country portfolios. The results show significant risk reduction for the hedged portfolios but no statistically significant differences in returns. We note that the first three strategies are purely naïve, and risk-minimizing hedging ratios account for the movements and comovements of portfolios and the currencies forward returns within a static framework.

In the present paper, we do not follow De Roon et al. (2011) or Campbell et al. (2010), and we do not consider the issue of direct investment in currencies. Instead, we focus on hedging decisions with respect to currency risk. A relatively inexpensive and reliable strategy for hedging foreign exchange risk involves the use of currency futures markets. Hedging with futures contracts is perhaps the simplest method of managing market risk arising from movements in foreign exchange markets. Hedgers usually short an amount of futures contracts if they hold a long position in international portfolios. In that case, optimal hedging ratios (OHR), namely, how many futures contracts should be held for each unit of the underlying portfolio, can be determined by minimizing the variance of the hedged portfolio returns or, equivalently, within a linear regression framework. Key inputs to obtain hedging ratios are the time series of portfolio and currency futures returns from which conditional and unconditional covariance matrices can be estimated with different approaches. In static or unconditional hedging, hedge ratios are estimated on a historical basis without taking into account the dynamic evolution of the returns (for both the investment assets and the currency) or of their risk. Implicitly, static hedging approaches assume that the covariance matrix is time-invariant, so that the OHR is constant over time, even if derived within a risk minimization approach. One way of moving toward dynamic hedging might involve the fundamental link between currencies and interest rates, as in de Roon et al. (2003), and Campbell et al. (2010). In these cases, dynamic hedges outperform static ones. A different approach for deriving dynamic hedge ratios comes from the time-varying nature of financial returns distribution. In fact, an extensive literature shows evidence of the presence of dynamic in the second and higher order moments of returns. Here, dynamic hedges are derived within a risk-minimization framework, thus making use of econometric models belonging to the multivariate GARCH class (see Caporin and McAleer 2010). The commonly adopted specifications allow for dynamic in variances, and covariance or correlations, following the taxonomy outlined in Bauwens et al. (2005), McAleer (2005), and Silvennoinen and Terasvirta (2009).

Multivariate conditional variance models have already been used within a currency hedging framework. Kroner and Sultan (1993) show the overperformance of dynamic hedging strategies based on a simple bivariate GARCH model compared to static hedging derived by a regression framework. Similar, though less strong, evidence has been provided by Chakraborty and Barkoulas (1999). Ku et al. (2007) evaluate the benefits of dynamically modeling correlations, as in Engle (2002), compared to specifications where only the conditional variance is dynamic. They verify the improvement in the hedge ratios with dynamic correlations. Chang et al. (2013) analyze the in-sample hedging effectiveness of alternative multivariate GARCH models when using two different currency futures maturities. Even though no significant differences among models are found, hedging leads to noticeable volatility reduction. Brown et al. (2012) examine dynamic hedging strategies for international portfolios of bonds and equities using the dynamic conditional correlation model (DCC) developed by Engle (2002). They compare their dynamic strategy with static hedging strategies (hedging ratios 0, 0.5, 1 and OLS estimates) and conclude that dynamic strategies, based on conditional variance matrices, outperform other strategies in terms of risk portfolio reduction during the in-sample period.

Similar results were found in the out-of-sample analysis and were especially evident for the period covering the global financial crisis.

When dealing with out-of-sample hedging effectiveness, further elements must be considered, for instance, the forecast performances of alternative models. An example is given in Hakim and McAleer (2009) that analyze whether multivariate GARCH models incorporating volatility spillovers and asymmetric effects of negative and positive shocks on the conditional variance provide different forecasts. Using three multivariate GARCH models – the CCC of Bollerslev (1990), the VARMA-GARCH of Ling and McAleer (2003), and the VARMA-AGARCH of McAleer et al. (2009) – they forecast conditional correlations between three classes of international financial assets (stocks, bonds, and foreign exchange rates). They suggest that incorporating volatility spillovers and asymmetric effects of negative and positive shocks on conditional variance does not affect the forecasts of conditional correlations.

Our paper belongs to the strand of literature which analyses dynamic currency hedging benefits, with a further focus on the impact of currency hedging before and during a period of financial turmoil. Consequently, we take the point of view of a Euro-based institutional investor and consider passive investment strategies. These might take the form of pure, passively managed portfolios or might represent the benchmark for an actively managed portfolio. In both cases, the institutional investor is willing to evaluate the potential improvements in the risk-return trade-off when currency risk is hedged. We stress that we will not consider the case of direct investment in currencies as in de Roon et al. (2011). We further assume that our reference investor is willing to allocate a fraction of his wealth in non-Euro denominated assets, namely in the UK and the US. The passive portfolios we consider differ in terms of their composition by asset classes (full bond, full equity, or balanced portfolios investing both in bonds and equities), and country weight (equally weighted across the selected investment areas or home biased toward Euro-denominated assets). Finally, with respect to the bond asset class, we consider bond investments with different maturities (a generic all-maturity allocation, and 1-3-year and 10+-year maturity allocations) to highlight the potential heterogeneity in currency risk hedging depending on the bond maturity.

Our implementations and results are novel in several aspects. We first analyze the impact of the model specification on the evaluation of the currency hedging effectiveness. To this end, we consider a wider selection of models compared to previous studies. Our empirical analyses include the following specifications: the well-known exponential weighted moving average filter; the DCC model of Engle (2002); the BEKK model of Engle and Kroner (1995); and finally, we use the OLS static hedging ratios as a benchmarks. In addition, we use US dollar and British pound futures, instead of forwards, to build our hedging strategies. While futures are similar to forward contracts, they also solve some of the shortcomings of forward markets: in a forward contract, we need to find a counterparty; futures are much more liquid because they are traded in an organized exchange market; futures provide greater flexibility because they are more easily offset than forwards; and finally, futures have the benefit of not being exposed to further counterparty risks for hedgers. The choice of taking the Euro-based point of view will allow us to focus on the impact of the GFC and ESC crises on passively managed strategies and currency hedging, a novel contribution to the literature. Our analyses will include both in-sample evaluations as well as out-of-sample analyses. The latter will be based on daily data with a rolling evaluation scheme.

An in-sample analysis shows that bearing currency risk using exchange rate futures improves the performance of international portfolios. Apparently, risk hedging not only reduces portfolio risk, it also enables improvements in the risk-returns trade-off. In line with previous studies, our findings suggest that currency exposure should be hedged and hedging ratios vary over time and currency. Therefore, there is evidence of the consistent dominance of risk minimizing strategies against static naïve ones. Optimal hedging ratios are similar across models. In terms of total hedging, namely, the sum of hedging ratios for each portfolio, OLS and EWMA seem to show higher averages. As in Schmittmann (2010), hedging effectiveness is higher for full bond portfolios than for portfolios that include equities; however, improved Sharpe ratios for full bond hedged portfolios are lower than for EMU portfolios for the full-sample and before crisis periods. This result confirms the idea that for European bond investors, holding foreign bonds during calm periods might not be a good strategy. Both hedging effectiveness and improved Sharpe ratios for EWMA, and especially for the DCC and BEKK procedures, are higher than for the OLS case, thereby confirming the advantages of using conditional hedging strategies over static ones.

The out-of-sample analysis produces slightly lower total hedging ratios than the in-sample study for all models and, as in the previous case, OLS seems to require, on average, higher short positions in currency futures. As expected, hedging effectiveness is lower than for the in-sample analysis. Differences between in- and out-of-sample hedging effectiveness are especially significant for OLS cases with an average reduction of 37%. On average, OLS provides the lowest improved Sharpe ratios, while BEKK provides the highest. Therefore, OLS requires higher hedging ratios, on average, but it does not imply a better return-risk trade-off.

The remainder of the paper is organized as follows. In Section 2, we describe the kinds of portfolios we are analyzing, risk minimizing hedging strategies as well as a hedging effectiveness measurement. In Section 3, four different models used to estimate optimal hedging ratios are described. Section 4 presents the data, including a preliminary statistical analysis of bonds, equities, and spot and currency futures. Sections 5 and 6 report on the results and Section 7 presents the conclusions.

2. A Simplified Multi-currency Portfolio

As discussed in the introduction, we analyze the perspective of a European (Euro-based) institutional investor managing a multi-currency portfolio. The allocation strategy we adopt is, by construction, passive, but might also represent the benchmark of an actively managed portfolio. As a consequence, the allocations we consider can be associated with strategic reference portfolios or strategic asset allocations. In this framework, the institutional investor is willing to evaluate the benefits of currency hedging from a strategic perspective. Therefore, we partially deviate from previous studies as our allocations are not optimal in a mean-variance framework as, for instance, in de Roon et al. (2003 and 2011), and Campbell et al. (2010). The portfolio designs defined here are reasonable for institutional investors who are willing to introduce foreign assets (bonds and equities) in their asset allocation. They thus face the strategic decision of exposing, or not, the overall portfolio to the currency risk. To simplify the analyses, we consider a three-currency portfolio in which the investor is holding EMU, British and US stocks and/or bonds. We restrict the portfolio design to selected developed markets for a simple reason: institutional portfolios, in particular, those largely invested in bonds, normally include a limited fraction of foreign assets in order to indirectly control the currency risk. As foreign investment areas, we select a standard world reference, given by the US market, and a European alternative with non-Euro issues. Our analyses are limited to selected financial markets, but they can be easily generalized to include additional non-Euro denominated markets such as Switzerland, Nordic countries, or Asian markets. As a consequence of our choices, the results we provide are dependent on the selected foreign markets, and the costs/benefits of hedging might turn out to be different for additional markets not considered in the present paper. Nevertheless, the approach provided would represent a methodology for evaluating the possible introduction of currency hedging strategies. We finally stress that the analyses we pursue pertain to potential improvements in a passive portfolio management framework. The central role here is assigned to the management of the currency risk, the only active element we consider. The investor compares the benefits of currency hedging in terms of the risk-return profiles of hedged and un-hedged passive portfolios.

In our generic framework, the nominal unhedged portfolio return at time, r_t^{UH}, is given as:

$$r_t^{UH} = w^{EMU}\left(w^{EMU,B} r_t^{EMU,B} + w^{EMU,S} r_t^{EMU,S}\right) + w^{UK}\left(w^{UK,B} r_t^{UK,B} + w^{EMU,S} r_t^{UK,S}\right) + w^{US}\left(w^{US,B} r_t^{US,B} + w^{US,S} r_t^{US,S}\right) \quad (1)$$

where $r^{country,B}$, with country equal to either EMU, UK or US, is the return in Euro for a European investor holding EMU, UK or US bonds; $r^{country,S}$ is the return in Euro for a European investor investing in EMU, UK or US stocks; and $w^{country}$ is the weight of EMU, UK or US assets in the portfolio; and $w^{country,S}$ and $w^{country,B}$ are the weights of bonds and equities at the country level. Note that, $w^{country,S}+w^{country,B}=1$, and that $w^{EMU} + w^{UK} + w^{US} =1$.

Portfolio returns are weighted averages of the country portfolio returns of the two asset classes we consider (bonds and equities). Note that all returns are expressed in Euro. As a consequence, the returns of the UK- and US-based portfolios are influenced by local currency returns as well as by the exchange rate of the Euro, that is $r^{UK,B}=(1+r^{UK,B,local,})(1+r^{GBP/Euro})-1$, and similarly, for equity and US-based investments.

Moreover, when we focus on risk, the variance of the three-currency portfolio depends on the covariances among the stock and bond market returns, the covariances among the exchange rate fluctuations changes and the cross-covariances among the stock and bond market returns and the exchange rate. For instance, the total risk of a bond position in the US is equal to $\sigma^2_{US,B} = \sigma^2_{US,B,local} + \sigma^2_{USD,EUR} + 2\sigma_{US,B,local}\sigma_{USD/EUR}\rho_{USD,B,local;USD/EUR}$. As a consequence, the institutional investor has to decide whether the currency risk should be completely hedged in order to obtain portfolio returns in (1) with local currency returns instead of Euro-based returns from UK and US assets. As an alternative, the use of hedging strategies for currency risks might be considered as an additional tool provided to the managers to generate superior returns.

In the following, we analyze four different investments strategies:

(1) An equally weighted three-currency full bond portfolio with $w^{country}$= 0.33, $w^{country,S}$ =0 and $w^{country,B}$ =1, for the three countries, EMU, the UK and the US.

(2) An equally weighted three-currency full stock portfolio, with $w^{country}$= 0.33, $w^{country,S}$ =1 and $w^{country,B}$ =0, for the three countries, EMU, the UK and the US.

(3) An equally weighted three-currency 50% bond and 50% stock portfolio where $w^{country}$= 0.33, $w^{country,S}$ =0.5 and $w^{country,B}$ =0.5, for the three countries, EMU, the UK and the US.

(4) And finally, a home biased three-currency portfolio, i.e., w^{EMU}.= 0.60 and $w^{country}$.= 0.20 for the UK and the US, 50% bond and 50% stock portfolio ($w^{country,S}$ =0.5 and $w^{country,B}$ =0.5).

These four cases will allow an evaluation of the benefits of currency hedging when focusing on full bond and full equity portfolios (cases 1 and 2). Conversely, the third case focuses on balanced portfolios equally weighted between bonds and equities. Finally, the last case is introduced to evaluate the effects of some home bias for a Euro-based investor willing to partially reduce currency risk exposure by appropriately designing the strategic benchmark. Clearly, the choice of the combination weights is merely subjective and can be easily generalized to other designs.

2.1 Optimal hedging ratios

The unhedged portfolio defined in (1) has a currency exposure to both GBP and USD exchange rate changes. The investor could hedge the currency exposure of the unhedged portfolio by selling an appropriate number of future currency contracts denominated in GBP and USD. In order to find an optimal hedging strategy, we follow Cecchetti et al. (1988) and Kroner and Sultan (1993), among others. We thus focus on the investor problem, that is, the need to minimize the variance of a hedged portfolio return given by:

$$r_t^H = r_t^{UH} - \beta_1 r_t^{Fut\_GBP} - \beta_2 r_t^{Fut\_USD} \tag{2}$$

where r^{UH} is the portfolio return in (1), and r^{Fut_GBP} and r^{Fut_USD} are the changes in the GBP and USD futures prices, respectively. In this framework, β_1 and β_2 , the optimal hedging ratios (OHR) would be the optimal number of futures contracts in GBP and USD, respectively, that the investor should sell for each Euro invested in the international portfolio. A positive value of β_i, for $i=1, 2,$ means that the investor could reduce the volatility of the unhedged portfolio by holding a short position in such a future currency. On the contrary, a negative value would mean that the investor should hold a long position in futures contracts. A future short position implies that the future currency tends to appreciate against the Euro when the unhedged returns, denominated in Euros, increase, while a future currency long position would mean that that future currency would tend to depreciate as the unhedged returns increased. To identify the optimal values of β_1 and β_2, the standard practice focuses on the variance of the hedged portfolio.

We follow the same approach, but we consider a more general framework for a multi-currency portfolio whose returns are defined as follows

$$r_t^H = r_t^{UH} - \boldsymbol{\beta}' \mathbf{r}_t^{Fut}$$

where $\mathbf{r}_t^{Fut}$ is a k-dimensional vector of currency futures, which are included/affecting the returns of the unhedged portfolio, and $\boldsymbol{\beta}$ is the vector of the corresponding number of futures contracts required for the hedge. The evaluation of the vector $\boldsymbol{\beta}$ comes from a minimum problem, i.e., we search for the vector that minimizes the variance of the hedged portfolio returns. The minimum problem is the following:

$$\min_{\boldsymbol{\beta}} \; Var\left[r_t^H\right]$$

The hedged portfolio variance can be represented as a function of the variance-covariance matrix of the unhedged portfolio returns and currency future returns defined as

$$Var\begin{bmatrix} r_t^{UH} \\ \mathbf{r}_t^{Fut} \end{bmatrix} = \begin{bmatrix} \sigma_{UH}^2 & \boldsymbol{\sigma}_{UH,Fut}' \\ \boldsymbol{\sigma}_{UH,Fut} & \Sigma_{Fut} \end{bmatrix} = \Sigma$$

where σ_{UH}^2 is the variance of the unhedged portfolio returns, Σ_{Fut} is the covariance matrix of the currency futures returns, $\boldsymbol{\sigma}_{UH,Fut}$ is the k-dimensional vector of the covariances between the currency futures and unhedged portfolio returns, and Σ is the full covariance matrix (of dimension k+1). The hedged portfolio variance is thus

$$Var\left[r_t^H\right] = \begin{bmatrix} 1 & -\boldsymbol{\beta}' \end{bmatrix} \begin{bmatrix} \sigma_{UH}^2 & \boldsymbol{\sigma}_{UH,Fut}' \\ \boldsymbol{\sigma}_{UH,Fut} & \Sigma_{Fut} \end{bmatrix} \begin{bmatrix} 1 \\ -\boldsymbol{\beta} \end{bmatrix} = \sigma_{UH}^2 + \boldsymbol{\beta}'\Sigma_{Fut}\boldsymbol{\beta} - 2\boldsymbol{\beta}'\boldsymbol{\sigma}_{UH,Fut}$$

The solution of the minimum problem comes by equating the *k* first-order conditions to zero

$$\min_{\boldsymbol{\beta}} \ \sigma_{UH}^2 + \boldsymbol{\beta}'\Sigma_{Fut}\boldsymbol{\beta} - 2\boldsymbol{\beta}'\boldsymbol{\sigma}_{UH,Fut}$$
$$\frac{\partial}{\partial \boldsymbol{\beta}'}\left(\sigma_{UH}^2 + \boldsymbol{\beta}'\Sigma_{Fut}\boldsymbol{\beta} - 2\boldsymbol{\beta}'\boldsymbol{\sigma}_{UH,Fut}\right) = 2\Sigma_{Fut}\boldsymbol{\beta} - 2\boldsymbol{\sigma}_{UH,Fut} = 0$$

The optimal vector $\boldsymbol{\beta}$ is then equal to

$$\hat{\boldsymbol{\beta}} = \Sigma_{Fut}^{-1}\boldsymbol{\sigma}_{UH,Fut}$$

In the two-currency case of equation (2), the optimal hedge ratios are equal to

$$\beta_1 = \frac{\sigma_{12}\sigma_{33}^2 - \sigma_{13}\sigma_{23}}{\sigma_{22}^2\sigma_{33}^2 - \sigma_{23}^2}$$
$$\beta_2 = \frac{\sigma_{13}\sigma_{22}^2 - \sigma_{12}\sigma_{23}}{\sigma_{22}^2\sigma_{33}^2 - \sigma_{23}^2} \quad (3)$$

where

$$\sigma_{22}^{2} = Var\left[r_t^{Fut\_GBP}\right]; \quad \sigma_{33}^{2} = Var\left[r_t^{Fut\_USD}\right]$$
$$\sigma_{12} = Cov\left(r_t^{UH}, r_t^{Fut\_GBP}\right); \quad \sigma_{13} = Cov\left(r_t^{UH}, r_t^{Fut\_USD}\right)$$
$$\sigma_{23} = Cov\left(r_t^{Fut\_GBP}, r_t^{Fut\_USD}\right)$$

The approach we follow resemble that of Brown et al. (2012) and leads to highly similar optimal hedge ratios. However, our result differs in one fundamental relevant aspect: future positions are not multiplied by the corresponding weights of the foreign currency positions in the portfolio. As a result, our approach is more general as we consider the covariance between the un-hedged portfolios and the un-weighted future positions. The optimal hedge ratios we provide differ from those of Brown et al. (2012) by a scale factor, the weight of foreign currency positions. The latter optimal hedge ratios refer to single foreign currency positions, while our optimal hedge ratios refer to the full un-hedged portfolio.

2.2 Hedging effectiveness

In order to compare the performance of the OHRs obtained from different multivariate conditional volatility models, Ku et al. (2007) suggest that a more accurate model of conditional volatility should also be superior in terms of hedging effectiveness, as measured by the variance reduction for any hedged portfolio compared with the unhedged portfolio. Thus, a hedging effective index (HE) is given as:

$$HE = \left[\frac{\sigma_{UH}^{2} - \sigma_{H}^{2}}{\sigma_{UH}^{2}}\right], \tag{4}$$

where σ_H^2 denotes the variances of the hedged portfolio returns r_t^H (see, for example, Ripple and Moosa, 2007). A higher HE indicates a higher hedging effectiveness and a larger risk reduction, such that the hedging method with a higher HE is regarded as a superior hedging strategy. When variances become dynamic, as will be highlighted in the following section, the evaluation of the hedging effectiveness becomes more complicated. In that case, the evaluation of HE would require the use of both descriptive tools and graphics (additional details will be provided in the empirical section). Moreover, the evaluation of the benefits of hedging will also be based on the analysis of hedged and unhedged portfolio returns and risk.

3. Multivariate Conditional Volatility Models

In order to estimate the conditional variances and covariances so as to find optimal hedging ratios, this paper uses three multivariate models, the exponential weighted moving average (EWMA), the DCC model of Engle (2002) and the diagonal BEKK model of Engle and Kroner (1995). The three modeling approaches will be, in all cases, fitted on three returns sequences: that of an unhedged portfolio and those of two currencies. Additionally, in order to compare our results with a benchmark, we estimate, by ordinary least squares, the following equation:

$$r_t^{UH} = \beta_0 + \beta_1 r_t^{Fut\_GBP} + \beta_2 r_t^{Fut\_USD} + u_t \tag{5}$$

The estimated betas will provide a static OHR. In the following, we briefly describe the three conditional covariance models we consider to estimate the hedge ratios in (3). In that case, the hedge ratios will be dynamic and will be based on the estimated conditional variances and covariances/correlations patterns.

3.1 Exponential weighted moving average

Consider the 3-dimensional vector or returns $r_t = r_t^{UH}, r_t^{Fut\_GBP}, r_t^{Fut\_USD}$ with a conditional mean, zero, and a conditional covariance matrix, H_t:

$$r_t = \varepsilon_t = \Sigma_t^{1/2} \eta_t \tag{6}$$

where η_t is *i.i.d* with $E(\eta_t) = 0$ and $\operatorname{var}(\eta_t) = I_n$. Following the RiskMetrics approach, we consider the class of conditional covariance matrices that are the weighted sum of the cross products of past returns and the elements of the variance and covariance matrix:

$$\Sigma_t = (1-\lambda) r_{t-1} r_{t-1}^{'} + \lambda \Sigma_{t-1} \tag{7}$$

The decay factor λ is set to 0.97. An important consequence of using an exponential weighting scheme is that regardless of the actual number of historical returns used in the volatility calculation, the effective number of days used is limited by the size of the decay factor. In other words, 99.9% of the information is contained in the last *log(0.001)/log(λ)* days. As we use *λ=0.97* 99.9% of the information is contained in the last 227 days. The EWMA one-day volatility estimate changes everyday as we incorporate new information and discard old observations. Note that this approach, despite being naïve compared to the following, allows obtaining time-varying conditional variances, covariances, and indirectly, time-varying conditional correlations.

3.2 BEKK

The EWMA described above is, however, a calibrated model. More appropriate model specifications are available in the literature (see the surveys by Bauwens et al., 2006; Silvennoinen and Terasvirta, 2011). Among the large number of available specifications, we consider the BEKK model of Engle and Kroner (1995). Such a specification has the attractive property that the conditional covariance matrices are positive definite by construction without the need of imposing too much structure on model parameters. This comes at a cost. In fact, the BEKK, as many other specifications, suffers from the so-called "curse of dimensionality" (see McAleer et al., 2009, and Caporin and Paruolo, 2013 for a comparison of the number of parameters in various multivariate conditional volatility models). The simplest BEKK model is given as follows:

$$\Sigma_t = CC' + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'\Sigma_{t-1}B, \tag{8}$$

where the matrix C is a lower triangular, and the parameter matrices A and B are full. In the BEKK model, the conditional variances and covariances are linear functions of past variances and covariances and past cross-products of return shocks. Note that the BEKK model has been used in several variants, including restricted specifications where the matrices A and B have been set diagonally or replaced with scalars. In our framework, such a general economically unjustified restriction is not needed. In fact, with just three variables included in the model, the parameter estimation is feasible. Note also that the BEKK formulation guarantees the conditional covariance to be positive definite for all t due to the dynamic equation involving the quadratic form, and under the condition that the recurrence equation is initialized with a positive definite matrix. Moreover, to avoid observationally equivalent outcomes, the upper left element of the matrices A and B is constrained to be positive (see Engle and Kroner for further details).

