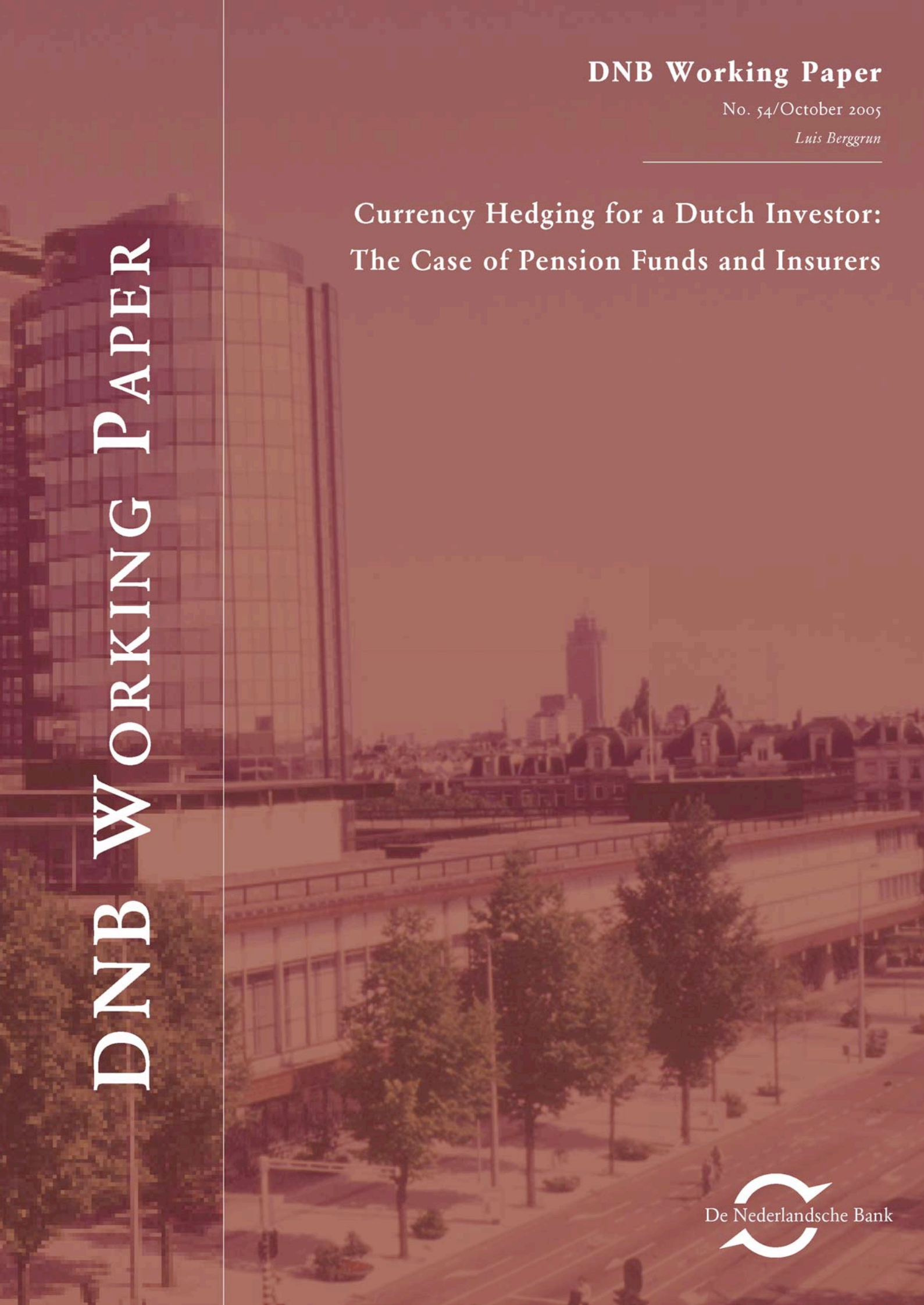
DNB WORKING PAPER

DNB Working Paper

No. 54/October 2005

Luis Berggrun

Currency Hedging for a Dutch Investor: The Case of Pension Funds and Insurers



De Nederlandsche Bank

Currency Hedging for a Dutch Investor: The Case of Pension Funds and Insurers

Luis Berggrun *

* Views expressed are those of the individual author and do not necessarily reflect official positions of De Nederlandsche Bank.