Similar to the EWMA, the BEKK model provides indirect dynamic conditional correlations (see Caporin and McAleer, 2008), whereby the scalar, diagonal and full versions of BEKK are also discussed and compared to the dynamic conditional correlation model, the subject of the next subsection.

3.3 Dynamic conditional correlation (DCC)

The dynamic conditional correlation model differs from EWMA and BEKK in the manner in which the dynamic of the conditional covariance is described. In fact, the present model takes off from the decomposition of the covariance matrix in its constituent elements, variances and correlations. Moreover, it also tries to give an answer to the unrealistic assumption of constant correlations proposed by Bollerslev (1990). Engle (2002) suggests a dynamic conditional correlation (DCC) model, which is defined as follows:

$$\Sigma_t = D_t R_t D_{t,} \tag{9}$$

where $D_t = diag\left(\sigma_{1,t},...,\sigma_{k,t}\right)$ is a diagonal matrix of conditional standard deviations, and R_t is the conditional correlation matrix. The conditional variance can be described by univariate GARCH models as follows:

$$\sigma_{i,t}^2 = \omega + \sum_{k=1}^{p} \alpha_{i,k} \varepsilon_{i,t-k} + \sum_{l=1}^{q} \beta_{i,l} \sigma_{j,t-l}^2 \tag{10}$$

And model orders p and q are, in most cases, restricted to 1. Note that the univariate specifications need not be equal across the variables included in the model.

If we define the variance standardized innovations $\eta_{i,t} = r_{i,t}\sigma_{i,t}^{-1}$, the conditional correlation matrix is driven by the following equations:

$$R_t = \left\{(diag(Q_t)^{-1/2}\right\} Q_t \left\{(diag(Q_t)^{-1/2}\right\} \tag{11}$$

where the $k \times k$ symmetric positive definitive matrix Q_t is given by

$$Q_t = \left(1-\theta_1-\theta_2\right)\bar{Q} + \theta_1\eta_{t-1}\eta_{t-1}' + \theta_2 Q_{t-1}, \tag{12}$$

In the previous equation, θ_1 and θ_2 are non-negative scalar parameters capturing the effects of previous shocks and of a past Q_t matrix on the current Q_t matrix. Moreover, $\bar{Q}$ is a positive definite matrix with unit elements on the main diagonal. When $\theta_1 = \theta_2 = 0, \bar{Q}$ in (12) is equivalent to the constant conditional correlations (CCC), the DCC collapses to the model of Bollerslev (1990). Note that the DCC model obtains a dynamic conditional correlation as a by-product of the dynamic of variance standardized residuals. The equation (12) is nothing more than a scalar BEKK specification for those residuals (for further discussion on the DCC model, see Engle, 2002; and Caporin and McAleer, 2012). We also observe Aielli's (2013) note on an inconsistency problem in the DCC estimation approach commonly considered. We are not exposed to this inconsistency bias given that the parameters θ_1 and θ_2 are, in sum, close to 1 and the parameter θ_2 is larger than 0.95 in most cases.

Comparing our approach to that of Brown et al. (2012), we differ on the choice of covariance models, analyzing the impact of model complexity on currency hedging. Several authors have included a mean dynamic in the construction of optimal hedge ratios (see Brooks et al., 2002; Caporin, 2013; Hammoudeh et al., 2010, among others. We do not consider a mean dynamic in this work as we focus on the benefits of multi-currency hedging and we prefer to exclude the impact of model and parameter uncertainty related to the mean.

4. Data Description

Our empirical analysis utilized equity indices from Morgan Stanley Capital International (MSCI), and government bond indices, both provided by Thomson Reuters-Datastream. Spot exchange rates and currency futures prices from the Chicago Mercantile Exchange (CME) were provided by the Thomson Reuters-Ecowin Financial Database.

We used the MSCI Price Index (MSPI) that measures the price performance of markets without including dividends. For bonds, we considered the bond Price Index (PI), which reflects the total value of the holdings (that is, price plus accrued interest) for each date, and hence, it is equivalent to how much it would cost to purchase the bonds, ignoring expenses for settlement on the index date. We considered three alternative maturity buckets for the bond indices: all-maturity, 1-3-year and 10+-year maturities.

The Thomson Reuters-Ecowin Financial Database provided continuous time series of currency futures prices. They are perpetual series of futures prices formed from individual futures prices. It starts with the nearest contract month, which forms the first value of the continuous series, with a switchover following the last trading day using traditional months (March, June, September and December).

For all time series of interest, we downloaded data in the range, January of 1999 to October of 2012, at the daily frequency with a total of 3593 observations. We also split the sample into the 'before crisis' period (BC) and the 'during crisis' (DC) period. The second subsample started on 16 September 2008 after Lehman Brothers declared bankruptcy.

Table 1A reports averages and standard deviations of returns for the stock, bond and currency markets for three different cases: the whole period, January 03, 1999 to October 12, 2012; the BC period, spanning January 03, 1999 to September 15, 2008, and includes 2531 observations; and finally, the DC period, starting from the Lehman Brothers' bankruptcy to the end of the sample and has 1060 observations.

Table 1A shows that from a European perspective, before the crisis, domestic and foreign bond and stock returns tended to perform badly, while the Euro was appreciating against the GBP and USD, magnifying negative foreign stock and bond market movements. While negative EMU stock market returns were found in the DC period, the EMU bond market returns were positive. In addition, foreign markets showed positive average returns when the Euro was appreciating against the GBP and depreciating against the USD; therefore, the EUR/GBP exchange rate movement reduced the positive British yields, but the increasing EUR/USD exchange rate boosted the US stock and bond returns. A falling European stock market and an increasing bond market in the DC period should have driven European investors to hold domestic bonds and foreign stocks and bonds, thereby increasing their exposure to currency risk. However, the peculiar signs of average returns were associated with the presence of the technology market bubble in the 'before crisis' period, which negatively affected equity returns. Conversely, for the bond case, the BC period includes 2007 when the first symptoms of the GFC were identified, with possible impacts on returns. The bond market average returns also showed a dependence on the bond maturity. While the longer-term bonds provided higher returns during the crisis, shorter maturity instruments were always associated with negative average returns. If we compared the standard deviations, we would note that the crisis period was characterized, as expected, by higher risk for all asset classes, including currencies. Notably, the US bond market was characterized by a decrease in the volatility of shorter maturity bonds. This was expected and was associated with the flattening of the interest rate curve for short maturities.

In order to shed some light on the crisis impact in terms of average returns and risk, we analyzed a different partition of the sample, comparing a stable period, ranging from January of 2003 to December of 2006 (1042 observations), with the crisis period. The latter was further divided into two sub-samples, from the Lehman bankruptcy up to the end of November of 2011 (838 observations), and from the first of December 2011 to the end of the sample (223 observations). This second sub-sample identifies the period of ECB interventions. The results are reported in Table 1B.

A first interesting observation has to do with the risk level: during the ECB interventions, the risk returned to levels comparable to those of the 2003-2006 period, or sensibly decreased compared to the period from Lehman to November, 2011. This highlights the importance of the ECB intervention, which had a positive impact on equity returns, compared to the September, 2008 – November, 2011 period, and that contributed to the stabilization of bond risks. A second relevant finding comes from the comparison of the US bond returns in USD and Euro. We observed that USD-based US bond returns had a smaller dispersion after the ECB intervention compared to the 2003-2006 and 2008-2011 periods. This is associated with the true limited movement in US bond returns rather than an effect of ECB intervention. On the contrary, the

USD bond returns, expressed in Euro, suggest an increase in risk up to the BC, or stable periods, due to the inclusion of the currency risk. Such relevant differences support the potential impact of an appropriate hedging strategy on both the portfolio return and the portfolio risk.

In general, for the full period and for the different sub-samples, we observed that the local currency returns were characterized by lower risk levels compared to Euro returns. Such differences were more pronounced in the bond case than in that of equity. This empirical evidence supports the need to verify the impact of hedging strategies as a tool to control the impact of currency risk in managed portfolios. In fact, appropriate hedging approaches, focused, for instance, only on bonds, might allow the reduction of risk, but at the same time, they could allow for maintaining the benefit of currency exposure that, in some cases, induces an increase in the average returns level. This last point refers, for instance, to the comparison of local currency average returns to Euro-based returns in the DC period for US assets, noting that the latter are generally higher for equities and lower for bonds. Noteworthy, local currency returns are associated with the introduction of a perfect currency hedging strategy, while Euro-based returns are given as an aggregation of local market returns and foreign exchange returns.

5. In-Sample Results

We first compared the model and strategy performances in-sample using the estimated paths of conditional variances and covariances. For the OLS model, estimates were based on a full-sample evaluation, thus hedge ratios were constant. Tables 2 to 4 show the averages of the estimated optimal hedge ratios (β_1 and β_2), hedging effectiveness and Sharpe ratios, respectively, for all estimation approaches (OLS, EWMA, DCC and BEKK), three periods (whole sample (ALL), before crisis (BC), and during crisis (DC)) and each analyzed investment strategy: full bond portfolio (Full Bond), full equity portfolio (Full Equity), bond and equity portfolio (equally weighted, 50% bonds, 50% assets), home biased bond and equity portfolio (60% EMU, 20% the UK and 20% the US). For portfolios, including bonds, Tables 2-4 show results based on the all-maturities bond index. Additional tables with results for short-term (1-3 years) and long-term (+10 years) bond indices are included in the Appendix.

Table 3 displays the hede ratios that minimized the risk of the portfolio analyzed. A long (buy) position of one Euro in a portfolio should be hedged by a short (sell) position of β_1 Euros in British pound futures and β_2 Euros in US dollar futures. For example, based on the OLS approach, for each Euro invested in a full bond three-currency portfolio, to minimize the volatility of the portfolio a European investor should hold, on average, 0.2625 and 0.3195 Euro short positions in GBP and USD futures, respectively. We observe that β_1 is greater than β_2 for the ALL and DC periods, except for the full bond case in which we find the opposite behavior,

β_2 is greater than β_1, for the ALL and DC periods and lower before the crisis. This result held for all estimation approaches (OLS, EWMA, DCC and BEKK). For the full bond portfolio, this was because the positive correlation between *Euroland* portfolio and USD future returns was higher than for the GBP futures during high volatility periods

Consider now β_1 and β_2 separately. Again, with the exception of the full bond portfolio, β_1 is always higher for the DC period than for the whole and BC periods. For the DC period, dynamic correlations between the international unhedged portfolio and GBP future returns were positive, as well as between GBP and USD futures returns, but negative for the international unhedged portfolio and USD futures returns. Based on equation (3), this would explain why during the crisis period it was optimal for a European investor to over-hedge the British pound exposure implicit in his/her portfolio and hold long exposure to the USD currency. Different patterns appear for the full bond portfolio where the β_1 value was somewhat stable across periods. The optimal hedging ratio β_2 was positive for the BC period and turned negative during the crisis except for the full bond case. A negative β_2 implies that a risk minimizing strategy would be to hold a long position in USD futures.

Using estimated hedge ratios, we computed simulated portfolio returns with (hedged portfolios, denoted by H) and without (unhedged portfolios, denoted by UH) currency hedging. Moreover, we recovered the returns and reported some information of a portfolio based only on Euro denominated assets (EMU). We computed unhedged portfolio average returns (R_{UH}) and volatility (σ_{UH}), hedged portfolio average returns (R_H) and volatility (**σ_H**)**,** and EMU portfolio average returns (R_{EMU}) and volatility (**σ_{EMU}**)**.** These statistics allowed us to obtain hedging effectiveness **(***HE)*, shown in Table 3, and improved Sharpe ratios (*SHR*), found in Table 4, for the all-maturity bond index case. Note that due to the presence of negative average returns, the traditional Sharpe ratio turned out to be inappropriate for comparisons across allocation strategies, models, periods and hedging presence. In fact, given two assets, A and B, with the same negative average return, say -1%, and the volatility of A twice the volatility of B, 20% and 10%, respectively, the Sharpe ratio of A would be higher than that of B, -0.05 versus -0.1 (see Caporin et al., 2012 for additional comments). To overcome this limitation, we considered the modified Sharpe of Israelsen (2005) where the average returns are multiplied by the volatility if it is negative, thus restoring the appropriate ordering. Additional information for the 1-3 and 10+-year bond indices can be found in the Appendix. All data referring to returns and volatilities are reported in annualized terms.

The patterns observed for the average optimal hedge ratios were common across estimation strategies. Some difference should have appeared when we considered the portfolio variance and hedging effectiveness. The highest portfolio variances appeared for the full equity portfolio and the lowest for the full bond portfolio, as expected. Hedged portfolio variances always remained smaller than unhedged portfolio variances (in every portfolio, period and model used), confirming the correctness of the analyses. Moreover, the highest variance values were observed in the DC period and were due to the instability of financial markets.

Table 3 shows that the full bond portfolio reported the highest hedging effectiveness (HE), and the full equity portfolio, the lowest. For the full bond case, portfolio volatility was dominated by exchange rate volatility hedged by using futures contracts, thereby explaining why HE was higher for portfolios holding bonds. For the equity and bond portfolios, the higher the weight of domestic bonds and equity, the lower was the HE. This result was also expected as increasing the share of domestic equity in the portfolio reduced the exchange rate contribution to the variance of the unhedged portfolio through its variance and covariance with the foreign asset. Noteworthy, the sub-period analysis suggests some changes in risk reduction strategies. Hedging effectiveness was higher before the Lehman crisis for all portfolios except for the full bond portfolio. Currency risk turned out to be more difficult and hedged in the DC period, and the only way to improve the hedging strategy was to develop more conservative investments (full bond portfolios).

Table 4 provides the improved Sharpe ratios of Israelsen (2005) for three portfolios (UH, H and EMU). Average returns were, in general, negative across periods, investment strategies and models. Most of the positive returns could be found in the DC period. The full equity portfolios reported the highest returns (or less negative). Risky environments (DC periods) and the higher weight of the equity in the portfolio increased returns but was usually combined with a drop in HE. Average returns appeared higher for hedged portfolios. The modified Sharpe ratios were higher in most cases for the hedged portfolios. The only exceptions were given by the full bond investment strategy when the comparison was made on the full sample. If we contrasted the performances of portfolios with foreign assets to those of the Euro denominated portfolio, we would observe that the vast majority of modified Sharpe ratios would suggest a preference of investment strategies with foreign currencies and hedging. Such a result held across periods and models, and it was more evident when equities were included in the portfolio.

Comparing EWMA, DCC and BEKK models, we can only perceive that β_1 and β_2 values were closer in EWMA and DCC models and somewhat higher (lower) for the β_1 (β_2) full asset portfolio in BEKK. β_2 was negative for the full asset and bond+equity portfolios during the crisis period. A noteworthy result is that the OLS model reported the lowest hedging effectiveness for every portfolio except for the DC period; DCC did a very good job in obtaining the lowest HE in 6 out of 12 cases and the second lowest in 5 out of 6 remaining left; finally the BEKK procedure obtained slightly lower HE values. If we analyzed the difference across models in terms of portfolio returns and volatility, such differences would not emerge in a clear manner. We thus focused on the modified Sharpe ratios and noted that the Sharpe of the hedged portfolio (the only quantity influenced by the model choice) was highest for the BEKK model in many cases, 5 out of 12 considered: full sample and BC for the equally weighted and home biased bond and equity portfolios; BC for the full equity portfolio. The DCC model was the preferred choice in only three cases (during the crisis for the full bond, full equity and home biased bond and equity portfolio), and the EWMA was preferred in two instances. Finally, the static OLS hedging strategy turned out to be the optimal choice in the full bond portfolio for the full sample. These results have different explanations: first, the OLS approach provided static hedge ratios and thus the introduction of variance dynamic can sensibly affect the results; second, the models differed in terms of the number of parameters, the EWMA was calibrated, while DCC and BEKK had a similar number of parameters (the estimated parameters are reported in the appendix); third, the BEKK might be more stable than the DCC in small systems (see Caporin and McAleer, 2008); finally, the previous comments are related to average hedge ratios and to the volatility and returns of the Euro, unhedged and hedged portfolios over the selected periods. As a consequence, differences across models might not appear clearly. To this end, we graphically analyzed the optimal hedge ratios. Figure 2 reports an example of the time evolution of the hedged ratios for the three models. It clearly emerges that the ratios are very close to each other, with some local deviations. To appreciate the differences across models, Figures 3 to 5 provide the box plots for the full bond, full equity and equally weighted portfolios, and for the three periods and all models. These graphs refer to the all-maturity bond index; those with different bond indices are reported in the appendix. The box plots show further evidence of the closeness of the average hedge ratios across models. There were some differences when we focused on the dispersion of the hedge ratios. These were more volatile for the EWMA case and less volatile for the DCC model. Nevertheless, these differences were not very relevant. As a preliminary conclusion, we can state that the introduction of dynamic hedging is, at least in principle, beneficial. However, alternative dynamic covariance models are equally good as tools for the derivation of optimal hedge ratios.

Finally, we were interested in evaluating whether the previous observations could be preserved when the maturity of the underlying benchmark bond index was modified. We thus considered the short-term (1-3 years) or long-term (+10 years) bond indices as an alternative to the all-maturities bond index previously used. All tables and figures are reported in the appendix. If we considered the longer maturity bonds, the introduction of foreign currencies and dynamic hedging would be beneficial compared to the Euro-only portfolio case in most cases; few exceptions were given by the full bond portfolio and by the balanced portfolios in the BC period. Moreover, the introduction of hedging provided better, modified Sharpe ratios (again, with the exception of the full bond portfolio strategy). For the short maturity bond, similar results appeared. In particular, the full bond portfolio was always characterized by opposite results to the portfolios, including equities. We can thus draw a general conclusion that on the basis of our results, it appears that the introduction of foreign bonds does not improve the risk-adjusted performances of a Euro-denominated bond portfolio. Such a result is stronger for short-term bonds. Other comments reported for the all-maturity bond indices were also confirmed with short- and long-term bond indices.

We can conclude that international portfolios for European investors holding domestic and foreign assets showed higher improved Sharpe ratios than portfolios holding only domestic assets in 8 out of 12 cases analyzed (the EMU portfolio produced higher Sharpe ratios for full bond in the All and BC periods, and for bond+equity portfolios during the BC period). Therefore, international investment led to an improvement in portfolio performance, especially during crisis periods, but at the same time, this strategy increased the impact of currency risk. The in-sample analysis demonstrated that bearing this risk using exchange rate futures improved the performance of international portfolios. Apparently, risk hedging not only reduces portfolio risk; it also provides improvements in the risk-returns trade-off.

Our findings suggests that currency exposure should be hedged, and that the optimal hedging ratios should be dynamic and, obviously, defined on a single asset base. Contrary to Campbell et al. (2010), risk-minimizing hedging strategies are far from full currency hedging. Moreover, optimal hedging ratios were similar across models, thus suggesting that simpler specifications might be considered. Nevertheless, hedging effectiveness was higher for EWMA, DCC and BEKK procedures than for the OLS case, which confirms the advantages of using conditional hedging strategies over static ones. Furthermore, our historical analysis recommends holding a short position in GBP and USD futures as these currencies tended to move in line with the portfolio returns for the All and BC periods. However, during the crisis we found that over-hedging the pound risk exposure, and holding a long position in USD would have been optimal as a result of increasing EUR/USD exchange that boosted US bond and equity returns. In addition, hedging effectiveness was higher for full bond portfolios than for other portfolios including equities. However, the improved Sharpe ratios for full bond hedged portfolios were lower than EMU portfolios for the All and BC periods. This finding supports that of de Roon et al. (2003), in that, this might not be a good strategy for European bond investors holding foreign bonds during calm periods. Finally, we stress that the in-sample evidence does not guarantee identical out-of-sample behavior. This is analyzed in the following section.

6. Out-of-Sample Evaluation

To further analyze the benefits of hedging and dynamic covariance modeling, we performed an out-of sample analysis. In this case, we estimated the various models on a 1-day rolling basis, keeping the estimation window size fixed and equal to five years of data (roughly, 1500 observations). In each estimation window, the various models, including the OLS case, were used to provide optimal one-step-ahead hedging ratios. We then assumed that the optimal hedges were constructed and updated on a daily basis according to the model forecasts. This gave rise to an out-of-sample period ranging from 01 September 2004 to 12 October 2012. Note that the first five years of data were needed to initialize the forecasting procedure. The out-of-sample range was then divided into before and during crisis sub-periods, similar to what we did in the previous section. However, due to the different sample sizes the before crises period (BC) began 01 September 2004 and ended 15 September 2008. We then replicated the in-sample analysis across periods and models. Tables 5 to 7 show out-sample optimal hedging ratios, hedging effectiveness and improved Sharpe ratios, respectively. Additional results are included in the Appendix. For the in-sample period, we started from the comparison across models when the all-maturity bond index was used to build the passive portfolios.

In Table 5, we see that even in the out-of-sample analyses, excluding the DCC model case, β_1 was larger than β_2 for both the whole and DC periods, while for the BC period β_2 dominated. In the DCC case, β_1 was always higher, suggesting that heterogeneity across models increased in the out-of-sample exercise. We also note that the dispersion of the hedge ratios was smallest for the OLS, followed by the DCC case, and then higher for the BEKK and EWMA. Separately considering the hedge ratios, we found confirmation of higher values for β_1 and smaller values for β_2 during the crises, with the exception of the full bond portfolio where the result was reversed. Notably, hedging ratios were still negative for the Euro against the USD during the crisis. For the full bond portfolio during the crisis period, β_2 was not only positive but also higher than β_1. The intuition behind this fact is that the correlation between unhedged full bond portfolio returns and EUR/USD and EUR/GBP future returns moved in the same direction during this period. Looking again at Table 1A, the behavior in EMU bonds (1.23%) along with positive returns in the British (3.66%) and American (4.11%) bond returns were boosted by the Euro depreciation against both the GBP and USD, inducing investors to hold short positions in both currency futures to minimize portfolio risk. As in the in-sample analysis during the crisis, for portfolios holding equities, β_2 was always negative or close to zero.

Table 6 presents the results on out-of-sample hedging effectiveness (the HE was evaluated ex-post). These quantities were computed on the realized portfolio returns, and for that reason, EMU and unhedged results were constant across estimation methods (no hedge ratios, and thus no impact from the model as the portfolio allocation was calibrated). The hedged portfolios always recorded a lower variance than the unhedged ones, and when equity was included, hedged portfolios recorded a lower variance than the full EMU portfolios. Higher variances were associated with the crisis period, as expected. The results were substantially similar across models, thus showing limited differences across the ex-post realized hedged portfolio variances. Hedging effectiveness was higher for the full bond portfolio and decreased when equity indices entered the portfolio, as in the in-sample analysis. Hedging effectiveness was especially low for the OLS procedure and full equity case during the crisis. The OLS did not provide the highest HE, and the EWMA did a very good job, with 7 out of 12 cases providing the highest HE.