Working Paper No. 054/2005

October 2005

De Nederlandsche Bank NV
P.O. Box 98
1000 AB AMSTERDAM
The Netherlands

Currency Hedging For a Dutch Investor: The Case of Pension Funds and Insurers

By: Luis Berggrun*

Abstract

This paper analyzes the risk reduction effectiveness of currency hedging international portfolios from the perspective of an average Dutch pension fund and insurer during the period 1999-2004. Several portfolios and approaches to hedging are analyzed. Passive hedging seems to be efficient in reducing the volatility of a foreign bond portfolio whereas the risk reduction achieved for a foreign equity portfolio is not significant.

The case of mixed (bonds and equities) portfolios and hedging is also analyzed. No significant risk reduction (at the same level of returns as that of an unhedged portfolio) was attained using a static hedging approach and portfolio optimization under short sale constraints. Using a selective (dynamic) hedging approach based on the forward premium, showed similar results; the volatility of an unhedged and hedged portfolio was virtually the same. Nevertheless, this selective hedging strategy had a positive impact improving the hedged portfolio returns.

JEL Code: F31

KEYWORDS: Currency Hedging, Investment portfolios, Static and Selective Hedging.

*This paper was written during an internship at De Nederlandsche Bank. I'd like to thank Klaas Knot, Maarten Gelderman, Eric Elvers, Iman van Lelyveld, Jeroen Ligterink, Sebastiano Manzan and Joost Driessen for helpful advice.

1. INTRODUCTION

During 1999-2003, Dutch pension funds and insurers together had a considerable investment portfolio of equities and bonds. This portfolio amounted to approximately 500 billion euro, allocated roughly in equal proportion between equities and bonds.

Table 1. Current value of investments of Dutch pension funds and insurers[1], 1999-2003.

EUR million	2003	2002	2001	2000	1999
Equities	257,576	214,752	272,823	270,743	282,750
Bonds	281,561	263,615	250,125	240,361	209,843
Total	539,137	478,367	522,948	511,104	492,593

Source: De Nederlandsche Bank

Almost one third of these investments are denominated in currencies different than the euro. The main foreign (non-euro) investments by these institutions are concentrated in Japan, Sweden, Switzerland, the United Kingdom (UK) and the United States (US).

More specifically, foreign equity investments are heavily concentrated in three markets: the US, the UK and Japan. Foreign bond investments are concentrated primarily in the US (82%) and the United Kingdom (11%). (See Appendix A for more details).

From these figures it is evident that exchange rate movements[2] have a considerable impact on the return and risk characteristics of a diversified portfolio owned by Dutch pension funds and insurers. So a sensible strategy would be to be hedge (as much as possible) the currency exposure using financial instruments such as currency forwards, futures or swaps to minimize the variability of a diversified foreign portfolio.

The main objective of this paper is to evaluate if the strategy to hedge a currency exposure is adequate for different kind of portfolios, since Dutch pension funds and insurers may want to use hedging as a means of minimizing regulatory capital requirements. In the literature, there are two basic approaches to evaluate if hedging is adequate. The first approach uses a utility maximization framework in which the Sharpe ratio is preferred (Excess return / standard deviation). Clearly, if hedging is efficient, a hedged portfolio must produce a significantly

[1] Insurers include life, non-life and funeral in kind insurers. Of course, pension funds and insurers manage other assets like mortgage and private loans, real estate investments and so on, but the focus of this paper is on investments in equities and bonds exclusively.