In Table 7, we focus on hedging performance, as monitored by the modified Sharpe ratios. Comparing the Sharpe ratios of the hedged portfolios versus the unhedged ones, as markets experienced turbulence, we observed that hedging and foreign investments improved performance compared to the simple Euro-based portfolios. On the contrary, during stable market phases, Euro-based portfolios resulted in better performance than unhedged international portfolios. In general (except for the full bond case before the crisis), hedging improved remuneration per unit of risk. OLS hedging worsened during the crises. We related this finding to the limited flexibility of the model. When conditional variance models are used, even if they are naive (like the EWMA), they provide a greater flexibility than simple linear regression, with relevant effects on the estimation of the optimal hedge ratios during market turbulence. On the contrary, when markets are somewhat stable, the use of time series models for the estimation of hedge ratios becomes suboptimal. In fact, in the BC period the OLS model provided the highest modified Sharpe ratios. This might have been due to the impact of estimation and model errors which turned out to be more severe for conditional variance specifications compared to linear regression. Notably, the out-of-sample performance of the BEKK model worsened compared to the in-sample case. The BEKK model was frequently outperformed by the DCC and EWMA models. This might have been an effect of the limited flexibility of the BEKK compared to the DCC, and of the higher impact of estimation error with respect to the EWMA. Further differences across models appeared on the box-plots of the hedging ratios, presented in Figures 6-8. As for the in-sample case, we provided the analysis for the full bond, full equity and equally weighted portfolios. We observed that the DCC model (columns 2, 5 and 8) provided ratios with smaller dispersions across portfolios and periods, and this might explain the somewhat higher preference for this specification.

Finally, we evaluated the results with respect to the different maturities of the bond index. Previous findings were substantially confirmed. With respect to the advantages associated with the introduction of both foreign investments and hedging, in particular, we noted the following: hedging always improved portfolio performance; for BEKK, EWMA and DCC models, results suggest that hedging and foreign investments were most beneficial to performance during market turbulence; results for the OLS case were less clear and indicated a higher preference for portfolios with foreign investments, irrespective of the phase of the market.

To conclude, similar to the in-sample analysis and contrary to static strategies that do not take correlation among assets into account, or the universal hedge ratio of 0.77 popularized by Black (1990), we found that optimal hedging ratios changed depending on the portfolios and periods, but were relatively stable along the models. A short position in British pound futures was shown to be the optimal strategy for every period, model, and portfolio. A long position in dollar futures was optimal for portfolios holding equities during the financial crisis. Looking at total hedging, namely, the sum of hedging ratios for each portfolio, we found that for each Euro invested in an international portfolio, on average, for all models, portfolios and periods, around 60 cents should be used for hedging, going from 1.43 cents for the full equity portfolio during the crisis to 23 cents for the home biased portfolio in the EWMA model. Total hedging was lower for the home biased portfolios; the lower the international risk exposure, the lower the risk to be hedged by currency futures. Finally, on average, OLS and EWMA provided the highest total hedging ratios per Euro invested in an international portfolio with an average short position in futures of 61 cents against 52 and 58 cents of the DCC and BEKK models, respectively. The average short position was higher for the in-sample analysis than for the out-of-sample case.

As expected, HE was lower than for the in-sample analysis. Differences between in- and out-of-sample HE results were especially significant for the OLS case, with an average reduction of 37%. OLS recorded the lowest average hedging effectiveness, around 20% against 25%, 23% and 25% of the EWMA, DCC and BEKK procedures, respectively.

On average, for all portfolios and periods OLS resulted in the lowest improved Sharpe ratios (-2.49). EWMA, DCC and BEKK produced lower averages, -0.49, -0.25 and -0.19, respectively. Therefore, OLS required higher hedging ratios on average, but it did not imply a better return-risk trade-off.

7. Conclusions

This paper investigated dynamic currency hedging benefits, with a further focus on the impact of currency hedging before and during a period of financial turmoil. From the point of view of a Euro-based institutional investor who considers passive investment strategies in portfolios holding European, British and US assets, we analyzed the impact of the model specification to improve the risk-return trade-off when currency risk is hedged.

The empirical study, which involved both in-sample evaluations as well as out-of-sample analyses, included three main contributions: (1) we analyzed the impact of model specification, that is, why we used three models, EWMA, DCC, and BEKK, and OLS static hedging ratios as a benchmark; (2) we used US dollar and British pound futures, instead of forwards, to build our hedging strategies. While futures are similar to forward contracts, they also solve some of the shortcomings of forward markets; and (3) the choice of taking the Euro-based point of view allowed us to focus on the impact of the GFC and ESC crises on passively managed strategies and currency hedging, a novel contribution to the literature.

We found that for the portfolios, models and periods analyzed, international investment improved the risk-return trade-off in almost all cases. Therefore, international investment led to improvements in portfolio performance, especially during crisis periods, but at the same time, this strategy increased exposure to currency risk. An in-sample analysis showed that bearing this risk using exchange rate futures improved the performance of international portfolios. Apparently, risk hedging not only reduces portfolio risk, but also provides improvements in the risk-returns trade-off. Our finding suggests that currency exposure should be hedged, but hedging ratios vary over time and currency. Therefore, there was evidence of the consistent dominance of risk minimizing strategies against static naïve policies (constant hedging ratios of 0, 0.5 and 1). Optimal hedging ratios were similar across models. In terms of total hedging, the OLS and EWMA seemed to show higher averages. Hedging effectiveness was higher for full bond portfolios than for portfolios including equities, however, improved Sharpe ratios for full bond hedged portfolios were lower than for EMU portfolios for the All and BC periods. This result confirmed the idea that holding foreign bonds during calm periods might not be a good strategy for European bond investors. Both hedging effectiveness and improved Sharpe ratios for EWMA, and especially for the DCC and BEKK procedures, were higher than for the OLS case, thereby confirming the advantage of using conditional hedging strategies over static ones.

The out-of-sample analysis produced slightly lower total hedging ratios than the in-sample study for all the models, and as in the previous case, OLS seemed to require, on average, higher short positions in currency futures. As expected, hedging effectiveness was lower than for the in-sample analysis. Differences between in- and out-of-sample HE were especially significant for the OLS cases, with an average reduction of 37%. On average, OLS provided the lowest improved Sharpe ratios, while BEKK provided the highest. Therefore, OLS required higher hedging ratios on average, but it did not imply a better return-risk trade-off. The analysis utilized several models, in-sample and out-sample studies, and currency futures for hedging, and confirmed that hedging strategies depend on the portfolio composition and period. The DCC and BEKK models seemed to recommend, on average, slightly lower hedging ratios than OLS and EWMA and better results in terms of improved Sharpe ratios. This fact stood out in the out-sample study.

Finally, it is noteworthy to point out that: (1) as we provided an analysis based on theoretically hedged portfolio returns where hedging was dynamic and updated daily, and where hedging was implemented in a real framework, we must consider the effect on liquidity and margin requirements for daily adjustments; (2) our analyses were limited to selected financial markets, but they can easily be generalized to include additional non-Euro denominated markets such as Switzerland, Nordic countries, or Asian markets. The results obtained were dependent on selected foreign markets, and the costs/benefits of hedging might turn out to be different for additional markets not considered in the present paper. Nevertheless, the approach provided represents a methodology for evaluating the possible introduction of currency hedging strategies; and (3) the analyses we pursued referred to potential improvements in a passive portfolio management framework. The central role here was assigned to the management of the currency risk, the only active element we considered. The investor compared the benefits of currency hedging in terms of the risk-return profiles of hedged and unhedged passive portfolios.

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Table 1A. Descriptive Statistics of Returns (annualized)

		Whole January 03, 1999 -October 12, 2012 N=3591		BC January 03, 1999 September 15, 2008 N=2531		DC September 16, 2008 October 12, 2012 N=1060	
		Ave.	**Std**	**Ave.**	**Std**	**Ave.**	**Std**
stock Market	EMU (EUR)	-1.8821	22.4917	-0.6727	20.1263	-4.2810	27.3221
	U.K. (GBP)	-0.1249	19.9366	-1.1682	17.9523	3.2515	23.9732
	U.S. (USD)	0.9293	20.8963	-0.5236	17.7783	4.0807	26.9126
	U.K. (EUR)	-0.9455	21.3596	-2.2005	19.5033	2.8394	25.2113
	U.S. (EUR)	0.3506	22.2862	-2.3471	21.6663	6.3688	23.6760
Bond Market – All maturities	EMU (EUR)	-0.1998	3.5591	-0.8216	3.2508	1.2325	4.2027
	U.K. (GBP)	0.3506	6.1111	-1.2423	5.4881	4.1068	7.3839
	U.S. (USD)	0.7780	5.1118	0.3255	4.9964	1.8671	5.3806
	U.K. (EUR)	-0.4988	9.7999	-2.2739	8.5160	3.6653	12.3297
	U.S. (EUR)	0.1752	11.3289	-1.5135	9.8979	4.1068	14.1702
Bond Market – 1-3-year	EMU (EUR)	-1.2423	1.5464	-1.4889	1.4230	-0.6231	1.8057
	U.K. (GBP)	-1.2669	3.2366	-1.5135	3.3994	-0.6479	2.8128
	U.S. (USD)	-0.1998	1.8736	-0.1499	2.0302	-0.2746	1.4293
	U.K. (EUR)	-2.0782	8.6409	-2.5423	7.8345	-1.0693	10.3169
	U.S. (EUR)	-0.7968	10.4497	-1.9802	9.4805	1.9181	12.4610
Bond Market – +10 Year	EMU (EUR)	0.5012	7.0013	-0.4988	6.5475	2.7110	7.9705
	U.K. (GBP)	0.9797	9.2339	-1.1187	7.9626	5.9443	11.7162
	U.S. (USD)	1.8926	11.1249	0.6773	9.4394	4.7855	14.3757
	U.K. (EUR)	0.1251	11.8680	-2.1516	10.0972	5.4951	15.2801
	U.S. (EUR)	1.2831	15.1821	-1.1682	12.1495	7.0891	20.6860
Currencies	EUR/GBP (Spot)	-0.8464	8.2282	-1.0445	7.3001	-0.3992	10.1082
	EUR/USD(Spot)	-0.5982	10.4861	-1.8331	9.6370	2.1987	12.2744
	EUR/GBP(Fut)	-0.7720	8.1492	-0.8712	7.3112	-0.4739	9.8710
	EUR/USD(Fut)	-0.5485	10.1762	-1.6611	9.4489	1.9691	11.7336

Note: mean and standard deviations across periods and assets. The first column identifies the asset type, the second column reports the country and in parenthesis the currency or the type of exchange.

Table 1B. Descriptive Statistics of Returns (annualized)

			January 2003/ December 2006 N=1042		September 15, 2008/ November 30, 2011 N=838		December 1, 2011/ October 12, 2012 N=223	
			Ave.	**Std**	**Ave.**	**Std**	**Ave.**	**Std**
stock Market		EMU (EUR)	16.1202	15.4983	-9.0643	28.5743	7.3302	20.5564
		U.K. (GBP)	11.6251	12.8942	0.8788	25.5338	4.2891	14.4801
		U.S. (USD)	12.2685	12.2285	-0.1249	29.2985	15.6569	13.1345
		U.K. (EUR)	10.7084	14.2540	-1.5873	26.9837	11.8764	14.6919
		U.S. (EUR)	6.2625	16.2177	2.0456	25.6919	21.0069	11.2846
Bond Market	**All maturities**	EMU (EUR)	-0.4988	3.2903	-0.7720	4.2295	9.1971	4.0778
		U.K. (GBP)	-1.1682	4.9332	4.9166	7.4567	2.3265	7.1167
		U.S. (USD)	-1.5873	4.4446	1.9436	5.7459	0.9545	3.6888
		U.K. (EUR)	-1.9557	7.0740	2.4801	12.9606	10.2115	9.6102
		U.S. (EUR)	-6.8780	8.9872	3.7172	14.9908	5.6006	10.5636
	1-3-year	EMU (EUR)	-1.9312	1.2270	-1.3903	1.7898	2.2754	1.8594
		U.K. (GBP)	-2.2739	3.3188	0.1000	2.5694	-3.1980	3.5892
		U.S. (USD)	-1.5873	1.6997	-0.1499	1.5938	-0.9703	0.4791
		U.K. (EUR)	-3.0526	6.6771	-2.2250	11.0111	4.2370	7.1467
		U.S. (EUR)	-6.8548	9.0552	1.5620	13.2831	3.5876	8.7548
	+10- Year	EMU (EUR)	1.5366	6.6186	-0.2996	8.1397	15.5125	7.3191
		U.K. (GBP)	-0.4490	7.2543	6.9286	11.8348	4.6024	11.2435
		U.S. (USD)	-1.0940	8.6947	4.7332	14.7520	3.7690	12.8072
		U.K. (EUR)	-1.2423	8.6204	4.4195	15.8209	12.6338	13.0365
		U.S. (EUR)	-6.4111	10.6932	6.5551	21.3406	8.5441	18.0092
Currencies		EUR/GBP (Spot)	-0.8216	6.1000	-2.4447	10.9383	7.2766	6.2060
		EUR/USD(Spot)	-5.3521	9.3667	2.1732	13.0634	4.6285	8.7358
		EUR/GBP(Fut)	-0.9703	6.2076	-2.5666	10.7233	6.9821	5.7680
		EUR/USD(Fut)	-5.7064	9.1564	1.9946	12.4309	4.2891	8.5555

Note: mean and standard deviations across periods and assets. The first column identifies the asset type, the second column reports the country and in parenthesis the currency or the type of exchange.

Table 2: in-sample optimal hedge ratios for alternative models

		OLS		EWMA		DCC		BEKK	
		β_1	β_2	β_1	β_2	β_1	β_2	β_1	β_2
Full Bond	**ALL**	0.2625	0.3195	0.2782	0.3026	0.2766	0.3021	0.2781	0.3009
	BC	0.2766	0.2466	0.2885	0.2476	0.2845	0.2500	0.2871	0.2474
	DC	0.2575	0.4236	0.2543	0.4338	0.2667	0.4344	0.2546	0.4329
Full Equity	**ALL**	0.5448	0.0580	0.3358	0.2699	0.3532	0.2700	0.3370	0.2661
	BC	0.2667	0.6405	0.1603	0.6722	0.2143	0.6481	0.1862	0.6373
	DC	0.7884	-0.7475	0.7570	-0.7106	0.7105	-0.6468	0.7259	-0.6783
Bond + Equity (0.33 each country)	**ALL**	0.4036	0.1888	0.3070	0.2863	0.3227	0.2782	0.3145	0.2755
	BC	0.2716	0.4436	0.2244	0.4599	0.2528	0.4486	0.2431	0.4384
	DC	0.5230	-0.1619	0.5057	-0.1384	0.4902	-0.1135	0.4889	-0.1158
Bond + Equity (0.60 EMU)	**ALL**	0.3024	0.0486	0.2033	0.1527	0.2186	0.1486	0.2119	0.1319
	BC	0.1586	0.3341	0.1118	0.3513	0.1488	0.3324	0.1472	0.2888
	DC	0.4307	-0.3446	0.4234	-0.3324	0.4000	-0.3004	0.3710	-0.2547

Portfolio composition is reported in the first column: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US). The second column reports the reference period: whole period (ALL), Before Crisis (BC), During Crisis (DC). The other columns are model-specific and include Euro units of British Pound future sold (**β_1**) and Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio. Bond portfolio results are based on the all-maturities bond index.

Table 3: in-sample hedging effectiveness

		OLS	EWMA	DCC	BEKK
Full Bond	**ALL**	54.2271	55.9783	56.4614	56.2802
	BC	48.0645	48.6290	49.1129	49.1935
	DC	64.7259	64.5369	64.6881	64.4991
Full Equity	**ALL**	6.3218	17.3255	17.1643	16.8419
	BC	17.8482	19.9368	21.2931	20.3778
	DC	14.8817	14.9784	15.7008	13.2536
Bond + Equity (0.33 each country)	**ALL**	21.9506	29.3108	28.6606	28.9987
	BC	34.4463	35.5593	36.5888	35.9210
	DC	18.8174	18.5926	18.5926	16.9739
Bond + Equity (0.60 EMU)	**ALL**	7.9051	17.6812	17.2069	14.7019
	BC	18.5955	20.1025	21.5190	17.7134
	DC	14.7541	15.2196	16.3327	11.7418

Portfolio composition is reported in the first column: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US). The second column reports the reference period: whole period (ALL), Before Crisis (BC), During Crisis (DC). The other columns are model-specific and include the hedging effectiveness in percentage points. Bond portfolio results are based on the all-maturities bond index.

Table 4: in-sample improved Sharpe ratios

		UH	OLS	EWMA	DCC	BEKK	EMU
Full Bond	**ALL**	-1.1250	0.0517	-1.7042	-1.2718	-1.4865	-0.7113
	BC	-8.4267	-3.4957	-5.9460	-5.3222	-5.1260	-2.6718
	DC	0.3650	0.4658	0.4584	0.4863	0.4169	0.2932
Full Equity	**ALL**	-15.4869	-6.8421	0.0821	0.0465	-6.8393	-42.3323
	BC	-29.9870	-6.6629	0.0084	-10.7644	0.0243	-13.5394
	DC	0.0695	0.1678	0.2701	0.2776	0.2179	-116.969
Bond + Equity (0.33 each country)	**ALL**	-4.9022	-0.6494	0.0607	-0.1656	0.0698	-11.4112
	BC	-15.5454	-4.9724	-5.3264	-8.0766	-3.0291	-7.2155
	DC	0.2134	0.2988	0.4067	0.3500	0.3089	-21.0662
Bond + Equity (0.60 EMU)	**ALL**	-7.0131	-4.1969	0.0317	-0.4431	0.0339	-11.4112
	BC	-28.9056	-4.9157	-4.4775	-7.8264	-3.0385	-7.2155
	DC	0.0655	0.1572	0.2746	0.2921	0.2182	-21.0662

Portfolio composition is reported in the first column: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US). The second column reports the reference period: whole period (ALL), Before Crisis (BC), During Crisis (DC). The other columns report the improved Sharpe Ratio of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided) for the unhedged portfolio (UH), for the hedged portfolios where hedge ratios are model-dependent, and for the portfolio containing only assets denominated in Euro (composition by asset class is here consistent to that in the first column). Bond portfolio results are based on the all-maturities bond index.

Table 5: out-of-sample optimal hedge ratios for alternative models

		OLS		EWMA		DCC		BEKK	
		β_1	**β_2**	**β_1**	**β_2**	**β_1**	**β_2**	**β_1**	**β_2**
Full Bond	**ALL**	0.2644	0.2814	0.2678	0.3611	0.3782	0.2321	0.2701	0.3490
	BC	0.2794	0.2115	0.2820	0.2879	0.3594	0.1785	0.2761	0.2806
	DC	0.2495	0.3509	0.2536	0.4339	0.3969	0.2853	0.2642	0.4170
Full Equity	**ALL**	0.4495	0.2230	0.5132	-0.1862	0.4311	-0.0015	0.4394	-0.0277
	BC	0.2228	0.7077	0.2709	0.3203	0.4053	0.2868	0.2401	0.4526
	DC	0.6748	-0.2585	0.7540	-0.6894	0.4568	-0.2878	0.6375	-0.5048
Bond + Equity (0.33 each country)	**ALL**	0.3570	0.2522	0.3905	0.0875	0.3936	0.1082	0.3532	0.1517
	BC	0.2511	0.4596	0.2765	0.3041	0.3737	0.2250	0.2579	0.3655
	DC	0.4621	0.0462	0.5038	-0.1278	0.4134	-0.0079	0.4480	-0.0607
Bond + Equity (0.60 EMU)	**ALL**	0.2580	0.1273	0.3034	-0.0742	0.2609	0.0138	0.2636	0.0082
	BC	0.1454	0.3592	0.1846	0.1744	0.2511	0.1469	0.1665	0.2444
	DC	0.3699	-0.1031	0.4214	-0.3210	0.2707	-0.1185	0.3601	-0.2265

Portfolio composition is reported in the first column: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US). The second column reports the reference period: whole period (ALL), Before Crisis (BC), During Crisis (DC). The other columns are model-specific and include Euro units of British Pound future sold (**β_1**) and Euro units of US dollar future sold (**β₂**) per Euro invested in an international portfolio. Bond portfolio results are based on the all-maturities bond index.

Table 6: out-of-sample hedging effectiveness

		OLS	EWMA	DCC	BEKK
Full Bond	**ALL**	57.4547	58.4404	54.6875	58.5361
	BC	41.6089	42.9759	39.3177	43.3117
	DC	63.4246	64.2737	60.4934	64.2709
Full Equity	**ALL**	4.2412	12.1629	10.1212	11.0508
	BC	5.4192	8.5194	9.1866	8.9343
	DC	3.8049	13.5258	10.4710	11.8421
Bond + Equity (0.33 each country)	**ALL**	14.2884	20.0723	18.9343	19.3880
	BC	25.0534	26.3492	25.6997	26.6090
	DC	9.3884	17.2353	15.8632	16.1128
Bond + Equity (0.60 EMU)	**ALL**	5.7603	13.1157	10.8842	12.2160
	BC	9.0645	11.1853	11.7767	11.5658
	DC	4.5082	13.8568	10.5483	12.4666

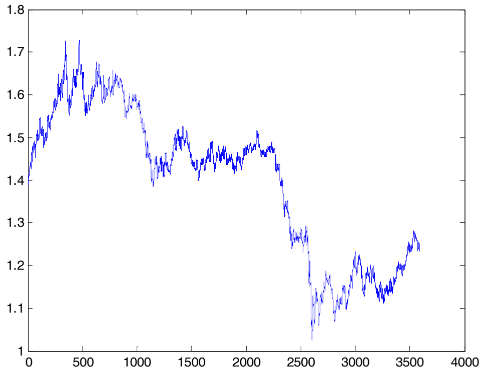
Portfolio composition is reported in the first column: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US). The second column reports the reference period: whole period (ALL), Before Crisis (BC), During Crisis (DC). The other columns are model-specific and include the hedging effectiveness in percentage points. Bond portfolio results are based on the all-maturities bond index.

Table 7: out-of-sample improved Sharpe ratios

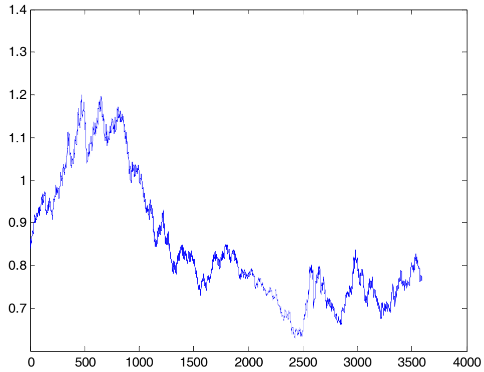
		UH	OLS	EWMA	DCC	BEKK	EMU
Full Bond	**ALL**	0.0300	0.1500	0.0800	0.1600	0.1300	0.0300
	BC	-12.4600	-3.5200	-5.3200	-5.0700	-3.7900	-3.5000
	DC	0.3600	-10.3200	0.4300	0.5400	0.4300	0.2900
Full Equity	**ALL**	0.0600	0.1600	0.1600	0.1700	0.1500	-3.0600
	BC	0.0300	0.3300	0.0500	0.1400	0.0800	0.2900
	DC	0.0700	0.0200	0.2400	0.2000	0.2000	-113.670
Bond + Equity (0.33 each country)	**ALL**	0.0700	0.2200	0.1900	0.1800	0.1817	-0.0700
	BC	-7.3300	0.2700	-2.4300	0.0100	-0.3199	0.2300
	DC	0.2200	-8.9500	0.3600	0.3000	0.3109	-20.290
Bond + Equity (0.60 EMU)	**ALL**	0.0400	0.1500	0.1400	0.1500	0.1312	-0.0700
	BC	-0.1400	0.3100	-0.0600	0.0800	0.0418	0.2300
	DC	0.0700	-8.7000	0.2400	0.2000	0.1927	-20.290

Portfolio composition is reported in the first column: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US). The second column reports the reference period: whole period (ALL), Before Crisis (BC), During Crisis (DC). The other columns report the improved Sharpe Ratio of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided) for the unhedged portfolio (UH), for the hedged portfolios where hedge ratios are model-dependent, and for the portfolio containing only assets denominated in Euro (composition by asset class is here consistent to that in the first column). Bond portfolio results are based on the all-maturities bond index.

Figure 1: future prices of British Pound and US Dollar against the Euro.

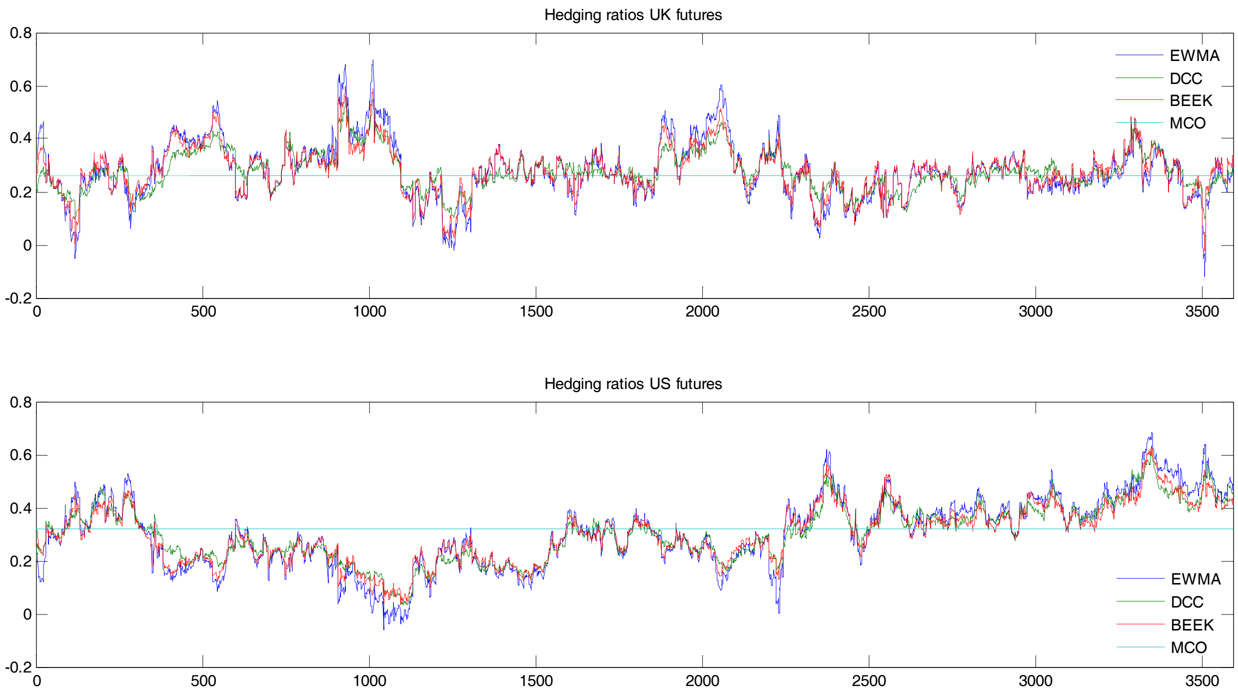


GBP Future prices



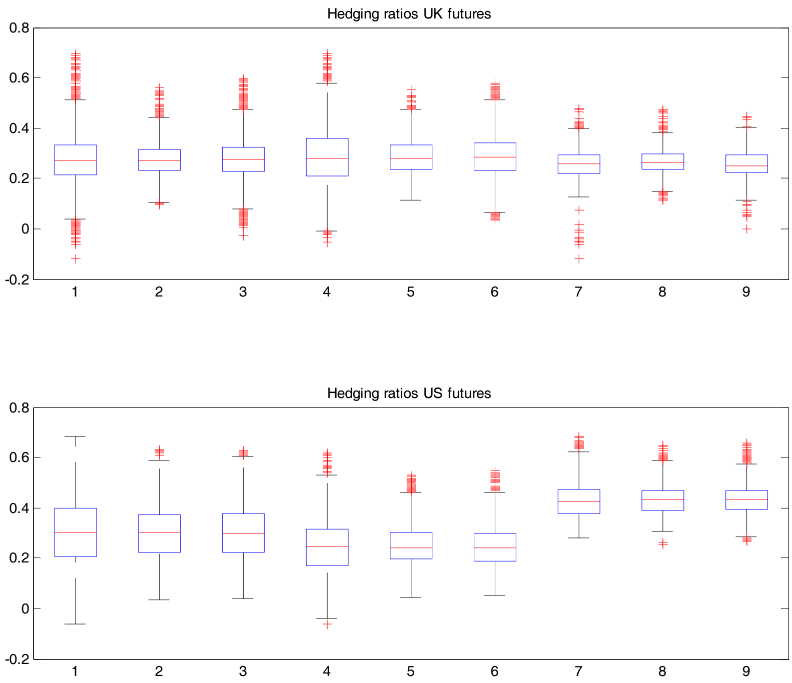
USD Future prices

Figure 2: Time path of hedge ratios (Full bond portfolio with All-maturities bond index)



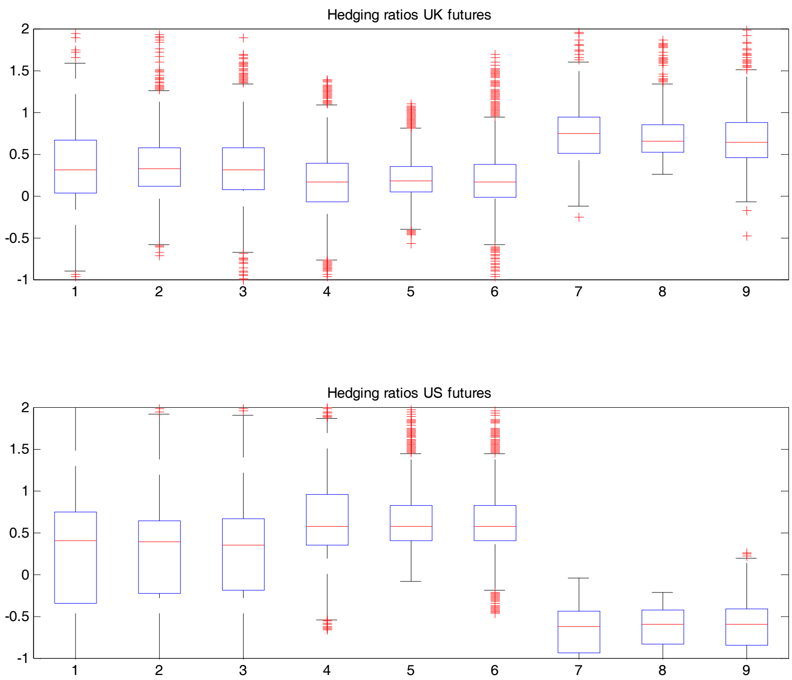
Note: hedging rations for the British Pound (upper panel) and US Dollar (lower panel).

Figure 3. In-sample Hedging ratios box-plots: Full bond portfolio



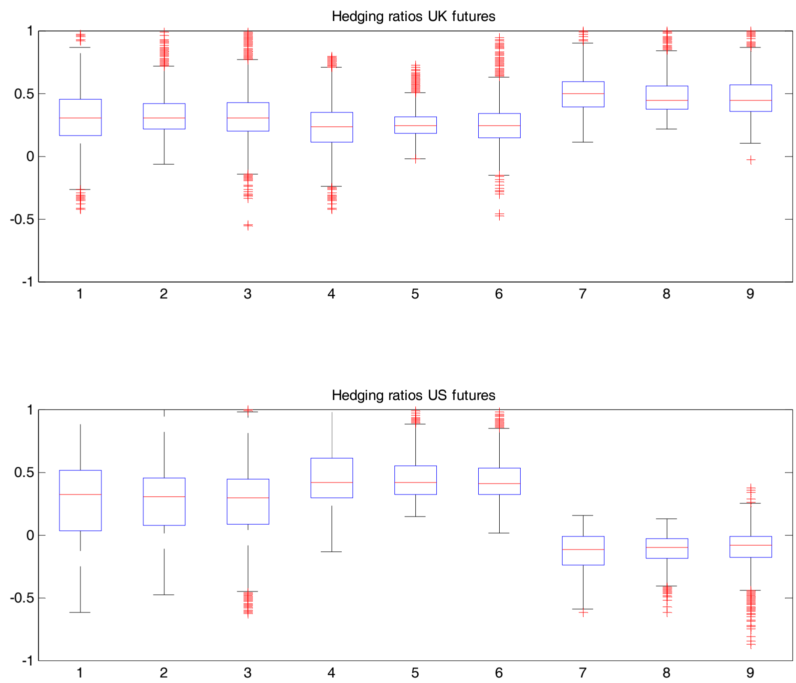
Note: 1-3 full sample; 4-6 Before crisis; 7-9 During Crisis; 1-4-7 EWMA; 2-5-8 DCC; 3-6-9 BEKK.

Figure 4. In-sample Hedging ratios box-plots: Full equity portfolio



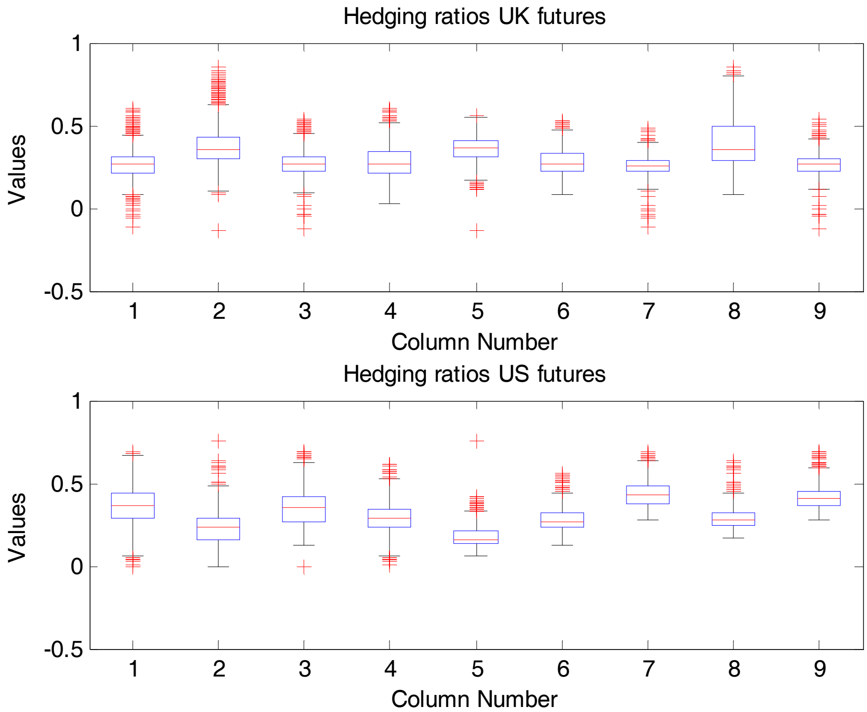
Note: 1-3 full sample; 4-6 Before crisis; 7-9 During Crisis; 1-4-7 EWMA; 2-5-8 DCC; 3-6-9 BEKK.

Figure 5. In-sample Hedging ratios box-plots: equally weighted equity and bond portfolio



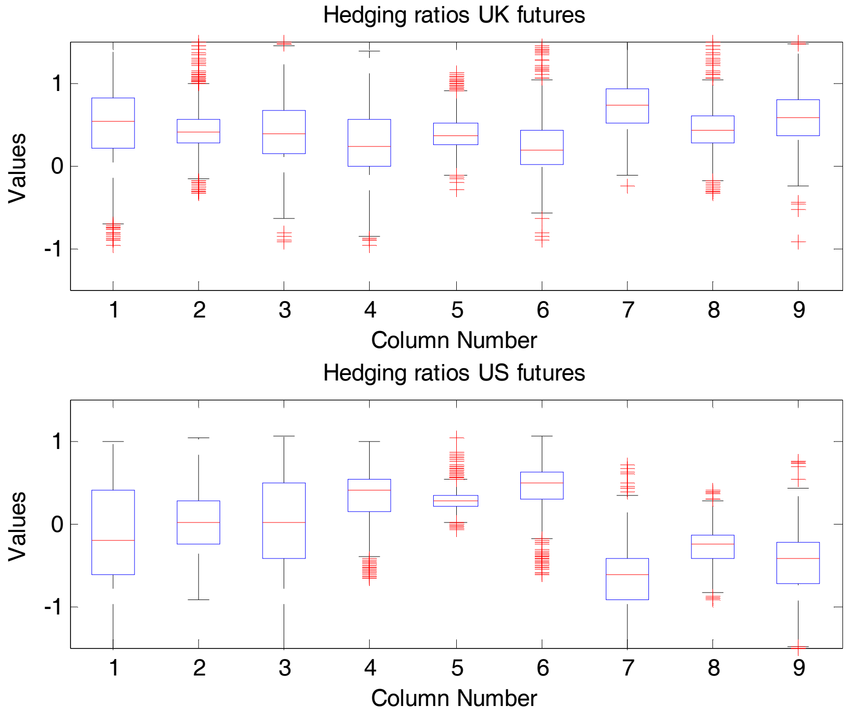
Note: 1-3 full sample; 4-6 Before crisis; 7-9 During Crisis; 1-4-7 EWMA; 2-5-8 DCC; 3-6-9 BEKK.

Figure 6. Out-of-sample Hedging ratio. Full bond portfolio



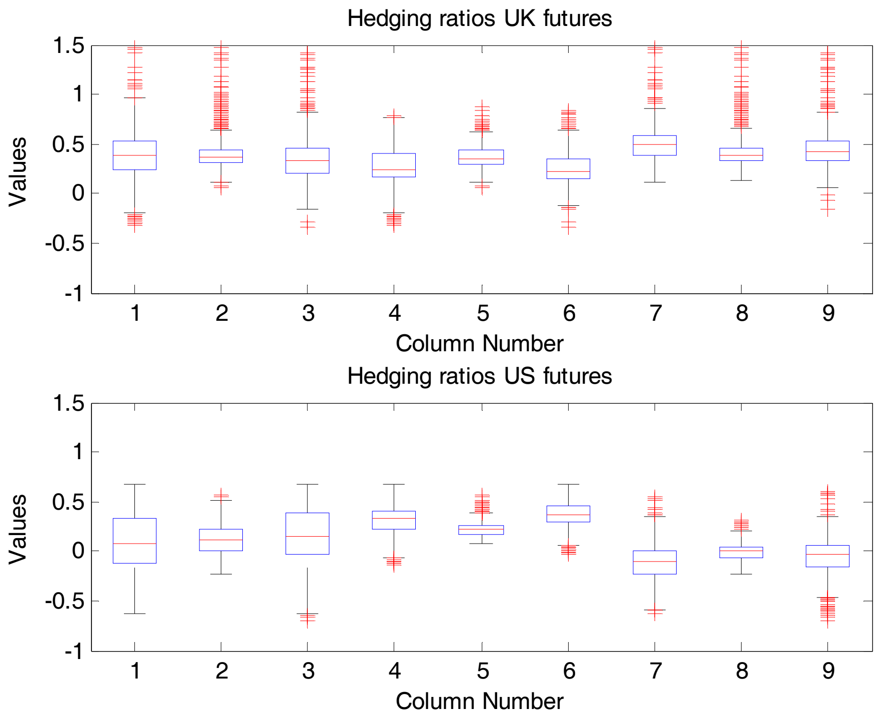
Note: 1-3 full sample; 4-6 Before crisis; 7-9 During Crisis; 1-4-7 EWMA; 2-5-8 DCC; 3-6-9 BEKK.

Figure 7. Out-of-sample Hedging ratios. Full equity portfolio



Note: 1-3 full sample; 4-6 Before crisis; 7-9 During Crisis; 1-4-7 EWMA; 2-5-8 DCC; 3-6-9 BEKK.

Figure 8. Out-of-sample Hedging ratios. equally weighted equity and bond portfolio



Note: 1-3 full sample; 4-6 Before crisis; 7-9 During Crisis; 1-4-7 EWMA; 2-5-8 DCC; 3-6-9 BEKK.

Appendix

Table A.1 OLS MODEL – All maturities – In-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2625	0.3195	6.4343	4.3532	54.2271	3.5602	-0.1748	0.2253	-0.1998	-1.1250	0.0517	-0.7113
	BC	0.2766	0.2466	5.5678	4.0125	48.0645	3.2519	-1.5135	-0.8712	-0.8216	-8.4074	-3.4957	-2.6718
	DC	0.2575	0.4236	8.1317	4.8296	64.7259	4.2042	2.9680	2.2498	1.2325	0.3652	0.4658	0.2932
Full Equity	ALL	0.5448	0.0580	18.8865	18.2798	6.3218	22.4917	-0.8216	-0.3743	-1.8821	-15.4869	-6.8421	-42.3323
	BC	0.2667	0.6405	17.3335	15.7107	17.8482	20.1259	-0.0173	-0.4241	-0.6727	-29.9870	-6.6629	-13.5394
	DC	0.7884	-0.7475	22.1670	20.4512	14.8817	27.3226	0.0154	3.4324	-4.2810	0.0695	0.1678	-116.9693
Bond + Equity (0.33 each country)	ALL	0.4036	0.1888	9.8043	8.6617	21.9506	10.9247	-0.4988	-0.0750	-1.0445	-4.9022	-0.6494	-11.4112
	BC	0.2716	0.4436	9.4789	7.6746	34.4463	9.6566	-1.6365	-0.6479	-0.7472	-15.5454	-4.9724	-7.2155
	DC	0.5230	-0.1619	10.5451	9.5013	18.8174	13.4805	2.2498	2.8394	-1.5627	0.2134	0.2988	-21.0662
Bond + Equity (0.60 EMU)	ALL	0.3024	0.0486	9.7404	9.3475	7.9051	10.9247	-0.7224	-0.4490	-1.0445	-7.0131	-4.1969	-11.4112
	BC	0.1586	0.3341	9.1077	8.2174	18.5955	9.6566	-1.2916	-0.5982	-0.7472	-28.9056	-4.9157	-7.2155
	DC	0.4307	-0.3446	11.1142	10.2616	14.7541	13.4805	0.7276	1.6128	-1.5627	0.0655	0.1572	-21.0662

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds); whole period (ALL), Before Crisis (BC), During Crisis (DC); Euro units of British Pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio; annualized unhedged portfolio standard deviation (**σ_{UH}**), annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** annualized European portfolio standard deviation **(σ_{EMU}),** annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), annualized European portfolio return (**R_{EMU}**), modified Sharpe Ratio (**SHR**) of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided).

Table A.2 OLS MODEL – 1-3-Year Maturity – In-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2959	0.3202	5.5272	2.4187	80.8511	1.5492	-1.3656	-0.9455	-1.2423	-7.5481	-2.2869	-1.9245
	BC	0.2820	0.3108	5.0349	2.3558	78.1065	1.4230	-1.9802	-1.2423	-1.4889	-9.9701	-2.9265	-2.1187
	DC	0.3143	0.3367	6.5555	2.5298	85.1076	1.8028	0.0750	-0.4490	-0.6231	0.0114	-1.1359	-1.1232
Full Equity	ALL	0.5448	0.0580	18.8865	18.2798	6.3218	22.4917	-0.8216	-0.3743	-1.8821	-15.5175	-6.8421	-42.3323
	BC	0.2667	0.6405	17.3335	15.7107	17.8482	20.1259	-0.0173	-0.4241	-0.6727	-0.3007	-6.6629	-13.5394
	DC	0.7884	-0.7475	22.1670	20.4512	14.8817	27.3226	0.0154	3.4324	-4.2810	0.0007	0.1678	-116.9693
Bond +Equity (0.33 each country)	ALL	0.3910	0.1877	10.2140	9.0526	21.4474	11.1524	-1.0940	-0.6231	-1.5627	-11.1740	-5.6403	-17.4279
	BC	0.2461	0.4744	9.8005	7.8358	36.0750	9.8944	-1.8576	-0.7720	-1.0693	-18.2054	-6.0494	-10.5798
	DC	0.5207	-0.2072	11.1490	10.0660	18.4835	13.6958	0.8032	1.4859	-2.4691	0.0720	0.1476	-33.8167
Bond +Equity (0.60 EMU)	ALL	0.2976	0.0509	10.1193	9.7082	7.9590	11.1524	-1.2916	-0.9703	-1.5627	-13.0703	-9.4197	-17.4279
	BC	0.1436	0.3621	9.4101	8.4202	19.9322	9.8944	-1.5627	-0.7720	-1.0693	-14.7053	-6.5005	-10.5798
	DC	0.4341	-0.3780	11.6458	10.7168	15.3180	13.6958	-0.5236	0.4510	-2.4691	-6.0981	0.0421	-33.8167

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds); whole period (ALL), Before Crisis (BC), During Crisis (DC); Euro units of British Pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio; annualized unhedged portfolio standard deviation (**σ_{UH}**), annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** annualized European portfolio standard deviation (**σ_{EMU}**), annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), annualized European portfolio return (**R_{EMU}**), modified Sharpe Ratio (**SHR**) of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided).

Table A.3. OLS MODEL - +10-year maturity– In-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2278	0.3338	8.8671	7.5531	27.4404	7.0018	0.6269	1.0050	0.5012	0.0707	0.1331	0.0716
	BC	0.2811	0.1832	7.3739	6.5689	20.6437	6.5479	-1.2669	-0.7224	-0.4988	-9.3423	-4.7453	-3.2658
	DC	0.1886	0.5441	11.6705	9.0111	40.3818	7.9703	5.0215	4.0287	2.7110	0.4303	0.4471	0.3401
Full Equity	ALL	0.5448	0.0580	18.8865	18.2798	6.3218	22.4917	-0.8216	-0.3743	-1.8821	-15.5175	-6.8421	-42.3323
	BC	0.2667	0.6405	17.3335	15.7107	17.8482	20.1259	-1.7348	-0.4241	-0.6727	-30.0708	-6.6629	-13.5394
	DC	0.7884	-0.7475	22.1670	20.4512	14.8817	27.3226	1.5366	3.4324	-4.2810	0.0693	0.1678	-116.9693
Bond +Equity (0.33 each country)	ALL	0.3863	0.1959	9.6605	8.5381	21.8859	10.9121	-0.1000	0.3255	-0.6976	-0.9656	0.0381	-7.6119
	BC	0.2739	0.4119	9.4167	7.7910	31.5478	9.6825	-1.4889	-0.5734	-0.5982	-14.0201	-4.4670	-5.7922
	DC	0.4885	-0.1017	10.2213	9.2399	18.2819	13.4052	3.2774	3.7172	-0.8464	0.3206	0.4023	-11.3463
Bond +Equity (0.60 EMU)	ALL	0.2890	0.0505	9.5825	9.2100	7.6232	10.9121	-0.3494	-0.0750	-0.6976	-3.3480	-0.6905	-7.6119
	BC	0.1615	0.3030	9.0554	8.2840	16.3110	9.6825	-1.1434	-0.4988	-0.5982	-10.3543	-4.1317	-5.7922
	DC	0.4033	-0.2977	10.7424	10.0250	12.9116	13.4052	1.6128	2.4289	-0.8464	0.1501	0.2423	-11.3463

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds); whole period (ALL), Before Crisis (BC), During Crisis (DC); Euro units of British Pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio; annualized unhedged portfolio standard deviation (**σ_{UH}**), annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** annualized European portfolio standard deviation (**σ_{EMU}**), annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), annualized European portfolio return (**R_{EMU}**), modified Sharpe Ratio (**SHR**) of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided).