[2] The case of the US dollar is illustrative. While in 2000 the average euro/dollar rate was 1.09, in 2003 the euro strengthened to 0.88 euro per dollar.

higher reward per unit of risk. The second approach is concerned with risk reduction, where the emphasis is to find the hedge ratio that minimizes the risk of a portfolio. In this paper, this second approach is used.

More specifically, I test if by passively and fully hedging a foreign bond or equity portfolio Dutch pension funds and insurers can achieve a significant risk reduction. Then, the analysis is expanded to allow for several hedge ratios to get an idea of the optimal (minimum variance) hedge ratio of a representative international bond or equity portfolio. Currency hedging is also analyzed in the context of mixed (bonds and equities) portfolios. Two hedging strategies are considered; one static that relies on portfolio optimization under short sale constraints to find the optimal hedge ratios, and one selective (or active), based on the forward premium and time varying hedge ratios.

This article is structured as follows. Section 2 includes a brief literature review discussing some relevant findings about hedging the currency risk of diversified portfolios. The next section includes a description of the data and methodology used to assess if currency hedging is effective in reducing risk of several representative portfolios. Section 4 provides the main results of this research and finally, section 5 contains some concluding remarks.

2. LITERATURE REVIEW

Abken et. al (1997) analyze the benefits of currency hedging a portfolio of equities (from 1980 to 1996) and bonds (from 1986 to 1996). Initially, the apparent risk reducing benefits of currency hedging equity portfolios in the early 1980s are not confirmed for the 1986-1996 period overall or for sub periods.

In contrast, foreign long-term bond portfolios consistently exhibited dramatically lower variability of hedged returns vs. unhedged returns, but hedged returns were lower than unhedged returns. Then, they analyze portfolios in a context of mean variance using efficient frontiers as proposed by Markowitz.

They use Eun and Resnick's (1988) approximation to calculate the standard deviation of the unhedged and hedged portfolio. The standard deviation of the unhedged portfolio is the sum of three components: securities return covariances, foreign exchange rate covariances and local return-foreign exchange rate covariances. The standard deviation of the hedged portfolio is the sum of three components: local return covariances, forward premium covariances and security return-forward premium covariances. The forward premium (fp_{t-1}) is equal to f_{t-1} / s_{t-1} and f_t = forward rate, s_t = spot rate.

The key argument for currency hedging is that the variance reduction by diversifying internationally that may be realized through (lower) securities covariances may be offset by the contributions of the second two terms for the exchange rate interactions. Foreign exchange returns tend to be more highly correlated than international equity or bond returns. In contrast, the forward premium has a much lower standard deviation and a lower correlation with local returns than the spot exchange rate. Both of these characteristics may improve the risk return trade off for internationally diversified hedged portfolios.

For 1980-1985, the efficient frontier shows that a hedged portfolio of equities was more efficient. For 1986-1996 the picture radically changes. The unhedged efficient frontier dominates the hedged frontier. This coincided with an appreciation of foreign currencies against the dollar. This change (from a better performance of the hedged portfolio in the first sub period to the opposite case in the following sub period) is explained by the different correlation structure in these two time periods.

For a bond portfolio, the average reduction in the standard deviation of hedged dollar returns relative to the unhedged dollar returns across countries is larger than for the case of equities. Looking at the efficient frontiers, the paper suggest that the decision to hedge a bond portfolio depends on the investor's preference for risk and return, thus there is no clear dominance and the only way an investor can improve its portfolio's returns is through tolerating higher (currency) risks.

Bugar et. al (2001) analyze the case of equity investing locally and abroad (in Canada, Switzerland, Germany, France, Great Britain, Hungary, Japan and the U.S.) from the perspective of German and Hungarian investors. For the case of a German investor[3], unhedged returns of investing in each of the 7 foreign markets tend to be higher than the hedged returns. However, fully hedging the currency exposure reduces the volatility of returns in all stock markets.