Table A.4 EWMA MODEL – All maturities – In-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2782	0.3026	6.4343	4.2691	55.9783	3.5602	-0.1748	-0.3992	-0.1998	-1.1250	-1.7042	-0.7113
	BC	0.2885	0.2476	5.5678	3.9906	48.6290	3.2519	-1.5100	-1.4900	-0.8200	-8.4074	-5.9460	-2.6666
	DC	0.2543	0.4338	8.1317	4.8425	64.5369	4.2042	2.9700	2.2200	1.2300	0.3652	0.4584	0.2926
Full Equity	ALL	0.3358	0.2699	18.8865	17.1727	17.3255	22.4917	-0.8200	1.4100	-1.8800	-15.4869	0.0821	-42.2844
	BC	0.1603	0.6722	17.3335	15.5097	19.9368	20.1259	-1.7300	0.1300	-0.6700	-29.9870	0.0084	-13.4844
	DC	0.7570	-0.7106	22.1670	20.4395	14.9784	27.3226	1.5400	5.5200	-4.2800	0.0695	0.2701	-116.9407
Bond +Equity (0.33 each country)	ALL	0.3070	0.2863	9.8043	8.2432	29.3108	10.9247	-0.5000	0.5000	-1.0400	-4.9022	0.0607	-11.3617
	BC	0.2244	0.4599	9.4789	7.6092	35.5593	9.6566	-1.6400	-0.7000	-0.7500	-15.5454	-5.3264	-7.2425
	DC	0.5057	-0.1384	10.5451	9.5145	18.5926	13.4805	2.2500	3.8700	-1.5600	0.2134	0.4067	-21.0296
Bond +Equity (0.60 EMU)	ALL	0.2033	0.1527	9.7404	8.8374	17.6812	10.9247	-0.7200	0.2800	-1.0400	-7.0131	0.0317	-11.3617
	BC	0.1118	0.3513	9.1077	8.1409	20.1025	9.6566	-3.1738	-0.5500	-0.7500	-28.9056	-4.4775	-7.2425
	DC	0.4234	-0.3324	11.1142	10.2335	15.2196	13.4805	0.0072	2.8100	-1.5600	0.0655	0.2746	-21.0296

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds); whole period (ALL), Before Crisis (BC), During Crisis (DC); Euro units of British Pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio; annualized unhedged portfolio standard deviation (**σ_{UH}**), annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** annualized European portfolio standard deviation (**σ_{EMU}**), annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), annualized European portfolio return (**R_{EMU}**), modified Sharpe Ratio (**SHR**) of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided).

Table A.5. EWMA MODEL- 1-3-year maturity– In-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2948	0.3199	5.5272	2.4444	80.4419	1.5492	-1.3656	-1.0198	-1.2423	-7.5481	-2.4927	-1.9245
	BC	0.2848	0.3138	5.0349	2.3822	77.6134	1.4230	-1.9800	-1.2400	-1.4900	-9.9691	-2.9539	-2.1203
	DC	0.3189	0.3346	6.5555	2.5739	84.5841	1.8028	0.0800	-0.5200	-0.6200	0.0122	-1.3384	-1.1177
Full Equity	ALL	0.3358	0.2699	18.8865	17.1727	17.3255	22.4917	-0.8200	1.4100	-1.8800	-15.4869	0.0821	-42.2844
	BC	0.1603	0.6722	17.3335	15.5097	19.9368	20.1259	-1.7300	0.1300	-0.6700	-29.9870	0.0084	-13.4844
	DC	0.7570	-0.7106	22.1670	20.4395	14.9784	27.3226	1.5400	5.5200	-4.2800	0.0695	0.2701	-116.9407
Bond +Equity (0.33 each country)	ALL	0.3153	0.2949	10.2140	8.5308	30.2420	11.1524	-1.0900	0.1800	-1.5600	-11.1333	0.0211	-17.3977
	BC	0.2226	0.4930	9.8005	7.7669	37.1942	9.8944	-1.8600	-0.5700	-1.0700	-18.2289	-4.4271	-10.5870
	DC	0.5380	-0.1880	11.1490	10.0474	18.7852	13.6958	0.8000	2.4500	-2.4700	0.0718	0.2438	-33.8286
Bond +Equity (0.60 EMU)	ALL	0.2084	0.1632	10.1193	9.1022	19.0918	11.1524	-1.2900	-0.0500	-1.5600	-13.0539	-0.4551	-17.3977
	BC	0.1091	0.3813	9.4101	8.3217	21.7956	9.8944	-3.8252	-0.5200	-1.0700	-35.9957	-4.3273	-10.5870
	DC	0.4468	-0.3678	11.6458	10.6595	16.2212	13.6958	-1.2916	1.6100	-2.4700	-15.0419	0.1510	-33.8286

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds); whole period (ALL), Before Crisis (BC), During Crisis (DC); Euro units of British Pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio; annualized unhedged portfolio standard deviation (**σ_{UH}**), annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** annualized European portfolio standard deviation (**σ_{EMU}**)**,** annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), annualized European portfolio return (**R_{EMU}**), modified Sharpe Ratio (**SHR**) of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided).

Table A.6. EWMA MODEL- +10-year maturity– In-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2635	0.2974	8.8671	7.3110	32.0191	7.0018	0.6269	-0.2497	0.5012	0.0707	-1.8255	0.0716
	BC	0.3041	0.1785	7.3739	6.5307	21.5632	6.5479	-1.2700	-1.9300	-0.5000	-9.3649	-12.6043	-3.2740
	DC	0.1685	0.5800	11.6705	8.8685	42.2540	7.9703	5.0200	3.9000	2.7100	0.4301	0.4398	0.3400
Full Equity	ALL	0.3358	0.2699	18.8865	17.1727	17.3255	22.4917	-0.8200	1.4100	-1.8800	-15.4869	0.0821	-42.2844
	BC	0.1603	0.6722	17.3335	15.5097	19.9368	20.1259	-1.7300	0.1300	-0.6700	-29.9870	0.0084	-13.4844
	DC	0.7570	-0.7106	22.1670	20.4395	14.9784	27.3226	1.5400	5.5200	-4.2800	0.0695	0.2701	-116.9407
Bond +Equity (0.33 each country)	ALL	0.2997	0.2837	9.6605	8.2523	27.0292	10.9121	-0.1000	0.5800	-0.7000	-0.9661	0.0703	-7.6385
	BC	0.2322	0.4254	9.4167	7.7427	32.3936	9.6825	-1.4900	-0.9200	-0.6000	-14.0309	-7.1233	-5.8095
	DC	0.4628	-0.0653	10.2213	9.2763	17.6358	13.4052	3.2800	4.7100	-0.8500	0.3209	0.5077	-11.3944
Bond +Equity (0.60 EMU)	ALL	0.2000	0.1454	9.5825	8.8318	15.0558	10.9121	-0.3500	0.3500	-0.7000	-3.3539	0.0396	-7.6385
	BC	0.1206	0.3175	9.0554	8.2356	17.2866	9.6825	-2.8099	-0.7200	-0.6000	-25.4450	-5.9296	-5.8095
	DC	0.3918	-0.2767	10.7424	10.0374	12.6950	13.4052	4.1068	3.5400	-0.8500	0.3823	0.3527	-11.3944

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds); whole period (ALL), Before Crisis (BC), During Crisis (DC); Euro units of British Pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio; annualized unhedged portfolio standard deviation (**σ_{UH}**), annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** annualized European portfolio standard deviation (**σ_{EMU}**)**,** annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), annualized European portfolio return (**R_{EMU}**), modified Sharpe Ratio (**SHR**) of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided).

Table A.7. DCC MODEL – All maturities – In-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2766	0.3021	6.4343	4.2456	56.4614	3.5602	-0.1748	-0.2996	-0.1998	-1.1250	-1.2718	-0.7113
	BC	0.2845	0.2500	5.5678	3.9718	49.1129	3.2519	-1.5100	-1.3400	-0.8200	-8.4074	-5.3222	-2.6666
	DC	0.2667	0.4344	8.1317	4.8322	64.6881	4.2042	2.9700	2.3500	1.2300	0.3652	0.4863	0.2926
Full Equity	ALL	0.3532	0.2700	18.8865	17.1894	17.1643	22.4917	-0.8200	0.8000	-1.8800	-15.4869	0.0465	-42.2844
	BC	0.2143	0.6481	17.3335	15.3777	21.2931	20.1259	-1.7300	-0.7000	-0.6700	-29.9870	-10.7644	-13.4844
	DC	0.7105	-0.6468	22.1670	20.3525	15.7008	27.3226	1.5400	5.6500	-4.2800	0.0695	0.2776	-116.9407
Bond +Equity (0.33 each country)	ALL	0.3227	0.2782	9.8043	8.2810	28.6606	10.9247	-0.5000	-0.0200	-1.0400	-4.9022	-0.1656	-11.3617
	BC	0.2528	0.4486	9.4789	7.5482	36.5888	9.6566	-1.6400	-1.0700	-0.7500	-15.5454	-8.0766	-7.2425
	DC	0.4902	-0.1135	10.5451	9.5145	18.5926	13.4805	2.2500	3.3300	-1.5600	0.2134	0.3500	-21.0296
Bond +Equity (0.60 EMU)	ALL	0.2186	0.1486	9.7404	8.8628	17.2069	10.9247	-0.7200	-0.0500	-1.0400	-7.0131	-0.4431	-11.3617
	BC	0.1488	0.3324	9.1077	8.0685	21.5190	9.6566	-3.1738	-0.9700	-0.7500	-28.9056	-7.8264	-7.2425
	DC	0.4000	-0.3004	11.1142	10.1661	16.3327	13.4805	0.7276	2.9700	-1.5600	0.0655	0.2921	-21.0296

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds); whole period (ALL), Before Crisis (BC), During Crisis (DC); Euro units of British Pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio; annualized unhedged portfolio standard deviation (**σ_{UH}**), annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** annualized European portfolio standard deviation (**σ_{EMU}**), annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), annualized European portfolio return (**R_{EMU}**), modified Sharpe Ratio (**SHR**) of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided).

Table A.8. DCC PARAMETERS- all- year maturity– In-sample

		ω_1	α_1	β_1	ω_2	α_2	β_2	ω_3	α_3	β_3	θ_1	θ_2
Full Bond	ALL	0.0007	0.0405	0.9561	0.0013	0.0418	0.9538	0.0013	0.0273	0.9699	0.0117	0.9861
	BC	0.0008	0.0411	0.9538	0.0013	0.0397	0.955	0.0007	0.022	0.9766	0.0109	0.9857
	DC	0.0055	0.061	0.9184	0.0022	0.056	0.9386	0.0056	0.043	0.9462	0.0123	0.9848
Full Equity	ALL	0.0157	0.0885	0.9001	0.0013	0.0418	0.9538	0.0013	0.0273	0.9699	0.0185	0.9787
	BC	0.0133	0.0809	0.9089	0.0013	0.0397	0.955	0.0007	0.022	0.9766	0.0178	0.9737
	DC	0.0215	0.0925	0.8914	0.0022	0.056	0.9386	0.0056	0.043	0.9462	0.0145	0.9825
Bond +Equity (0.33 each country)	ALL	0.0054	0.0884	0.8977	0.0013	0.0418	0.9538	0.0013	0.0273	0.9699	0.021	0.9736
	BC	0.0043	0.0747	0.9147	0.0013	0.0397	0.955	0.0007	0.022	0.9766	0.017	0.9741
	DC	0.0098	0.1492	0.8269	0.0022	0.056	0.9386	0.0056	0.043	0.9462	0.0188	0.9745
Bond +Equity (0.60 EMU)	ALL	0.0051	0.0958	0.8911	0.0013	0.0418	0.9538	0.0013	0.0273	0.9699	0.0166	0.9806
	BC	0.0045	0.0889	0.899	0.0013	0.0397	0.955	0.0007	0.022	0.9766	0.0147	0.9782
	DC	0.0082	0.123	0.8592	0.0022	0.056	0.9386	0.0056	0.043	0.9462	0.0131	0.9846

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), whole period (ALL), Before Crisis (BC), During Crisis (DC). Vector of returns $r_t = r_t^{UH}, r_t^{Fut\_GBP}, r_t^{Fut\_USD}$. 1-3 year maturity bonds.

Table A.9. DCC MODEL - 1-3-year maturity– In-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2895	0.3227	5.5272	2.4495	80.3601	1.5492	-1.3656	-1.0445	-1.2423	-7.5481	-2.5586	-1.9245
	BC	0.2767	0.3192	5.0349	2.3927	77.4162	1.4230	-1.9800	-1.2700	-1.4900	-9.9691	-3.0387	-2.1203
	DC	0.3242	0.3368	6.5555	2.6173	84.0605	1.8028	0.0800	-0.4700	-0.6200	0.0122	-1.2301	-1.1177
Full Equity	ALL	0.3532	0.2700	18.8865	17.1894	17.1643	22.4917	-0.8200	0.8000	-1.8800	-15.4869	0.0465	-42.2844
	BC	0.2143	0.6481	17.3335	15.3777	21.2931	20.1259	-1.7300	-0.7000	-0.6700	-29.9870	-10.7644	-13.4844
	DC	0.7105	-0.6468	22.1670	20.3525	15.7008	27.3226	1.5400	5.6500	-4.2800	0.0695	0.2776	-116.9407
Bond +Equity (0.33 each country)	ALL	0.3261	0.2901	10.2140	8.5542	29.8586	11.1524	-1.0900	-0.2500	-1.5600	-11.1333	-2.1386	-17.3977
	BC	0.2471	0.4849	9.8005	7.7088	38.1312	9.8944	-1.8600	-0.9500	-1.0700	-18.2289	-7.3234	-10.5870
	DC	0.5212	-0.1640	11.1490	10.0374	18.9461	13.6958	0.8000	2.2000	-2.4700	0.0718	0.2192	-33.8286
Bond +Equity (0.60 EMU)	ALL	0.2202	0.1623	10.1193	9.1159	18.8477	11.1524	-1.2900	-0.3500	-1.5600	-13.0539	-3.1906	-17.3977
	BC	0.1424	0.3658	9.4101	8.2508	23.1225	9.8944	-3.8252	-0.9500	-1.0700	-35.9957	-7.8383	-10.5870
	DC	0.4242	-0.3357	11.6458	10.5948	17.2350	13.6958	-1.2916	1.8900	-2.4700	-15.0419	0.1784	-33.8286

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds); whole period (ALL), Before Crisis (BC), During Crisis (DC); Euro units of British Pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio; annualized unhedged portfolio standard deviation (**σ_{UH}**), annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** annualized European portfolio standard deviation (**σ_{EMU}**)**,** annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), annualized European portfolio return (**R_{EMU}**), modified Sharpe Ratio (**SHR**) of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided).

Table A.10. DCC PARAMETERS- 1-3 year maturity– In-sample

		ω_1	α_1	β_1	ω_2	α_2	β_2	ω_3	α_3	β_3	θ_1	θ_2
Full Bond	ALL	0.0005	0.0389	0.958	0.0013	0.0418	0.9538	0.0013	0.0273	0.9699	0.0157	0.978
	BC	0.0006	0.0406	0.9553	0.0013	0.0397	0.955	0.0007	0.022	0.9766	0.0094	0.9858
	DC	0.0027	0.0616	0.9242	0.0022	0.056	0.9386	0.0056	0.043	0.9462	0.0305	0.9543
Full Equity	ALL	0.0157	0.0885	0.9001	0.0013	0.0418	0.9538	0.0013	0.0273	0.9699	0.0185	0.9787
	BC	0.0133	0.0809	0.9089	0.0013	0.0397	0.955	0.0007	0.022	0.9766	0.0178	0.9737
	DC	0.0215	0.0925	0.8914	0.0022	0.056	0.9386	0.0056	0.043	0.9462	0.0145	0.9825
Bond +Equity (0.33 each country)	ALL	0.0052	0.083	0.9047	0.0013	0.0418	0.9538	0.0013	0.0273	0.9699	0.0224	0.973
	BC	0.0041	0.071	0.9194	0.0013	0.0397	0.955	0.0007	0.022	0.9766	0.019	0.9714
	DC	0.0095	0.1349	0.8449	0.0022	0.056	0.9386	0.0056	0.043	0.9462	0.021	0.9718
Bond +Equity (0.60 EMU)	ALL	0.0049	0.0894	0.8987	0.0013	0.0418	0.9538	0.0013	0.0273	0.9699	0.0177	0.9796
	BC	0.0044	0.0836	0.905	0.0013	0.0397	0.955	0.0007	0.022	0.9766	0.0162	0.9761
	DC	0.0079	0.1134	0.8712	0.0022	0.056	0.9386	0.0056	0.043	0.9462	0.0142	0.9831

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), whole period (ALL), Before Crisis (BC), During Crisis (DC). Vector of returns $r_t = r_t^{UH}, r_t^{Fut\_GBP}, r_t^{Fut\_USD}$. 1-3 year maturity bonds.

Table A.11. DCC MODEL- +10-Year maturity– In-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2671	0.2925	8.8671	7.2560	33.0366	7.0018	0.6269	0.0000	0.5012	0.0707	0.0000	0.0716
	BC	0.3020	0.1796	7.3739	6.4827	22.7126	6.5479	-1.2700	-1.5400	-0.5000	-9.3649	-9.9834	-3.2740
	DC	0.1920	0.5711	11.6705	8.8105	43.0066	7.9703	5.0200	4.1300	2.7100	0.4301	0.4688	0.3400
Full Equity	ALL	0.3532	0.2700	18.8865	17.1894	17.1643	22.4917	-0.8200	0.8000	-1.8800	-15.4869	0.0465	-42.2844
	BC	0.2143	0.6481	17.3335	15.3777	21.2931	20.1259	-1.7300	-0.7000	-0.6700	-29.9870	-10.7644	-13.4844
	DC	0.7105	-0.6468	22.1670	20.3525	15.7008	27.3226	1.5400	5.6500	-4.2800	0.0695	0.2776	-116.9407
Bond +Equity (0.33 each country)	ALL	0.3214	0.2733	9.6605	8.2976	26.2256	10.9121	-0.1000	0.0500	-0.7000	-0.9661	0.0060	-7.6385
	BC	0.2644	0.4120	9.4167	7.6795	33.4931	9.6825	-1.4900	-1.2900	-0.6000	-14.0309	-9.9066	-5.8095
	DC	0.4508	-0.0373	10.2213	9.2992	17.2290	13.4052	3.2800	3.9000	-0.8500	0.3209	0.4194	-11.3944
Bond +Equity (0.60 EMU)	ALL	0.2195	0.1383	9.5825	8.8685	14.3479	10.9121	-0.3500	-0.0200	-0.7000	-3.3539	-0.1774	-7.6385
	BC	0.1610	0.2964	9.0554	8.1609	18.7805	9.6825	-2.8099	-1.0900	-0.6000	-25.4450	-8.8954	-5.8095
	DC	0.3678	-0.2439	10.7424	9.9649	13.9515	13.4052	4.1068	3.3500	-0.8500	0.3823	0.3362	-11.3944

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds); whole period (ALL), Before Crisis (BC), During Crisis (DC); Euro units of British Pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio; annualized unhedged portfolio standard deviation (**σ_{UH}**), annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** annualized European portfolio standard deviation **(σ_{EMU}),** annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), annualized European portfolio return (**R_{EMU}**), modified Sharpe Ratio (**SHR**) of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided).

Table A.12. DCC PARAMETERS- +10 - year maturity– In-sample

		ω_1	α_1	β_1	ω_2	α_2	β_2	ω_3	α_3	β_3	θ_1	θ_2
Full Bond	ALL	0.0021	0.0438	0.9499	0.0013	0.0418	0.9538	0.0013	0.0273	0.9699	0.0119	0.9857
	BC	0.0029	0.0388	0.9486	0.0013	0.0397	0.955	0.0007	0.022	0.9766	0.0111	0.9852
	DC	0.0123	0.0638	0.9131	0.0022	0.056	0.9386	0.0056	0.043	0.9462	0.0142	0.9817
Full Equity	ALL	0.0157	0.0885	0.9001	0.0013	0.0418	0.9538	0.0013	0.0273	0.9699	0.0185	0.9787
	BC	0.0133	0.0809	0.9089	0.0013	0.0397	0.955	0.0007	0.022	0.9766	0.0178	0.9737
	DC	0.0215	0.0925	0.8914	0.0022	0.056	0.9386	0.0056	0.043	0.9462	0.0145	0.9825
Bond +Equity (0.33 each country)	ALL	0.0055	0.0862	0.8992	0.0013	0.0418	0.9538	0.0013	0.0273	0.9699	0.0184	0.9754
	BC	0.0048	0.0798	0.9085	0.0013	0.0397	0.955	0.0007	0.022	0.9766	0.0144	0.978
	DC	0.0101	0.1294	0.8413	0.0022	0.056	0.9386	0.0056	0.043	0.9462	0.0127	0.9836
Bond +Equity (0.60 EMU)	ALL	0.0058	0.1012	0.8837	0.0013	0.0418	0.9538	0.0013	0.0273	0.9699	0.0144	0.9826
	BC	0.0052	0.0942	0.8924	0.0013	0.0397	0.955	0.0007	0.022	0.9766	0.0121	0.9823
	DC	0.0088	0.1301	0.8486	0.0022	0.056	0.9386	0.0056	0.043	0.9462	0.0111	0.987

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), whole period (ALL), Before Crisis (BC), During Crisis (DC). Vector of returns $r_t = r_t^{UH}, r_t^{Fut\_GBP}, r_t^{Fut\_USD}$. 1-3 year maturity bonds.

Table A.13. BEKK MODEL – All maturities – In-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2781	0.3009	6.4343	4.2544	56.2802	3.5602	-0.1748	-0.3494	-0.1998	-1.1250	-1.4865	-0.7113
	BC	0.2871	0.2474	5.5678	3.9686	49.1935	3.2519	-1.5135	-1.2916	-0.8216	-8.4267	-5.1260	-2.6718
	DC	0.2546	0.4329	8.1317	4.8451	64.4991	4.2042	2.9680	2.0201	1.2325	0.3650	0.4169	0.2932
Full Equity	ALL	0.5444	0.0579	18.8865	18.2722	6.3989	22.4917	-0.8216	-0.3743	-1.8821	-15.5175	-6.8393	-42.3323
	BC	0.1862	0.6373	17.3335	15.4669	20.3778	20.1259	-1.7348	0.3757	-0.6727	-30.0708	0.0243	-13.5394
	DC	0.7259	-0.6783	22.1670	20.6458	13.2536	27.3226	1.5366	4.4978	-4.2810	0.0693	0.2179	-116.9693
Bond +Equity (0.33 each country)	ALL	0.3145	0.2755	9.8043	8.2614	28.9987	10.9247	-0.4988	0.5766	-1.0445	-4.8900	0.0698	-11.4112
	BC	0.2431	0.4384	9.4789	7.5878	35.9210	9.6566	-1.6365	-0.3992	-0.7472	-15.5124	-3.0291	-7.2155
	DC	0.4889	-0.1158	10.5451	9.6086	16.9739	13.4805	2.2498	2.9680	-1.5627	0.2134	0.3089	-21.0662
Bond +Equity (0.60 EMU)	ALL	0.2089	0.1461	9.7404	8.8600	17.2596	10.9247	-0.7224	0.3004	-1.0445	-7.0363	0.0339	-11.4112
	BC	0.1341	0.3262	9.1077	8.1179	20.5546	9.6566	-1.2916	-0.3743	-0.7472	-11.7637	-3.0385	-7.2155
	DC	0.3992	-0.3112	11.1142	10.3102	13.9445	13.4805	0.7276	2.2498	-1.5627	0.0655	0.2182	-21.0662

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds); whole period (ALL), Before Crisis (BC), During Crisis (DC); Euro units of British Pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio; annualized unhedged portfolio standard deviation (**σ_{UH}**), annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** annualized European portfolio standard deviation (**σ_{EMU}**)**,** annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), annualized European portfolio return (**R_{EMU}**), modified Sharpe Ratio (**SHR**) of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided).

Table A.14. BEKK PARAMETERS - All maturities– In-sample

		C_{11}	C_{12}	C_{13}	C_{22}	C_{23}	C_{33}	A_{11}	A_{22}	A_{33}	B_{11}	B_{22}	B_{33}
Full Bond	ALL	0.0291	0.0192	0.0248	0.0288	0.0062	-0.0271	0.1702	0.1715	0.1445	0.9827	0.9826	0.9877
	BC	0.0293	0.0187	0.0222	0.0286	0.0052	-0.0216	0.1613	0.1622	0.1253	0.9834	0.9838	0.9906
	DC	0.0601	0.0266	0.0531	0.0149	-0.0028	0.0357	0.1809	0.1545	0.1618	0.9759	0.986	0.9826
Full Equity	ALL	0.1029	0.0122	0.0167	0.0327	0.0126	0.0298	0.2629	0.1699	0.1674	0.9609	0.983	0.9843
	BC	0.1115	0.0121	0.027	0.0316	0.007	0.0267	0.2588	0.1538	0.1446	0.9605	0.9852	0.9873
	DC	0.1693	0.0075	-0.0246	0.0286	0.0489	0.0199	0.303	0.1608	0.1546	0.9421	0.9853	0.9845
Bond +Equity (0.33 each country)	ALL	0.0617	0.0215	0.0285	0.0318	0.005	-0.0272	0.2534	0.1757	0.1634	0.9621	0.9814	0.9846
	BC	0.0629	0.0188	0.0336	0.0315	0.0017	-0.0263	0.2369	0.1586	0.1454	0.9654	0.9839	0.9866
	DC	0.0838	0.0341	0.0216	0.015	0.0465	-0.0234	0.312	0.1709	0.1469	0.9395	0.9829	0.9858
Bond +Equity (0.60 EMU)	ALL	0.0595	0.0145	0.0181	0.0312	0.011	0.0297	0.2651	0.1666	0.1624	0.9593	0.9836	0.9851
	BC	0.064	0.0146	0.0276	0.0294	0.0043	0.0262	0.2588	0.1483	0.1404	0.9592	0.9862	0.9879
	DC	0.0894	0.0112	-0.017	0.0283	0.0495	-0.0207	0.3044	0.1598	0.1479	0.9415	0.9854	0.9856

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), whole period (ALL), Before Crisis (BC), During Crisis (DC). Vector of returns $r_t = r_t^{UH}, r_t^{Fut\_GBP}, r_t^{Fut\_USD}$. 1-3 year maturity bonds.

Table A.15. BEKK MODEL 1-3 year maturity– In-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2924	0.3228	5.5272	2.4393	80.5237	1.5492	-1.3656	-1.0198	-1.2423	-7.5481	-2.4875	-1.9245
	BC	0.2820	0.3169	5.0349	2.3717	77.8107	1.4230	-1.9800	-1.1200	-1.4900	-9.9691	-2.6563	-2.1203
	DC	0.3207	0.3335	6.5555	2.5788	84.5259	1.8028	0.0800	-0.5200	-0.6200	0.0122	-1.3410	-1.1177
Full Equity	ALL	0.5444	0.0579	18.8865	18.2722	6.3989	22.4917	-0.8216	-0.3743	-1.8821	-15.5175	-6.8393	-42.3323
	BC	0.1862	0.6373	17.3335	15.4669	20.3778	20.1259	-1.7348	0.3757	-0.6727	-30.0708	0.0243	-13.5394
	DC	0.7259	-0.6783	22.1670	20.6458	13.2536	27.3226	1.5366	4.4978	-4.2810	0.0693	0.2179	-116.9693
Bond +Equity (0.33 each country)	ALL	0.4201	0.1891	10.2140	9.0540	21.4234	11.1524	-1.0940	-0.6479	-1.5627	-11.1740	-5.8661	-17.4279
	BC	0.2741	0.4757	9.8005	7.8438	35.9448	9.8944	-1.8576	-0.8216	-1.0693	-18.2054	-6.4446	-10.5798
	DC	0.5513	-0.2054	11.1490	10.0499	18.7450	13.6958	0.8032	1.4605	-2.4691	0.0720	0.1453	-33.8167
Bond +Equity (0.60 EMU)	ALL	0.3151	0.0517	10.1193	9.7005	8.1055	11.1524	-1.2916	-1.0198	-1.5627	-13.0703	-9.8924	-17.4279
	BC	0.1604	0.3628	9.4101	8.4143	20.0452	9.8944	-1.5627	-0.8216	-1.0693	-14.7053	-6.9133	-10.5798
	DC	0.4526	-0.3769	11.6458	10.6958	15.6498	13.6958	-0.5236	0.4259	-2.4691	-6.0981	0.0398	-33.8167

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds); whole period (ALL), Before Crisis (BC), During Crisis (DC); Euro units of British Pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio; annualized unhedged portfolio standard deviation (**σ_{UH}**), annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** annualized European portfolio standard deviation (**σ_{EMU}**), annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), annualized European portfolio return (**R_{EMU}**), modified Sharpe Ratio (**SHR**) of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided).

Table A.16. BEKK PARAMETERS 1-3-year maturity– In-sample

		C_{11}	C_{12}	C_{13}	C_{22}	C_{23}	C_{33}	A_{11}	A_{22}	A_{33}	B_{11}	B_{22}	B_{33}
Full Bond	ALL	0.0391	0.0319	0.0514	-0.0308	0.0095	-0.0259	0.1947	0.1832	0.1539	0.9741	0.9786	0.9835
	BC	0.0478	0.0353	0.0583	0.032	-0.0176	0	0.2007	0.1756	0.1364	0.9674	0.9784	0.9849
	DC	0.0425	0.0368	0.0674	-0.0253	0.0083	0.0404	0.181	0.1682	0.1799	0.9778	0.9819	0.9775
Full Equity	ALL	0.1029	0.0122	0.0167	0.0327	0.0126	0.0298	0.2629	0.1699	0.1674	0.9609	0.983	0.9843
	BC	0.1115	0.0121	0.027	0.0316	0.007	0.0267	0.2588	0.1538	0.1446	0.9605	0.9852	0.9873
	DC	0.1693	0.0075	-0.0246	0.0286	0.0489	0.0199	0.303	0.1608	0.1546	0.9421	0.9853	0.9845
Bond +Equity (0.33 each country)	ALL	0.0603	0.0206	0.028	0.0329	0.006	-0.0272	0.2496	0.1779	0.1685	0.9638	0.981	0.9838
	BC	0.0629	0.0185	0.0347	0.0331	0.0028	-0.0274	0.2357	0.1629	0.1502	0.9661	0.983	0.9857
	DC	0.0854	0.0302	0.0135	0.0221	0.044	-0.0303	0.3062	0.171	0.153	0.9422	0.9828	0.9851
Bond +Equity (0.60 EMU)	ALL	0.0573	0.014	0.0189	0.0322	0.0111	0.0292	0.2599	0.1689	0.1657	0.9615	0.9831	0.9846
	BC	0.0625	0.014	0.0288	0.0311	0.0053	0.0265	0.2548	0.1523	0.1434	0.961	0.9854	0.9873
	DC	0.0908	0.0097	-0.0179	0.0291	0.0471	-0.024	0.2943	0.1605	0.1533	0.9454	0.9852	0.9849

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), whole period (ALL), Before Crisis (BC), During Crisis (DC). Vector of returns $r_t = r_t^{UH}, r_t^{Fut\_GBP}, r_t^{Fut\_USD}$. 1-3 year maturity bonds.

Table A.17. BEKK MODEL - +10-year maturity– In-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2672	0.2887	8.8671	7.2938	32.3370	7.0018	0.6269	-0.1000	0.5012	0.0707	-0.7290	0.0716
	BC	0.3002	0.1791	7.3739	6.4904	22.5287	6.5479	-1.2669	-1.5627	-0.4988	-9.3423	-10.1426	-3.2658
	DC	0.1763	0.5761	11.6705	8.8586	42.3825	7.9703	5.0215	3.6912	2.7110	0.4303	0.4167	0.3401
Full Equity	ALL	0.5444	0.0579	18.8865	18.2722	6.3989	22.4917	-0.8216	-0.3743	-1.8821	-15.5175	-6.8393	-42.3323
	BC	0.1862	0.6373	17.3335	15.4669	20.3778	20.1259	-1.7348	0.3757	-0.6727	-30.0708	0.0243	-13.5394
	DC	0.7259	-0.6783	22.1670	20.6458	13.2536	27.3226	1.5366	4.4978	-4.2810	0.0693	0.2179	-116.9693
Bond +Equity (0.33 each country)	ALL	0.3137	0.2675	9.6605	8.2614	26.8685	10.9121	-0.1000	0.7276	-0.6976	-0.9656	0.0881	-7.6119
	BC	0.2545	0.4008	9.4167	7.7217	32.7601	9.6825	-1.4889	-0.5236	-0.5982	-14.0201	-4.0433	-5.7922
	DC	0.4519	-0.0407	10.2213	9.3368	16.5590	13.4052	3.2774	3.7950	-0.8464	0.3206	0.4065	-11.3463
Bond +Equity (0.60 EMU)	ALL	0.2888	0.0505	9.5825	9.2060	7.7049	10.9121	-0.3494	-0.0750	-0.6976	-3.3480	-0.6902	-7.6119
	BC	0.1611	0.3029	9.0554	8.2795	16.4024	9.6825	-1.1434	-0.4988	-0.5982	-10.3543	-4.1295	-5.7922
	DC	0.4032	-0.2976	10.7424	10.0112	13.1499	13.4052	1.6128	2.4289	-0.8464	0.1501	0.2426	-11.3463

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds); whole period (ALL), Before Crisis (BC), During Crisis (DC); Euro units of British Pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio; annualized unhedged portfolio standard deviation (**σ_{UH}**), annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** annualized European portfolio standard deviation **(σ_{EMU}),** annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), annualized European portfolio return (**R_{EMU}**), modified Sharpe Ratio (**SHR**) of Israelsen (2005) (when average returns are negative those are multiplied by the standard deviation rather than divided).

Table A.18. BEKK PARAMETERS - +10year maturities– In-sample

		C_{11}	C_{12}	C_{13}	C_{22}	C_{23}	C_{33}	A_{11}	A_{22}	A_{33}	B_{11}	B_{22}	B_{33}
Full Bond	ALL	0.0407	0.0139	0.0151	0.0338	0.0143	-0.0299	0.1727	0.1776	0.1478	0.9822	0.9813	0.9873
	BC	0.0443	0.0135	0.013	0.0327	0.0121	0.0243	0.158	0.1645	0.1271	0.9829	0.9832	0.9905
	DC	0.0985	0.0208	0.0446	0.0183	0.0159	-0.0388	0.1906	0.1616	0.1682	0.9719	0.9853	0.9819
Full Equity	ALL	0.1029	0.0122	0.0167	0.0327	0.0126	0.0298	0.2629	0.1699	0.1674	0.9609	0.983	0.9843
	BC	0.1115	0.0121	0.027	0.0316	0.007	0.0267	0.2588	0.1538	0.1446	0.9605	0.9852	0.9873
	DC	0.1693	0.0075	-0.0246	0.0286	0.0489	0.0199	0.303	0.1608	0.1546	0.9421	0.9853	0.9845
Bond +Equity (0.33 each country)	ALL	0.0657	0.0214	0.0289	0.0311	0.0049	-0.0276	0.2525	0.1731	0.1552	0.9614	0.9819	0.9858
	BC	0.0659	0.0188	0.0319	0.0302	0.0012	-0.0251	0.239	0.1545	0.1395	0.9644	0.9847	0.9877
	DC	0.0832	0.0331	0.0304	0.0102	0.0417	-0.0281	0.2898	0.1682	0.1414	0.9457	0.9836	0.9863
Bond +Equity (0.60 EMU)	ALL	0.066	0.0148	0.0173	0.0304	0.0112	0.0302	0.2701	0.1645	0.1563	0.9566	0.984	0.986
	BC	0.07	0.0149	0.0257	0.0277	0.0038	0.026	0.2643	0.1442	0.1362	0.9565	0.987	0.9886
	DC	0.0894	0.0138	-0.0112	0.0266	0.0529	-0.0185	0.3088	0.1601	0.1393	0.9393	0.9854	0.9867

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), whole period (ALL), Before Crisis (BC), During Crisis (DC). Vector of returns $r_t = r_t^{UH}, r_t^{Fut\_GBP}, r_t^{Fut\_USD}$. 1-3 year maturity bonds.

Table A.19. OLS MODEL-All maturities – Out-of-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	**ALL**	0.2644	0.2814	6.7623	4.4108	57.4547	3.7992	0.2100	0.6800	0.1300	0.0300	0.1500	0.0300
		0.0220	**0.0757**										
	BC	0.2794	0.2115	5.0128	3.8305	41.6089	3.3424	-2.4900	-0.9200	-1.0500	-12.4600	-3.5200	-3.5000
		0.0208	**0.0095**										
	DC	0.2495	0.3509	8.1349	4.9198	63.4246	4.2047	2.9600	-2.1000	1.2200	0.3600	-10.3200	0.2900
		0.0098	**0.0406**										
Full Equity	**ALL**	0.4495	0.2230	18.3956	18.0013	4.2412	22.2192	1.0600	2.9500	-0.1400	0.0600	0.1600	-3.0600
		0.2336	**0.5134**										
	BC	0.2228	0.7077	13.5760	13.2030	5.4192	15.4552	0.4500	4.2900	4.5400	0.0300	0.3300	0.2900
		0.0584	**0.0714**										
	DC	0.6748	-0.2585	22.1763	21.7503	3.8049	27.3345	1.6600	0.3300	-4.1600	0.0700	0.0200	-113.6700
		0.0593	**0.2344**										
Bond +Equity (0.33 each country)	**ALL**	0.3570	0.2522	9.0076	8.3393	14.2884	10.8509	0.6300	1.8100	-0.0100	0.0700	0.2200	-0.0700
		0.1090	**0.2191**										
	BC	0.2511	0.4596	7.1292	6.1718	25.0534	7.2977	-1.0300	1.6500	1.7100	-7.3300	0.2700	0.2300
		0.0201	**0.0320**										
	DC	0.4621	0.0462	10.5500	10.0425	9.3884	13.4868	2.3100	-0.8900	-1.5000	0.2200	-8.9500	-20.2900
		0.0328	**0.0973**										
Bond +Equity (0.60 EMU)	**ALL**	0.2580	0.1273	9.2475	8.9772	5.7603	10.8509	0.3800	1.3500	-0.0100	0.0400	0.1500	-0.0700
		0.1166	**0.2456**										
	BC	0.1454	0.3592	6.8722	6.5533	9.0645	7.2977	-0.0200	2.0000	1.7100	-0.1400	0.3100	0.2300
		0.0326	**0.0361**										
	DC	0.3699	-0.1031	11.1190	10.8655	4.5082	13.4868	0.7800	-0.8000	-1.5000	0.0700	-8.7000	-20.2900
		0.0306	**0.1112**										

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds), whole period (ALL), Before Crisis (BC), During Crisis (DC), Euro units of British pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio, annualized unhedged portfolio standard deviation (**σ_{UH}**), , annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** , annualized European portfolio standard deviation (**σ_{EMU}**), annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), , annualized European portfolio return (**R_{EMU}**), Sharpe Ratio (**SHR**). When returns are negative, following Israelsen (2005), we use the improved Sharpe ratio index that is the result of multiplying the average returns by the standard deviation. All maturities bonds.

Table A.20. OLS MODEL-1-3-Year Maturity – Out-of-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2853 **0.0166**	0.3188 **0.0156**	5.4712	2.3287	81.8835	1.5968	-1.4400	-0.7900	-0.9400	-7.8800	-1.8400	-1.5000
	BC	0.2758 **0.0127**	0.3041 **0.0055**	4.0970	2.0795	74.2378	1.3543	-2.9300	-0.9900	-1.2900	-12.0100	-2.0500	-1.7400
	DC	0.2948 **0.0144**	0.3334 **0.0056**	6.5578	2.5533	84.8409	1.8062	0.0600	-1.0300	-0.6100	0.0100	-2.6400	-1.1100
Full Equity	ALL	0.4495 **0.2336**	0.2230 **0.5134**	18.3956	18.0013	4.2412	22.2192	1.0600	2.9500	-0.1400	0.0600	0.1600	-3.0600
	BC	0.2228 **0.0584**	0.7077 **0.0714**	13.5760	13.2030	5.4192	15.4552	0.4500	4.2900	4.5400	0.0300	0.3300	0.2900
	DC	0.6748 **0.0593**	-0.2585 **0.2344**	22.1763	21.7503	3.8049	27.3345	1.6600	0.3300	-4.1600	0.0700	0.0200	-113.6700
Bond +Equity (0.33 each country)	ALL	0.3674 **0.1216**	0.2709 **0.2491**	9.4721	8.8457	12.7899	11.0567	-0.2000	1.0600	-0.5400	-1.9000	0.1200	-5.9700
	BC	0.2493 **0.0235**	0.5059 **0.0334**	7.4085	6.4595	23.9776	7.5115	-1.2500	1.6200	1.5900	-9.2900	0.2500	0.2100
	DC	0.4848 **0.0358**	0.0375 **0.1147**	11.1536	10.7050	7.8822	13.7015	0.8600	-0.3500	-2.4000	0.0800	-3.7900	-32.9200
Bond +Equity (0.60 EMU)	ALL	0.2662 **0.1265**	0.1448 **0.2714**	9.6668	9.4020	5.4035	11.0567	-0.3400	0.7200	-0.5400	-3.2600	0.0800	-5.9700
	BC	0.1440 **0.0356**	0.4007 **0.0372**	7.1385	6.8309	8.4338	7.5115	-0.2200	1.9800	1.5900	-1.5700	0.2900	0.2100
	DC	0.3876 **0.0326**	-0.1095 **0.1254**	11.6509	11.3987	4.2823	13.7015	-0.4500	-0.1500	-2.4000	-5.2900	-1.7300	-32.9200

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds), whole period (ALL), Before Crisis (BC), During Crisis (DC), Euro units of British pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio, annualized unhedged portfolio standard deviation (**σ_{UH}**), , annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE)**, , annualized European portfolio standard deviation (**σ_{EMU}**), annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), , annualized European portfolio return (**R_{EMU}**), Sharpe Ratio (**SHR**). When returns are negative, following Israelsen (2005), we use the improved Sharpe ratio index that is the result of multiplying the average returns by the standard deviation. All maturities bonds.

Table A.21. OLS MODEL- +10-year maturity– Out-of-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	**ALL**	0.2461 **0.0483**	0.2485 **0.1394**	9.6471	7.9222	32.5624	7.2925	1.4000	1.7000	0.9700	0.1400	0.2100	0.1300
	BC	0.2901 **0.0273**	0.1225 **0.0143**	7.0368	6.4034	17.1935	6.5385	-2.0900	-0.8600	-0.9300	-14.7000	-5.5000	-6.0900
	DC	0.2025 **0.0096**	0.3736 **0.0842**	11.6756	9.1861	38.0979	7.9730	4.9800	-3.5100	2.6600	0.4300	-32.2800	0.3300
Full Equity	**ALL**	0.4495 **0.2336**	0.2230 **0.5134**	18.3956	18.0013	4.2412	22.2192	1.0600	2.9500	-0.1400	0.0600	0.1600	-3.0600
	BC	0.2228 **0.0584**	0.7077 **0.0714**	13.5760	13.2030	5.4192	15.4552	0.4500	4.2900	4.5400	0.0300	0.3300	0.2900
	DC	0.6748 **0.0593**	-0.2585 **0.2344**	22.1763	21.7503	3.8049	27.3345	1.6600	0.3300	-4.1600	0.0700	0.0200	-113.6700
Bond +Equity (0.33 each country)	**ALL**	0.3478 **0.0942**	0.2358 **0.1883**	8.8453	8.1451	15.2056	10.8702	1.2300	2.3200	0.4200	0.1400	0.2900	0.0400
	BC	0.2564 **0.0186**	0.4151 **0.0321**	7.1956	6.2768	23.9077	7.4940	-0.8300	1.6900	1.7700	-5.9400	0.2700	0.2400
	DC	0.4386 **0.0282**	0.0576 **0.0767**	10.2259	9.6524	10.9013	13.4109	3.3100	-1.6100	-0.8100	0.3200	-15.5500	-10.8000
Bond +Equity (0.60 EMU)	**ALL**	0.2511 **0.1042**	0.1098 **0.2173**	9.0638	8.8062	5.6036	10.8702	0.9100	1.8000	0.4200	0.1000	0.2000	0.0400
	BC	0.1507 **0.0301**	0.3158 **0.0364**	6.9744	6.6610	8.7866	7.4940	0.1600	2.0100	1.7700	0.0200	0.3000	0.2400
	DC	0.3509 **0.0276**	-0.0950 **0.0933**	10.7478	10.5159	4.2687	13.4109	1.6600	-1.7100	-0.8100	0.1500	-18.0100	-10.8000

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds), whole period (ALL), Before Crisis (BC), During Crisis (DC), Euro units of British pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio, annualized unhedged portfolio standard deviation (**σ_{UH}**), , annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE)**, , annualized European portfolio standard deviation (**σ_{EMU}**), annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), , annualized European portfolio return (**R_{EMU}**), Sharpe Ratio (**SHR**). When returns are negative, following Israelsen (2005), we use the improved Sharpe ratio index that is the result of multiplying the average returns by the standard deviation. All maturities bonds.

Table A.22. EWMA MODEL-All maturities– Out-of-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	**ALL**	0.2678 **0.0904**	0.3611 **0.1148**	6.7623	4.3594	58.4404	3.7992	0.2100	0.3400	0.1300	0.0300	0.0800	0.0300
	BC	0.2820 **0.1077**	0.2879 **0.0984**	5.0128	3.7854	42.9759	3.3424	-2.4900	-1.4100	-1.0500	-12.4600	-5.3200	-3.5000
	DC	0.2536 **0.0660**	0.4339 **0.0778**	8.1349	4.8623	64.2737	4.2047	2.9600	2.1000	1.2000	0.3600	0.4300	0.2800
Full Equity	**ALL**	0.5132 **0.4704**	-0.1862 **0.6262**	18.3956	17.2406	12.1629	22.2192	1.0600	2.7300	-0.1400	0.0600	0.1600	-3.0600
	BC	0.2709 **0.4393**	0.3203 **0.3204**	13.5760	12.9849	8.5194	15.4552	0.4500	0.6200	4.5400	0.0300	0.0500	0.2900
	DC	0.7540 **0.3648**	-0.6894 **0.4143**	22.1763	20.6220	13.5258	27.3345	1.6600	4.8700	-4.1800	0.0700	0.2400	-114.2100
Bond +Equity (0.33 each country)	**ALL**	0.3905 **0.2163**	0.0875 **0.2728**	9.0076	8.0530	20.0723	10.8509	0.6300	1.5300	-0.0100	0.0700	0.1900	-0.0700
	BC	0.2765 **0.1969**	0.3041 **0.1474**	7.1292	6.1183	26.3492	7.2977	-1.0300	-0.4000	1.7100	-7.3300	-2.4300	0.2300
	DC	0.5038 **0.1704**	-0.1278 **0.1840**	10.5500	9.5978	17.2353	13.4868	2.3100	3.4800	-1.5300	0.2200	0.3600	-20.6000
Bond +Equity (0.60 EMU)	**ALL**	0.3034 **0.2359**	-0.0742 **0.3173**	9.2475	8.6198	13.1157	10.8509	0.3800	1.2200	-0.0100	0.0400	0.1400	-0.0700
	BC	0.1846 **0.2137**	0.1744 **0.1625**	6.8722	6.4764	11.1853	7.2977	-0.0200	-0.0100	1.7100	-0.1400	-0.0600	0.2300
	DC	0.4214 **0.1940**	-0.3210 **0.2284**	11.1190	10.3199	13.8568	13.4868	0.7800	2.4500	-1.5300	0.0700	0.2400	-20.6000

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds), whole period (ALL), Before Crisis (BC), During Crisis (DC), Euro units of British pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio, annualized unhedged portfolio standard deviation (**σ_{UH}**), , annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** , annualized European portfolio standard deviation **(σ_{EMU}),** annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), , annualized European portfolio return (**R_{EMU}**), Sharpe Ratio (**SHR**). When returns are negative, following Israelsen (2005), we use the improved Sharpe ratio index that is the result of multiplying the average returns by the standard deviation. All maturities bonds.