Analyzing the volatility (variance) of a global equity portfolio, the authors found that the correlations between local market's returns tend to be higher than those of the exchange rate returns. Furthermore, they found an average positive cross correlation term among local stock market returns and exchange rates for the case of a German investor, implying that movements of stock markets and exchange rates reinforce (rather than offset, when the correlation term is negative) the exchange rate volatility.

Given this trade-off between risk and return, the authors analyze currency hedged and unhedged equity portfolios using an efficient frontier. In this ex-post analysis, they found that above a critical risk level (namely, above the value of the standard deviation at the meeting point of the curves, which was 5.05%) it was not worthwhile for German investors to fully hedge their multi-currency portfolios, because they could not utilize the advantages of hedging either in terms of increasing the return or lowering the risk. This is a somewhat contradictory result when compared with the first paper analyzed, that showed a clearer picture (dominance) of hedging or not an equity portfolio (depending on the time period analyzed).

[3] I omit the findings for the case of the Hungarian investor since Hungary is an emerging market.

Glen et. al (1993) analyze currency hedging (using forwards) from the perspective of an American investor who invests in 5 markets (US, Japan, Germany, United Kingdom and France). Initially, they found significant risk reductions (decreases in volatility by more than half) for the case of unitarily hedging individual (country government bond indices) bond investments in the different foreign markets. However, for individual equity investments, these reductions were not as pronounced (in % terms).

Then, the authors evaluate the introduction of forward contracts with respect to the four foreign currencies to an optimized bond, equity and mixed (bonds and equities) portfolio imposing short selling restrictions (non-negative portfolio weights) and limiting the extent of hedging to the exposure in the underlying market[4].

If currency hedging is efficient in a mean variance context, one would expect a statistically higher Sharpe ratio for the hedged portfolio (containing the initial securities and the forwards) than for the unhedged one. Using F and Wald tests to examine if the difference in the Sharpe ratios was statistically significant, Glen et. al. found that by statically hedging a bonds only and a mixed portfolio, one could significantly improve the Sharpe ratio. However, for the case of a stocks only portfolio, this improvement was not statistically significant.

In addition, using an active (in-sample) hedging strategy[5] based on the forward premium, they found that time varying hedges statistically improve the risk/return profile of a bond, stock and mixed portfolio (see left upper part of Table V in the paper).

De Roon (1997) tests, for an American investor, if the mean variance frontier of an investment in three international stock indices (S&P 500, Germany's FAZ and UK's FTSE) coincides with the mean variance frontier of an investment in these three stock indices plus futures contracts (on the DM, British Pound and Japanese Yen). If the mean variance frontiers coincide, it is not efficient to add futures contracts (in other words, hedge) to the initial investment, because one can get a similar portfolio performance with a lower number of assets (these additional assets (futures contracts) may only increase the volatility of the portfolio without enhancing its returns). He finds that for a mean-variance investor with a

[4] See section IV of the paper. These restrictions are very realistic for Dutch pension funds and insurers.
[5] They also considered a second (out of sample) hedging strategy. However, they only report the results for passive investments in the World Bond and Stock indices.

non-traded position in the different currencies adding futures does not bring any abnormal performance (the frontiers coincide) even though there is an exposure to the foreign currency.

He argues that this result can be explained by the fact that international stock indices already contain a currency component which makes adding futures a less useful strategy for mean-variance investors.

However, using a different (conditional) hedging strategy, based on the concept of hedging pressure (net positions of large hedgers in the futures markets) as a way to predict futures returns, the author finds that currency hedging is a plausible strategy for mean-variance investors when the hedgers are predominantly long or short, not when their positions are uniformly spread.

More recently, De Roon et al (2001) analyze if the performance of a portfolio (denominated in US dollars and for the period February 1977 – December 1998) of international equity indices (G5 countries) can be enhanced by hedging its currency exposure; in other words, by adding currency forwards on the French Franc, German Mark, Japanese Yen and British Pound with respect to the US dollar.