Table A.23. EWMA MODEL-1-3-Year Maturity– Out-of-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	**ALL**	0.2983 **0.0487**	0.3332 **0.0332**	5.4712	2.3578	81.4282	1.5968	-1.4400	-0.9000	-0.9400	-7.8800	-2.1200	-1.5000
	BC	0.2778 **0.0524**	0.3321 **0.0353**	4.0970	2.1056	73.5865	1.3543	-2.9300	-1.2200	-1.2900	-12.0100	-2.5800	-1.7400
	DC	0.3186 **0.0344**	0.3344 **0.0309**	6.5578	2.5849	84.4628	1.8062	0.0600	-0.5700	-0.6400	0.0100	-1.4800	-1.1500
Full Equity	**ALL**	0.5132 **0.4704**	-0.1862 **0.6262**	18.3956	17.2406	12.1629	22.2192	1.0600	2.7300	-0.1400	0.0600	0.1600	-3.0600
	BC	0.2709 **0.4393**	0.3203 **0.3204**	13.5760	12.9849	8.5194	15.4552	0.4500	0.6200	4.5400	0.0300	0.0500	0.2900
	DC	0.7540 **0.3648**	-0.6894 **0.4143**	22.1763	20.6220	13.5258	27.3345	1.6600	4.8700	-4.1800	0.0700	0.2400	-114.2100
Bond +Equity (0.33 each country)	**ALL**	0.4058 **0.2365**	0.0735 **0.3137**	9.4721	8.4692	20.0563	11.0567	-0.2000	0.9000	-0.5400	-1.9000	0.1100	-5.9700
	BC	0.2744 **0.2119**	0.3262 **0.1547**	7.4085	6.3759	25.9331	7.5115	-1.2500	-0.3000	1.5900	-9.2900	-1.9400	0.2100
	DC	0.5363 **0.1808**	-0.1775 **0.2143**	11.1536	10.1317	17.4840	13.7015	0.8600	2.1100	-2.4200	0.0800	0.2100	-33.2200
Bond +Equity (0.60 EMU)	**ALL**	0.3129 **0.2513**	-0.0819 **0.3486**	9.6668	8.9667	13.9602	11.0567	-0.3400	0.6800	-0.5400	-3.2600	0.0800	-5.9700
	BC	0.1797 **0.2265**	0.1946 **0.1710**	7.1385	6.7201	11.3805	7.5115	-0.2200	0.0800	1.5900	-1.5700	0.0100	0.2100
	DC	0.4452 **0.1996**	-0.3566 **0.2486**	11.6509	10.7464	14.9242	13.7015	-0.4500	1.2800	-2.4200	-5.2900	0.1200	-33.2200

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds), whole period (ALL), Before Crisis (BC), During Crisis (DC), Euro units of British pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio, annualized unhedged portfolio standard deviation (**σ_{UH}**), , annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE)**, , annualized European portfolio standard deviation **(σ_{EMU})**, annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), , annualized European portfolio return (**R_{EMU}**), Sharpe Ratio (**SHR**). When returns are negative, following Israelsen (2005), we use the improved Sharpe ratio index that is the result of multiplying the average returns by the standard deviation. 1-3 year maturity bonds.

Table A.24. EWMA MODEL- +10-year maturity– Out-of-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	**ALL**	0.2362 **0.1763**	0.4079 **0.2603**	9.6471	7.7246	35.8849	7.2925	1.4000	0.9400	0.9700	0.1400	0.1200	0.1300
	BC	0.3059 **0.1765**	0.2339 **0.1749**	7.0368	6.3310	19.0536	6.5385	-2.0900	-1.7300	-0.9300	-14.7000	-10.9500	-6.0900
	DC	0.1669 **0.1463**	0.5808 **0.2113**	11.6756	8.8953	41.9544	7.9730	4.9800	3.6600	2.6400	0.4300	0.4100	0.3300
Full Equity	**ALL**	0.5132 **0.4704**	-0.1862 **0.6262**	18.3956	17.2406	12.1629	22.2192	1.0600	2.7300	-0.1400	0.0600	0.1600	-3.0600
	BC	0.2709 **0.4393**	0.3203 **0.3204**	13.5760	12.9849	8.5194	15.4552	0.4500	0.6200	4.5400	0.0300	0.0500	0.2900
	DC	0.7540 **0.3648**	-0.6894 **0.4143**	22.1763	20.6220	13.5258	27.3345	1.6600	4.8700	-4.1800	0.0700	0.2400	-114.2100
Bond +Equity (0.33 each country)	**ALL**	0.3747 **0.1964**	0.1108 **0.2255**	8.8453	7.9624	18.9664	10.8702	1.2300	1.8300	0.4200	0.1400	0.2300	0.0400
	BC	0.2884 **0.1916**	0.2771 **0.1557**	7.1956	6.2475	24.6147	7.4940	-0.8300	-0.5600	1.7700	-5.9400	-3.5000	0.2400
	DC	0.4605 **0.1604**	-0.0543 **0.1501**	10.2259	9.3607	16.2052	13.4109	3.3100	4.2600	-0.8300	0.3200	0.4600	-11.1200
Bond +Equity (0.60 EMU)	**ALL**	0.2943 **0.2211**	-0.0591 **0.2763**	9.0638	8.5585	10.8386	10.8702	0.9100	1.4500	0.4200	0.1000	0.1700	0.0400
	BC	0.1988 **0.2105**	0.1482 **0.1672**	6.9744	6.6206	9.8903	7.4940	0.1600	-0.1700	1.7700	0.0200	-1.1500	0.2400
	DC	0.3891 **0.1882**	-0.2651 **0.1981**	10.7478	10.1252	11.2498	13.4109	1.6600	3.0900	-0.8300	0.1500	0.3100	-11.1200

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds), whole period (ALL), Before Crisis (BC), During Crisis (DC), Euro units of British pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio, annualized unhedged portfolio standard deviation (**σ_{UH}**), , annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE)**, , annualized European portfolio standard deviation (**σ_{EMU}**), annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), , annualized European portfolio return (**R_{EMU}**), Sharpe Ratio (**SHR**). When returns are negative, following Israelsen (2005), we use the improved Sharpe ratio index that is the result of multiplying the average returns by the standard deviation. **+10-year maturity bonds**.

Table A.25. DCC MODEL – All maturities– Out-of-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.3782 **0.1217**	0.2321 **0.0853**	6.7623	4.5520	54.6875	3.7992	0.2100	0.7100	0.1300	0.0300	0.1600	0.0300
	BC	0.3594 **0.0763**	0.1785 **0.0701**	5.0128	3.9049	39.3177	3.3424	-2.4900	-1.3000	-1.0500	-12.4600	-5.0700	-3.5000
	DC	0.3969 **0.1519**	0.2853 **0.0628**	8.1349	5.1131	60.4934	4.2047	2.9600	2.7400	1.2200	0.3600	0.5400	0.2900
Full Equity	ALL	0.4311 **0.2811**	-0.0015 **0.3344**	18.3956	17.4398	10.1212	22.2192	1.0600	3.0000	-0.1400	0.0600	0.1700	-3.0600
	BC	0.4053 **0.2176**	0.2868 **0.1299**	13.5760	12.9374	9.1866	15.4552	0.4500	1.7500	4.5400	0.0300	0.1400	0.2900
	DC	0.4568 **0.3304**	-0.2878 **0.2040**	22.1763	20.9831	10.4710	27.3345	1.6600	4.2600	-4.1600	0.0700	0.2000	-113.6700
Bond +Equity (0.33 each country)	ALL	0.3936 **0.1378**	0.1082 **0.1414**	9.0076	8.1101	18.9343	10.8509	0.6300	1.4700	-0.0100	0.0700	0.1800	-0.0700
	BC	0.3737 **0.1082**	0.2250 **0.0725**	7.1292	6.1452	25.6997	7.2977	-1.0300	0.0700	1.7100	-7.3300	0.0100	0.2300
	DC	0.4134 **0.1595**	-0.0079 **0.0871**	10.5500	9.6771	15.8632	13.4868	2.3100	2.8900	-1.5000	0.2200	0.3000	-20.2900
Bond +Equity (0.60 EMU)	ALL	0.2609 **0.1328**	0.0138 **0.1579**	9.2475	8.7297	10.8842	10.8509	0.3800	1.3000	-0.0100	0.0400	0.1500	-0.0700
	BC	0.2511 **0.1012**	0.1469 **0.0612**	6.8722	6.4548	11.7767	7.2977	-0.0200	0.5400	1.7100	-0.1400	0.0800	0.2300
	DC	0.2707 **0.1574**	-0.1185 **0.1041**	11.1190	10.5162	10.5483	13.4868	0.7800	2.0600	-1.5000	0.0700	0.2000	-20.2900

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds), whole period (ALL), Before Crisis (BC), During Crisis (DC), Euro units of British pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio, annualized unhedged portfolio standard deviation (**σ_{UH}**), , annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE),** , annualized European portfolio standard deviation **(σ_{EMU}),** annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), , annualized European portfolio return (**R_{EMU}**), Sharpe Ratio (**SHR**). When returns are negative, following Israelsen (2005), we use the improved Sharpe ratio index that is the result of multiplying the average returns by the standard deviation. All maturities bonds.

Table A.26. DCC MODEL – 1-3-Year Maturity– Out-of-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.4004 **0.0984**	0.2296 **0.0809**	5.4712	2.6650	76.2735	1.5968	-1.4400	-0.5600	-0.9400	-7.8800	-1.4800	-1.5000
	BC	0.4021 **0.0847**	0.2092 **0.0802**	4.0970	2.3891	65.9946	1.3543	-2.9300	-1.2100	-1.2900	-12.0100	-2.9000	-1.7400
	DC	0.3988 **0.1104**	0.2498 **0.0765**	6.5578	2.9138	80.2570	1.8062	0.0600	0.1000	-0.6100	0.0100	0.0400	-1.1100
Full Equity	ALL	0.4311 **0.2811**	-0.0015 **0.3344**	18.3956	17.4398	10.1212	22.2192	1.0600	3.0000	-0.1400	0.0600	0.1700	-3.0600
	BC	0.4053 **0.2176**	0.2868 **0.1299**	13.5760	12.9374	9.1866	15.4552	0.4500	1.7500	4.5400	0.0300	0.1400	0.2900
	DC	0.4568 **0.3304**	-0.2878 **0.2040**	22.1763	20.9831	10.4710	27.3345	1.6600	4.2600	-4.1600	0.0700	0.2000	-113.6700
Bond +Equity (0.33 each country)	ALL	0.4018 **0.1502**	0.1033 **0.1692**	9.4721	8.5307	18.8895	11.0567	-0.2000	0.9000	-0.5400	-1.9000	0.1000	-5.9700
	BC	0.3767 **0.1204**	0.2444 **0.0822**	7.4085	6.4088	25.1679	7.5115	-1.2500	0.0700	1.5900	-9.2900	0.0100	0.2100
	DC	0.4267 **0.1713**	-0.0369 **0.1045**	11.1536	10.2141	16.1363	13.7015	0.8600	1.7200	-2.4000	0.0800	0.1700	-32.9200
Bond +Equity (0.60 EMU)	ALL	0.2671 **0.1442**	0.0112 **0.1808**	9.6668	9.0838	11.6987	11.0567	-0.3400	0.7700	-0.5400	-3.2600	0.0800	-5.9700
	BC	0.2534 **0.1117**	0.1650 **0.0703**	7.1385	6.7068	11.7312	7.5115	-0.2200	0.5300	1.5900	-1.5700	0.0800	0.2100
	DC	0.2808 **0.1694**	-0.1416 **0.1158**	11.6509	10.9489	11.6868	13.7015	-0.4500	1.0100	-2.4000	-5.2900	0.0900	-32.9200

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds), whole period (ALL), Before Crisis (BC), During Crisis (DC), Euro units of British pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio, annualized unhedged portfolio standard deviation (**σ_{UH}**), , annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE)**, , annualized European portfolio standard deviation (**σ_{EMU}**), annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), , annualized European portfolio return (**R_{EMU}**), Sharpe Ratio (**SHR**). When returns are negative, following Israelsen (2005), we use the improved Sharpe ratio index that is the result of multiplying the average returns by the standard deviation. All maturities bonds.

Table A.27. DCC MODEL – 10+-Year Maturity– Out-of-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	**ALL**	0.3738 **0.1719**	0.2315 **0.1344**	9.6471	7.8829	33.2300	7.2925	1.4000	1.5900	0.9700	0.1400	0.2000	0.1300
	BC	0.3574 **0.0921**	0.1280 **0.0798**	7.0368	6.3649	18.1847	6.5385	-2.0900	-1.1600	-0.9300	-14.7000	-7.3800	-6.0900
	DC	0.3901 **0.2235**	0.3343 **0.0919**	11.6756	9.1446	38.6553	7.9730	4.9800	4.4000	2.6600	0.4300	0.4800	0.3300
Full Equity	**ALL**	0.4311 **0.2811**	-0.0015 **0.3344**	18.3956	17.4398	10.1212	22.2192	1.0600	3.0000	-0.1400	0.0600	0.1700	-3.0600
	BC	0.4053 **0.2176**	0.2868 **0.1299**	13.5760	12.9374	9.1866	15.4552	0.4500	1.7500	4.5400	0.0300	0.1400	0.2900
	DC	0.4568 **0.3304**	-0.2878 **0.2040**	22.1763	20.9831	10.4710	27.3345	1.6600	4.2600	-4.1600	0.0700	0.2000	-113.6700
Bond +Equity (0.33 each country)	**ALL**	0.3908 **0.1282**	0.1191 **0.1104**	8.8453	8.0110	17.9744	10.8702	1.2300	1.7700	0.4200	0.1400	0.2200	0.0400
	BC	0.3809 **0.0997**	0.2064 **0.0695**	7.1956	6.2683	24.1127	7.4940	-0.8300	0.0900	1.7700	-5.9400	0.0100	0.2400
	DC	0.4006 **0.1507**	0.0324 **0.0663**	10.2259	9.4305	14.9502	13.4109	3.3100	3.4800	-0.8100	0.3200	0.3700	-10.8000
Bond +Equity (0.60 EMU)	**ALL**	0.2601 **0.1202**	0.0213 **0.1289**	9.0638	8.6535	8.8497	10.8702	0.9100	1.5900	0.4200	0.1000	0.1800	0.0400
	BC	0.2577 **0.0925**	0.1276 **0.0577**	6.9744	6.5928	10.6451	7.4940	0.1600	0.6200	1.7700	0.0200	0.0900	0.2400
	DC	0.2626 **0.1425**	-0.0843 **0.0860**	10.7478	10.3032	8.1015	13.4109	1.6600	2.5600	-0.8100	0.1500	0.2500	-10.8000

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds), whole period (ALL), Before Crisis (BC), During Crisis (DC), Euro units of British pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio, annualized unhedged portfolio standard deviation (**σ_{UH}**), , annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE)**, , annualized European portfolio standard deviation (**σ_{EMU}**), annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), , annualized European portfolio return (**R_{EMU}**), Sharpe Ratio (**SHR**). When returns are negative, following Israelsen (2005), we use the improved Sharpe ratio index that is the result of multiplying the average returns by the standard deviation. 10+ year maturity bonds.

Table A.28. BEKK MODEL – All maturities– Out-of-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	ALL	0.2701 **0.0788**	0.3490 **0.1014**	6.7623	4.3544	58.5361	3.7992	0.2100	0.5500	0.1300	0.0300	0.1300	0.0300
	BC	0.2761 **0.0849**	0.2806 **0.0751**	5.0128	3.7742	43.3117	3.3424	-2.4900	-1.0000	-1.0500	-12.4600	-3.7900	-3.5000
	DC	0.2642 **0.0719**	0.4170 **0.0750**	8.1349	4.8625	64.2709	4.2047	2.9600	2.1100	1.1400	0.3600	0.4300	0.2700
Full Equity	ALL	0.4394 **0.4524**	-0.0277 **0.6045**	18.3956	17.3494	11.0508	22.2192	1.0600	2.5500	-0.1400	0.0600	0.1500	-3.0600
	BC	0.2401 **0.3435**	0.4526 **0.2867**	13.5760	12.9554	8.9343	15.4552	0.4500	0.9800	4.5400	0.0300	0.0800	0.2900
	DC	0.6375 **0.4607**	-0.5048 **0.4357**	22.1763	20.8218	11.8421	27.3345	1.6600	4.1400	-4.2300	0.0700	0.2000	-115.7500
Bond +Equity (0.33 each country)	ALL	0.3532 **0.2078**	0.1517 **0.2647**	9.0076	8.0874	19.3880	10.8509	0.6310	1.4693	-0.0061	0.0701	0.1817	-0.0658
	BC	0.2579 **0.1611**	0.3655 **0.1246**	7.1292	6.1075	26.6090	7.2977	-1.0275	-0.0524	1.7081	-7.3256	-0.3199	0.2341
	DC	0.4480 **0.2058**	-0.0607 **0.1834**	10.5500	9.6627	16.1128	13.4868	2.3061	3.0038	-1.5851	0.2186	0.3109	-21.3782
Bond +Equity (0.60 EMU)	ALL	0.2636 **0.2292**	0.0082 **0.3027**	9.2475	8.6643	12.2160	10.8509	0.3796	1.1363	-0.0061	0.0410	0.1312	-0.0658
	BC	0.1665 **0.1686**	0.2444 **0.1388**	6.8722	6.4626	11.5658	7.2977	-0.0204	0.2701	1.7081	-0.1403	0.0418	0.2341
	DC	0.3601 **0.2405**	-0.2265 **0.2303**	11.1190	10.4029	12.4666	13.4868	0.7785	2.0042	-1.5851	0.0700	0.1927	-21.3782

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds), whole period (ALL), Before Crisis (BC), During Crisis (DC), Euro units of British pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio, annualized unhedged portfolio standard deviation (**σ_{UH}**), , annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE)**, , annualized European portfolio standard deviation (**σ_{EMU}**), annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), , annualized European portfolio return (**R_{EMU}**), Sharpe Ratio (**SHR**). When returns are negative, following Israelsen (2005), we use the improved Sharpe ratio index that is the result of multiplying the average returns by the standard deviation. All maturities bonds.

Table A.29. BEKK MODEL – 1-3-Year Maturity– Out-of-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	**ALL**	0.2936 **0.0455**	0.3324 **0.0305**	5.4712	2.3644	81.3244	1.5968	-1.4400	-0.9000	-0.9400	-7.8800	-2.1300	-1.5000
	BC	0.2734 **0.0444**	0.3346 **0.0280**	4.0970	2.0958	73.8331	1.3543	-2.9300	-1.1000	-1.2900	-12.0100	-2.3100	-1.7400
	DC	0.3137 **0.0369**	0.3302 **0.0327**	6.5578	2.6049	84.2219	1.8062	0.0600	-0.7000	-0.7000	0.0100	-1.8300	-1.2600
Full Equity	**ALL**	0.4394 **0.4524**	-0.0277 **0.6045**	18.3956	17.3494	11.0508	22.2192	1.0600	2.5500	-0.1400	0.0600	0.1500	-3.0600
	BC	0.2401 **0.3435**	0.4526 **0.2867**	13.5760	12.9554	8.9343	15.4552	0.4500	0.9800	4.5400	0.0300	0.0800	0.2900
	DC	0.6375 **0.4607**	-0.5048 **0.4357**	22.1763	20.8218	11.8421	27.3345	1.6600	4.1400	-4.2300	0.0700	0.2000	-115.7500
Bond +Equity (0.33 each country)	**ALL**	0.3635 **0.2274**	0.1452 **0.3021**	9.4721	8.5131	19.2247	11.0567	-0.2003	0.7630	-0.5403	-1.8971	0.0896	-5.9742
	BC	0.2523 **0.1722**	0.3896 **0.1371**	7.4085	6.3645	26.1987	7.5115	-1.2537	-0.0989	1.5853	-9.2879	-0.6293	0.2111
	DC	0.4740 **0.2218**	-0.0976 **0.2118**	11.1536	10.2123	16.1670	13.7015	0.8572	1.6265	-2.4816	0.0769	0.1593	-34.0011
Bond +Equity (0.60 EMU)	**ALL**	0.2695 **0.2434**	0.0045 **0.3335**	9.6668	9.0217	12.9016	11.0567	-0.3376	0.5612	-0.5403	-3.2636	0.0622	-5.9742
	BC	0.1583 **0.1778**	0.2662 **0.1515**	7.1385	6.7062	11.7446	7.5115	-0.2200	0.2462	1.5853	-1.5703	0.0367	0.2111
	DC	0.3800 **0.2496**	-0.2556 **0.2514**	11.6509	10.8464	13.3336	13.7015	-0.4543	0.8751	-2.4816	-5.2934	0.0807	-34.0011

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds), whole period (ALL), Before Crisis (BC), During Crisis (DC), Euro units of British pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio, annualized unhedged portfolio standard deviation (**σ_{UH}**), , annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE)**, , annualized European portfolio standard deviation **(σ_{EMU})**, annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), , annualized European portfolio return (**R_{EMU}**), Sharpe Ratio (**SHR**). When returns are negative, following Israelsen (2005), we use the improved Sharpe ratio index that is the result of multiplying the average returns by the standard deviation. All maturities bonds.

Table A.30. BEKK MODEL – 10+-Year Maturity– Out-of-sample

		β_1	β_2	σ_{UH}	σ_H	HE	σ_{EMU}	R_{UH}	R_H	R_{EMU}	SHR_{UH}	SHR_H	SHR_{EMU}
Full Bond	**ALL**	0.2473 **0.1539**	0.3703 **0.2330**	9.6471	7.7125	36.0864	7.2925	1.4000	1.1900	0.9700	0.1400	0.1500	0.1300
	BC	0.2978 **0.1329**	0.2061 **0.1272**	7.0368	6.3115	19.5515	6.5385	-2.0900	-1.1800	-0.9300	-14.7000	-7.4400	-6.0900
	DC	0.1972 **0.1569**	0.5335 **0.1967**	11.6756	8.8888	42.0400	7.9730	4.9800	3.6000	2.5800	0.4300	0.4000	0.3200
Full Equity	**ALL**	0.4394 **0.4524**	-0.0277 **0.6045**	18.3956	17.3494	11.0508	22.2192	1.0600	2.5500	-0.1400	0.0600	0.1500	-3.0600
	BC	0.2401 **0.3435**	0.4526 **0.2867**	13.5760	12.9554	8.9343	15.4552	0.4500	0.9800	4.5400	0.0300	0.0800	0.2900
	DC	0.6375 **0.4607**	-0.5048 **0.4357**	22.1763	20.8218	11.8421	27.3345	1.6600	4.1400	-4.2300	0.0700	0.2000	-115.7500
Bond +Equity (0.33 each country)	**ALL**	0.3461 **0.1907**	0.1658 **0.2249**	8.8453	7.9874	18.4569	10.8702	1.2264	1.8538	0.4169	0.1387	0.2321	0.0384
	BC	0.2753 **0.1604**	0.3418 **0.1213**	7.1956	6.2395	24.8071	7.4940	-0.8261	-0.0259	1.7670	-5.9441	-0.1613	0.2358
	DC	0.4164 **0.1924**	-0.0091 **0.1577**	10.2259	9.4092	15.3339	13.4109	3.3073	3.7558	-0.8875	0.3234	0.3992	-11.9016
Bond +Equity (0.60 EMU)	**ALL**	0.2587 **0.2118**	0.0193 **0.2626**	9.0638	8.5862	10.2607	10.8702	0.9093	1.4471	0.4169	0.1003	0.1685	0.0384
	BC	0.1857 **0.1689**	0.2205 **0.1338**	6.9744	6.6041	10.3382	7.4940	0.1570	0.2628	1.7670	0.0225	0.0398	0.2358
	DC	0.3313 **0.2248**	-0.1805 **0.1988**	10.7478	10.1830	10.2343	13.4109	1.6623	2.6374	-0.8875	0.1547	0.2590	-11.9016

Notes: Full bond portfolio (Full Bond), Full equity Portfolio (Full Equity), Bond and equity portfolio (equally 33% country weight, 50% bonds, 50% equities), home biased Bond and equity portfolio, (60% EMU, 20% the UK and 20% the US), for the EMU portfolio the investor is only holding domestic equities and/or bonds based on the kind of international portfolio we are comparing with (full bond, full equity or equities + bonds), whole period (ALL), Before Crisis (BC), During Crisis (DC), Euro units of British pound future sold (**β_1**), Euro units of US dollar future sold (**β_2**) per Euro invested in an international portfolio, annualized unhedged portfolio standard deviation (**σ_{UH}**), , annualized hedged portfolio standard deviation (**σ_H**), Hedging Effectiveness **(HE)**, , annualized European portfolio standard deviation **(σ_{EMU})**, annualized unhedged portfolio Return (**R_{UH}**), annualized hedged portfolio Return (**R_H**), , annualized European portfolio return (**R_{EMU}**), Sharpe Ratio (**SHR**). When returns are negative, following Israelsen (2005), we use the improved Sharpe ratio index that is the result of multiplying the average returns by the standard deviation. 10+ year maturity bonds.