They consider both the case of static and dynamic hedging. In the case of static hedging, where the optimal forward positions are kept constant throughout the sample, they found no statistically significant improvement for the case of a mean-variance investor, except for a highly risk averse one. However, using a dynamic hedging strategy based on interest rate differentials[6] (between local and foreign risk free rates), they found significant improvement in portfolio performance. They argue that this result can be explained by the lower correlation of the forward returns with the equity indices and the higher absolute forward mean returns (compared to the case of static hedging), making diversification (by actively adding forwards to the original equity investment) a profitable strategy for an American investor.

Haefliger et. al (2002), using basic buy and hold strategies try to analyze the risk-return characteristics of 5 types of portfolios (both for bonds and equities): domestic, single foreign currency (hedged and unhedged) and multiple foreign currencies (hedged and unhedged) from

[6] Basically, a short position in the foreign currency is taken when the home (U.S.) risk free rate is below the foreign risk free rate, while a long position is taken when the opposite occurs.

an aggregate perspective of American, British, German, Japanese and Swiss investors, covering the period 1985 - 2000.

They found that foreign currency bonds, on average, are far riskier than domestic bonds. Fully hedging currency risk tends to bring back the overall risk of a single foreign currency bond to roughly the same level as that of domestic bonds. Moreover, currency diversification (going from a single to a multi-foreign currency portfolio) marginally reduces the extra risk of foreign currency bonds. However, by hedging this multi-foreign currency portfolio an investor can enjoy the benefits of interest rate and currency diversification, even with a risk level below the one of domestic bonds.

For a portfolio of foreign equities, the authors initially hypothesize that domestic equities are not necessarily less risky than foreign ones. Think of a company like Aegon NV, though domiciled in Holland it may carry a multiple risk even for Dutch investors due to the company's worldwide activities and its resulting currency exposure. In practice, this fact makes quite difficult to determine the true identity and size of the currency risks associated with Aegon's shares.

Nevertheless, they found that foreign equities are slightly riskier than domestic ones. Furthermore, they found that currency hedging a single or a multi foreign currency equity portfolio is helpful reducing volatility but this risk reduction is of a far lower magnitude than for the case of bonds.

The authors also analyzed the risk reduction characteristics of several hedge ratios for multi foreign currency bond and equity portfolios (Table 7). They found that for foreign equities, there seems to be less of a need to hedge since on average, the risk reduction (%) achieved[7] as the hedge ratio increases (by 25%) is not substantial and it is much lower than for foreign bonds. Therefore, a unitary hedge ratio (100%) seems to be appropriate for bonds but for equities (considering transaction costs) the choice is not clear.

Statman (2004) analyzes the case of currency hedging a representative mixed portfolio for an American investor who allocates 60% of the portfolio in stocks (equally divided between

[7] They worked with the following hedge ratios: 0%, 25%, 50%, 75% and 100%.

American and international stocks) and 40% in fixed income securities (equally divided between US Treasury bills and long term U.S. Treasury bonds). He found that the unhedged and hedged[8] portfolio returns and standard deviations (of returns) for the whole sample (1988-2003) were virtually the same (the differences were not statistically significant). However[9], in eight of the sixteen years, the average monthly hedged returns were higher than the unhedged ones (and lower in the rest) but the standard deviation of these average mean monthly returns of hedged global portfolios was higher in 7 of the 16 years while lower in the remaining.

[8] Several hedge ratios were used.

[9] This fact helps to explain the constant switching of some portfolio managers from hedged to unhedged portfolios and vice versa in pursuit of "sure winners".

3. DATA AND METHODOLOGY

3.1 Data

This analysis is focused on an average Dutch pension fund and insurer, which invests in six financial markets: the Netherlands, Japan, Sweden, Switzerland, the UK and the US. These markets comprise a large part of the portfolio investments of these Dutch investors. The sample covers monthly observations from January, 1999 (date of introduction of the euro) to June, 2004. Monthly observations of bond (Government bonds with maturity 3-5 years) and equity (country indices) MSCI total return indices are obtained from Datastream. The spot and 1-month forward exchange rates are also obtained from Datastream. The monthly risk free rate (in euro) is calculated from a German Government bill with original maturity of 6 months but remaining maturity of 3 months (GETB1 index) and is provided by Bloomberg.

3.2. Currency hedging bond or equity portfolios

Initially hedged and unhedged returns and standard deviations in euro are calculated for single investments in the different foreign markets (Japan, Sweden, Switzerland, United Kingdom and United States) following a passive hedging strategy using currency forwards with a maturity of 1 month. To calculate the unhedged and hedged logarithmic returns and variances in euro for the case of an investment in bonds, the following formulas are used[10]:

$$R_{€,U} = \ln (B_{t+1} S_{t+1} / B_t S_t) = \ln(B_{t+1}/B_t) + \ln(S_{t+1}/S_t) = B_{FC} + S_{€,FC} \quad (1)$$

And for hedged (h=100%) returns:

$$R_{€,H} = \ln (B_{t+1} Ft / B_t S_t) = \ln(B_{t+1}/B_t) + \ln (F_t/S_t) = B_{FC} + F_{€,FC} \quad (2)$$

B_t is the value (in foreign currency) of the bond at time t, S_t is the spot exchange rate (euro/foreign currency) and F_t is the forward exchange rate. It is clear from the previous equations that the unhedged returns have two components; the return of the bond in foreign currency (B_{FC}) plus the spot exchange rate return ($S_{€,FC}$) and the unhedged returns comprise the return of the bond in foreign currency and the one-month forward premium ($F_{€,FC}$).

[10] See Levich (2001). In these formulas, transaction costs and taxes are omitted.

The variances of the unhedged and fully hedged returns are calculated as follows:

$$s^2(R_{€,U}) = s^2(B_{FC}) + s^2(S_{€,FC}) + 2\,Cov(B_{FC}, S_{€,FC}) \quad (3)$$

$$s^2(R_{€,H}) = s^2(B_{FC}) + s^2(F_{€,FC}) + 2\,Cov(B_{FC}, F_{€,FC}) \quad (4)$$

Where $R_{€,U}$ is the return in euro on an unhedged basis and $R_{€,H}$ is the return on a fully hedged basis.

The variance of the returns reflects the variance of each term of the return equation and the covariance between the returns on the foreign bond and the returns on the spot exchange rate (or forward premium) for the unhedged (and hedged) case respectively. The same formulas apply for an equity investment.

To reach more general conclusions about the risk reduction effectiveness of hedging (than the ones obtained analyzing particular markets), the following strategies for equities and bonds are considered:

1. Domestic investments: investments in domestic (Dutch) government bonds or equities denominated in euro.
2. Equally weighted foreign currency investments: investments in bonds or equities following a naïve diversification strategy (the portfolio is uniformly allocated in the five foreign markets (20% each))
3. Multi foreign currency investments: investments in a multi foreign currency portfolio of bonds or equities. The composition of these two portfolios follows more closely the actual composition of a typical portfolio of Dutch pension funds and insurers. For more details see Appendix A.
4. Hedged equally weighted foreign currency investments: same as strategy 2 but with currency hedging (100% for all currencies) with respect to the euro.
5. Hedged multi foreign currency investments: same as strategy 3 but with currency hedging (100% for all currencies) with respect to the euro.

Through a relative simple test of the equality of variances (of the hedged and unhedged returns), I analyze if hedging effectively helps to reduce risk in this kind of investments.

The F-test statistic requires computing the variance of the hedged and unhedged investments.