Figure A.1. Hedging ratio. Full bond / 1-3-year maturity

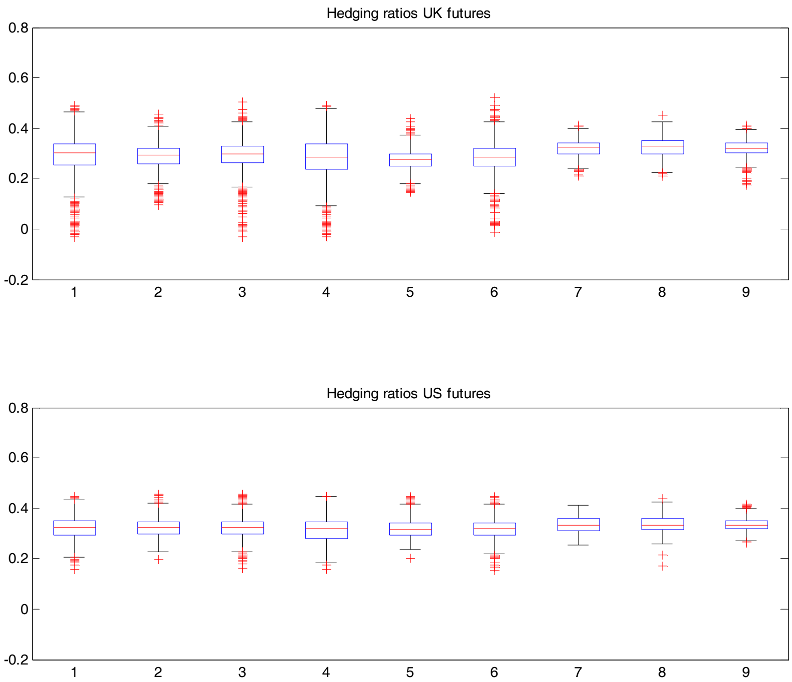


Figure A.2. Hedging ratios. Full bond / 10+-year maturity

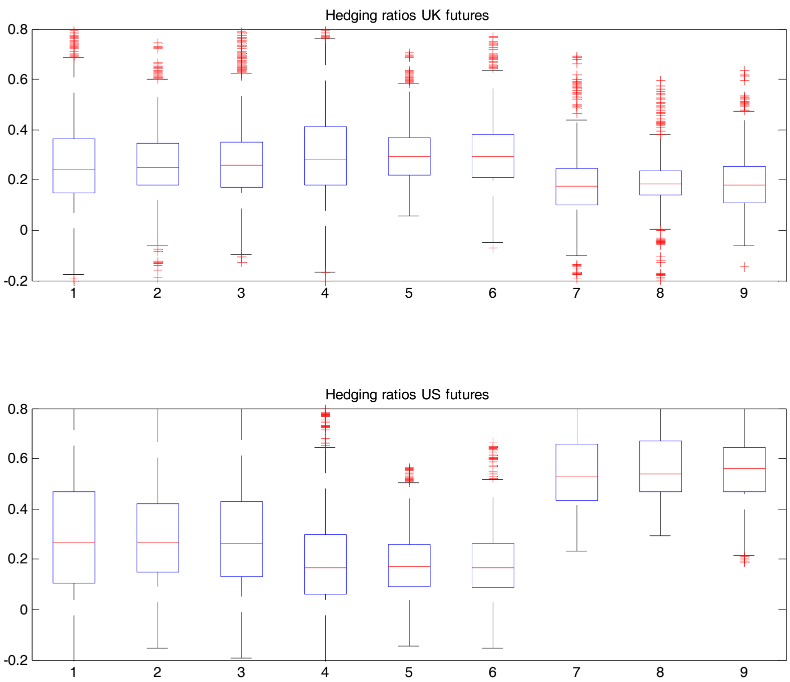


Figure A.3. Hedging ratios. Equity + Bond (0.33) / 1-3-year maturity

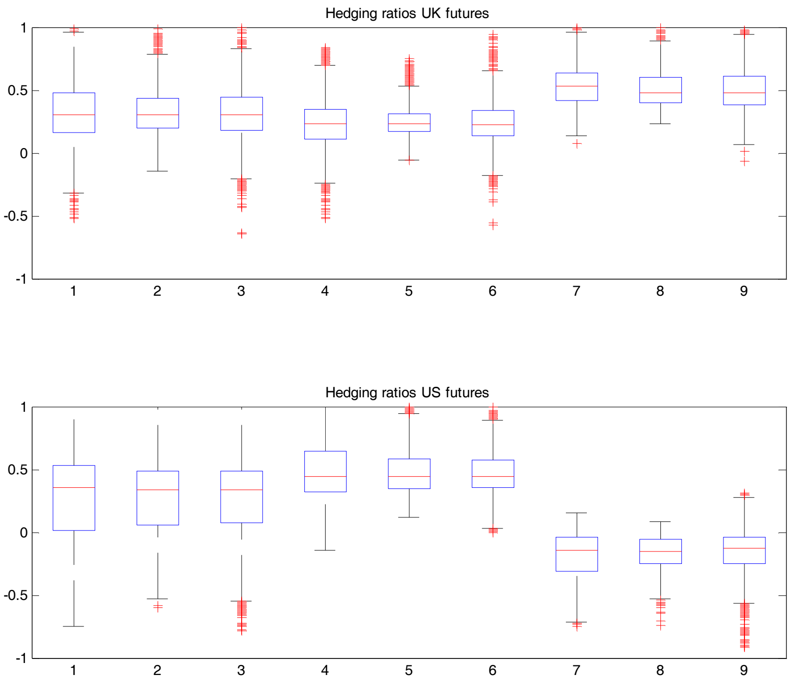


Figure A.4. Hedging ratios. Equity + Bond (0.33) / 10+-year maturity

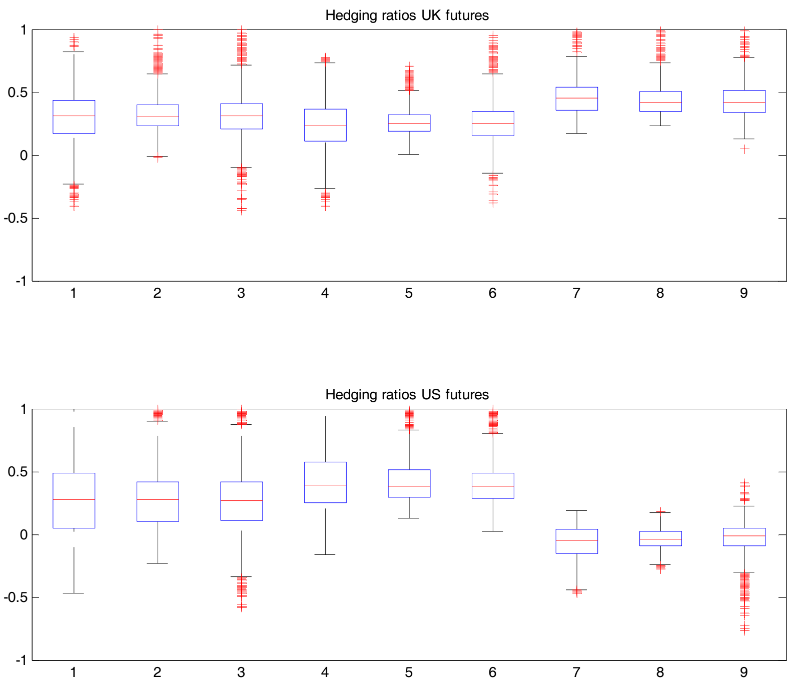


Figure A.5. Hedging ratios. Equity + Bond (0.6/0.20/0.20) / 1-3-year maturity

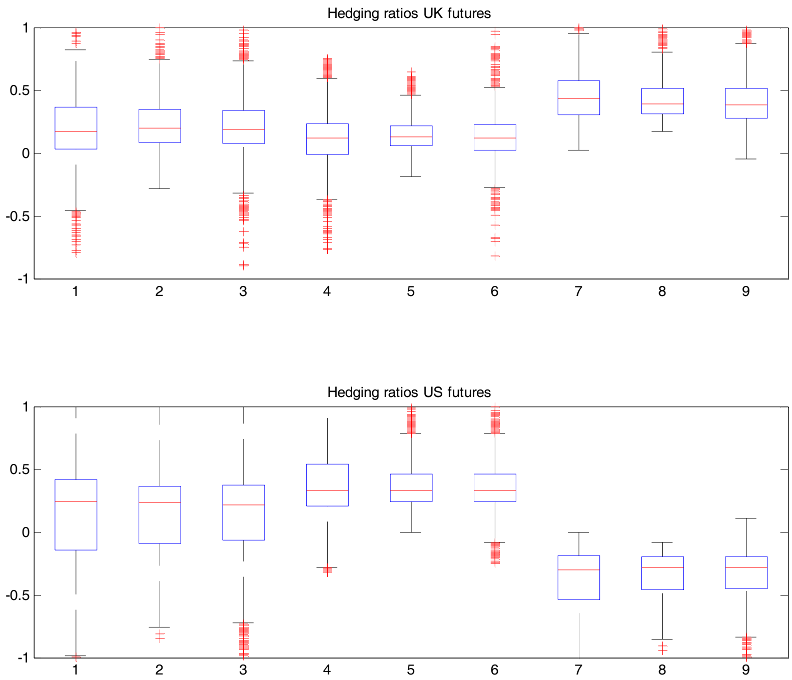


Figure A.6. Hedging ratios. Equity + Bond (0.6/0.20/0.20) / 10+year maturity

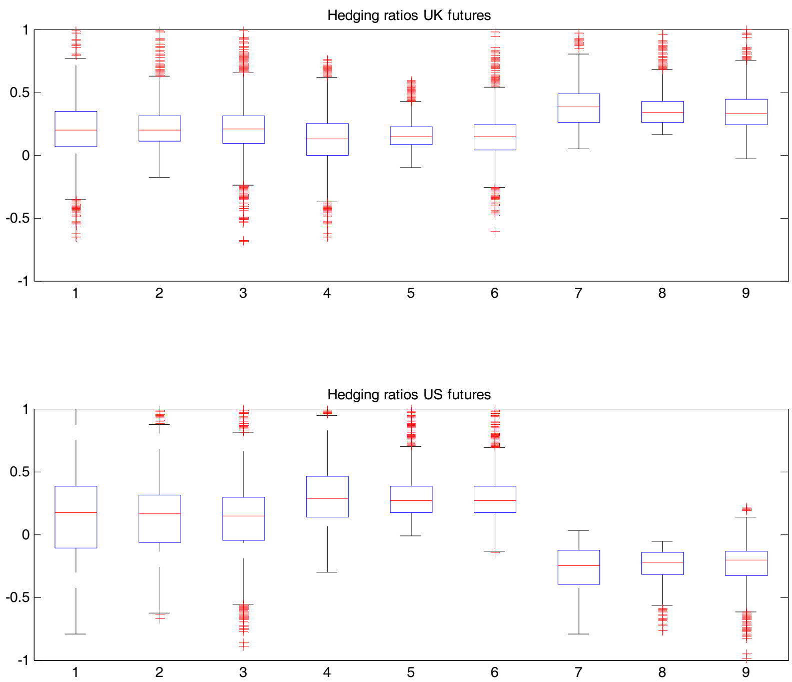


Figure A.7. Hedging ratio. Full bond / 1-3-year maturity– Out-of-Sample

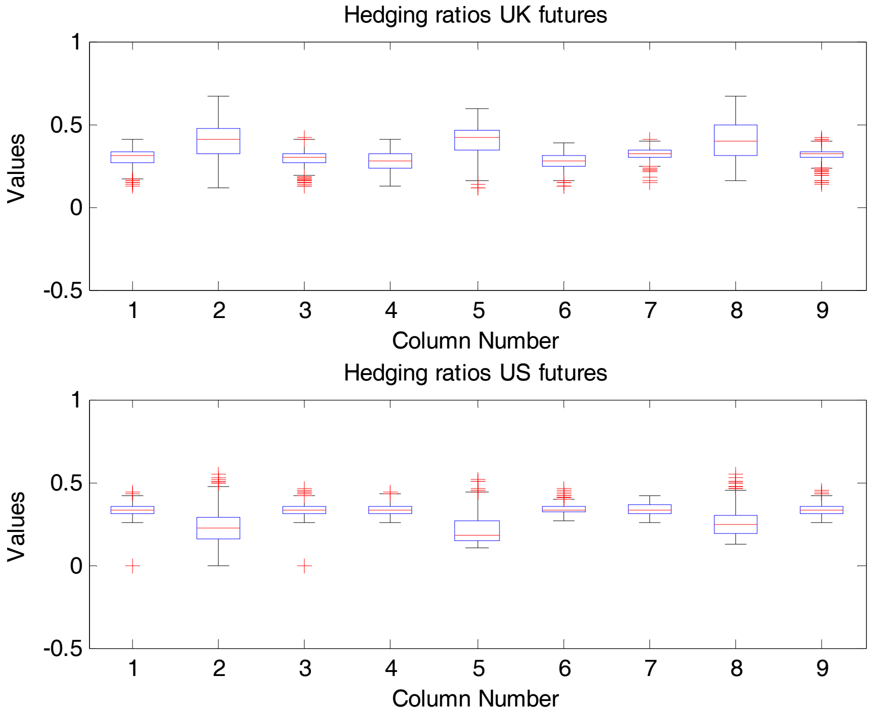


Figure A.8. Hedging ratios. Full bond / 10+-year maturity– Out-of-Sample

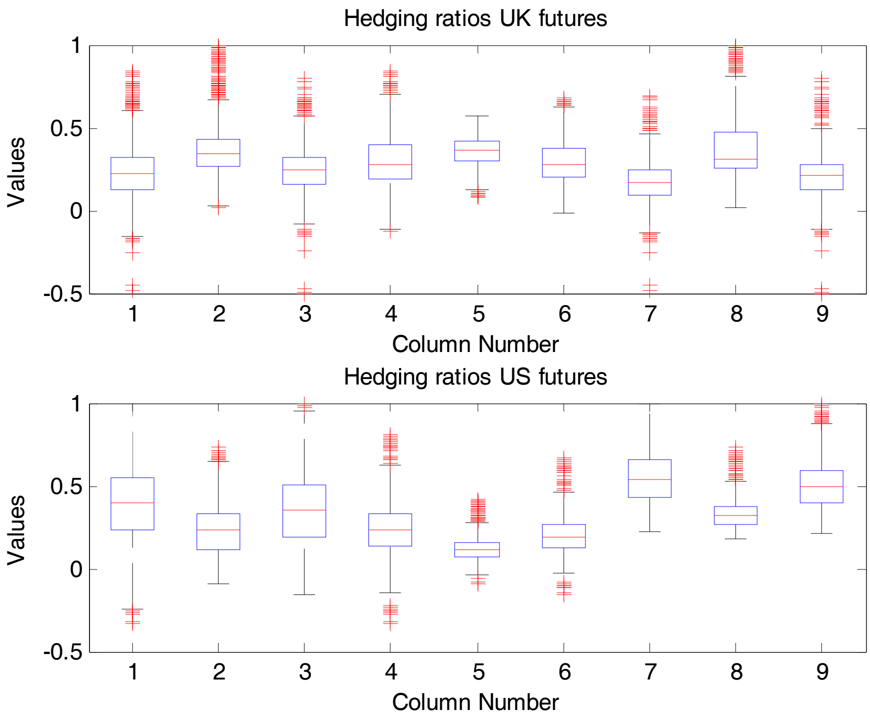


Figure A.9. Hedging ratios. Equity + Bond (0.33) / 1-3-year maturity– Out-of-Sample

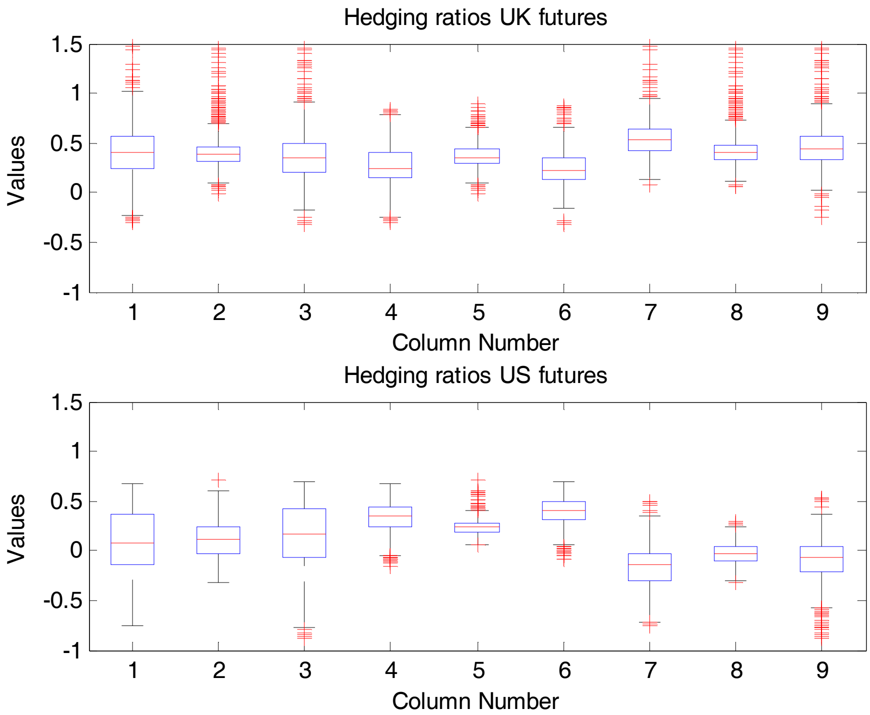


Figure A.10. Hedging ratios. Equity + Bond (0.33) / 10+-year maturity– Out-of-Sample

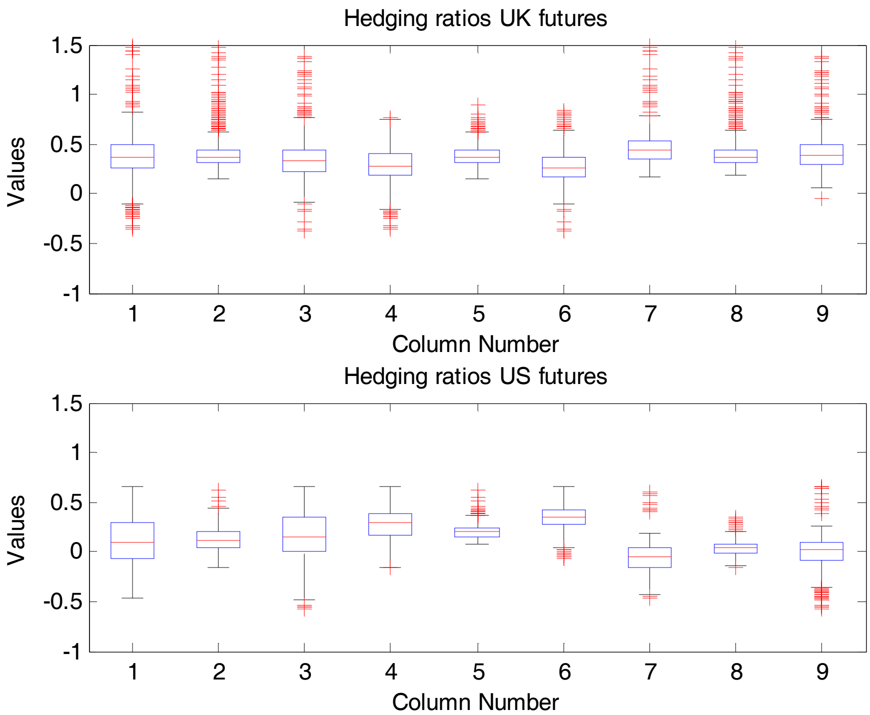


Figure A.11. Hedging ratios. Equity + Bond (0.6/0.20/0.20) / 1-3-year maturity– Out-of-Sample

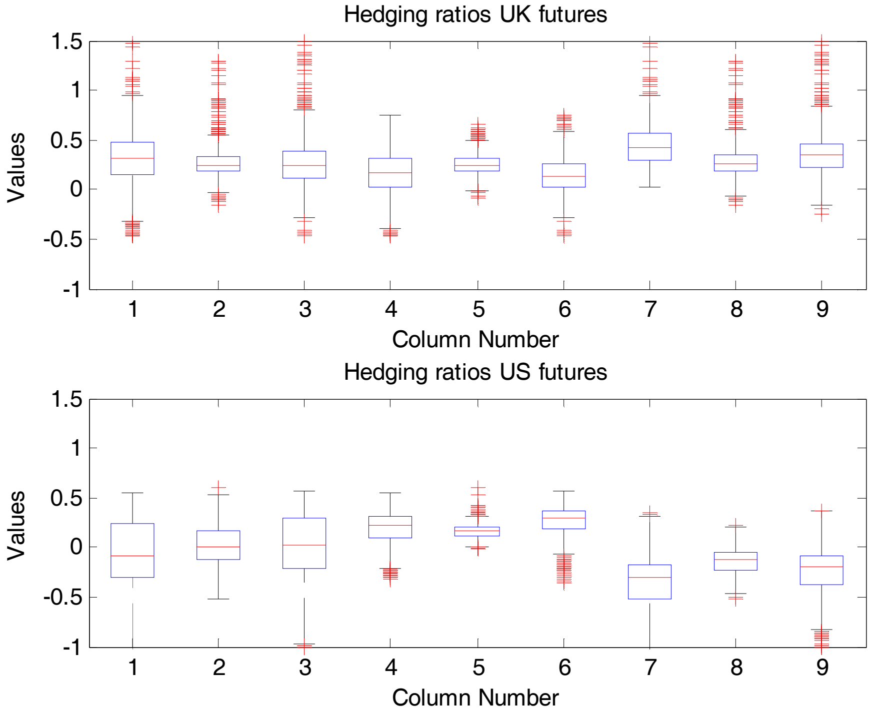


Figure A.12. Hedging ratios. Equity + Bond (0.6/0.20/0.20) / 10+year maturity – Out-of-Sample