Denoting the portfolio with the larger variance as L and the portfolio with the smaller variance as S, the F-statistic is equal to:

$$F = s^2_L / s^2_S \quad (5)$$

This F-statistic has a distribution with n_L-1 numerator degrees of freedom and n_S-1 denominator degrees of freedom under the null hypothesis of equal variance of the hedged and unhedged portfolios, where n represents the number of observations.

In addition, several hedge ratios are considered for the multi-foreign currency portfolios to get an idea of the optimal hedge ratio. This hedge ratio is the same for all the five foreign currencies involved[11]. Then, this assumption is relaxed.

Since equations (1) and (2) only consider the cases of a null or unitary hedge ratio, one can derive a more general formula to work with different hedge ratios.

Remember that the initial investment in euro is equal to $B_t S_t$ and the value in euro of the foreign bond after 1 period will have two portions; one hedged (the investor will receive the forward rate on this part of her investment) and one unhedged (the investor will receive the future spot rate). Using log returns:

$$R_{€,H} = \ln (hB_{t+1}F_t / B_tS_t) + \ln ((1-h)B_{t+1}S_{t+1} / B_tS_t) \quad (6)$$

$$R_{€,H} = h (\ln (B_{t+1} / B_t) + \ln (F_t / S_t)) + (1-h) (\ln (B_{t+1} / B_t) + \ln (S_{t+1} / S_t)) \quad (7)$$

For convenience, $s = B_{t+1} / B_t$, $f = F_t / S_t$ and $e = S_{t+1} / S_t$, so:

$$R_{€,H} = h \ln(s) + h \ln(f) + \ln(s) + \ln(e) - h \ln(s) - h \ln(e) \quad (8)$$

$$R_{€,H} = \ln(s) + (1-h) \ln(e) + h \ln(f) \quad (9)$$

[11] This can be though of as a naïve hedging strategy because it implies the same hedge ratio for all the currencies in the portfolio. It doesn't take into account covariance effects or market conditions that may suggest different hedge ratios for the different currencies.

It is clear that equation (9) produces equivalent results with respect to equations (1) and (2) when the hedge ratios are set to 0 and 1 correspondingly.

3.3. Currency hedging mixed portfolios

Initially two mixed portfolios are studied; portfolio 1 only considers foreign bonds and equities while portfolio 2 considers both domestic and foreign bonds and equities. Both mixed portfolios are composed of 60% in bonds and 40% in stocks. The latter portfolio weights are representative of the holdings of pension funds and insurers during the 1999 - 2004 period. The weights are as follows:

Table 2. Portfolio weights of mixed portfolios.

Portfolio weights	Portfolio 1	Portfolio 2
Bonds (60%)		
Netherlands	0.0%	53.4%
Japan	1.5%	0.6%
Sweden	2.6%	0.3%
Switzerland	0.1%	0.0%
United Kingdom	6.6%	0.6%
United States	49.2%	5.1%
Equities (40%)		
Netherlands	0.0%	18.0%
Japan	8.0%	4.4%
Sweden	1.6%	0.8%
Switzerland	1.2%	0.4%
United Kingdom	7.6%	4.4%
United States	21.6%	12.0%
	----------	----------
Total	100%	100%

3.3.1. Static hedging

Glen et. al (1993) showed that the return on a portfolio with forwards ($R_{h,\,t+1}$) can be written as the return of a portfolio without forwards (R_{t+1}) plus the normalized "payoff" on a long forward contract ($f_{i,\,t+1}$)[12]:

[12] This is a slightly different way to calculate the returns of a hedged portfolio. In section 3.2, hedged returns were calculated as the weighted average of the hedged returns of the individual (equity or bond) investments in the different markets. Moreover, in this (and next) subsection we work with excess returns (in excess of the risk free rate in euro) instead of simple returns.

$$R_{h,\,t+1} = R_{t+1} + ?\ (-h_{i,t} * x_{i,t}) * f_{i,\,t+1} \qquad (10)$$

Where $h_{i,t}$ is the hedge ratio with respect to currency i, $x_{i,t}$ is the fraction of wealth invested in asset i and $f_{i,\,t+1} = (S_{i,t+1}-F_{i,t})/(S_{i,t})$. The spot rate is equal to $S_{i,t}$ and the forward rate is equal to $F_{i,t.}$

In order to determine for a given menu of risky assets, the mean variance efficient frontier (portfolios that minimize risk for a certain level of expected return), the following parametric quadratic optimization problem could be solved for the vector of asset positions (x_1, x_2,…., x_N) and the vector of hedge ratios (h_1, h_2,…., h_N) simultaneously:

$$\text{Min Var } (R_{h,\,t+1};\ x_i,\ h_i)$$
$$\textit{Subject to}: R_{h,\,t+1} = E$$
$$? x_i = 1$$
$$0 \le x_i \le 1;\ 0 \le h_i \le 1 \qquad i = 1,2,...,N$$

In particular, since our purpose is to evaluate as realistically as possible, if adding forwards ("hedging") can have a beneficial effect in reducing the volatility of typical portfolios of Dutch pension funds and insurers, the portfolio weights (x_i) remained fixed in the quadratic optimization[13] (see table 2) and hedging was restricted to selling short no more than the exposure of the underlying market (bonds and equities). One can test if there is any improvement by statically and optimally adding forwards to an unhedged portfolio by comparing the volatility of the returns of a hedged and unhedged portfolio given a certain level of return. In our case, the appropriate level of return (E) is equal to $R_{t+1,}$ the return of a portfolio without forwards. The test (equality of variances) is performed in a similar fashion as in the previous section.

3.3.2. Selective hedging

So far, only static hedging strategies, in which the hedge ratios are kept constant across time, have been tested. Following Glen et. al (1993), I explore the possibility of reducing volatility by a selective (in-sample) strategy that allows the hedging coefficient to vary over time.

[13] Sometimes the optimization process can produce unrealistic bond and equity positions in the different markets.

This hedging strategy consist of setting the hedging coefficient equal to 1 each month, when $S_{i,t+1}-F_{i,t} < 0$ (forward premium) and equal to 0, when $S_{i,t+1}-F_{i,t} > 0$ (forward discount). Thus, the strategy sells a currency forward when it is at a premium and conversely, remains unhedged when it sells at a discount.

Then the monthly returns for this hedging rule are compared with the returns of an unhedged portfolio, to test if this type of selective hedging significantly reduces portfolio's return volatility. The tests are conducted using equation (5)[14].

[14] Initially I tried to obtain, via the optimization of the portfolio positions (as in 3.3.1), a level of hedged returns equal to that of the unhedged portfolio. However, the optimization produced trivial solutions or unrealistic positions. For this reason no optimization was performed to test the risk reduction effectiveness of this hedging rule.

4. RESULTS

4.1. Bond investments

The risk and returns for an average Dutch pension fund and insurer investing in a single foreign bond market are presented in the following table.

Table 3. Risk and return on international investments on bonds (1999-2004)

Bonds	Jap	Neth	Swe	Swi	UK	US
	Average annual returns (local currency)					
Local	1.53%	4.46%	4.60%	2.81%	4.65%	5.79%
	Average annual returns					
	Dutch investor (€)					
Unhedged	1.53%	4.46%	3.95%	3.86%	5.27%	4.58%
Fully Hedged	3.35%	4.46%	3.86%	4.82%	3.10%	5.62%
	(**)		(**)	(**)	(**)	(**)
	Standard deviation of returns					
Local	1.59%	2.71%	2.99%	2.45%	2.70%	4.07%
	Dutch investor (€)					
Unhedged	11.32%	2.71%	5.07%	4.28%	6.95%	8.93%
Fully Hedged	2.44%	2.71%	3.26%	2.62%	2.77%	4.12%
	(*)		(*)	(*)	(*)	(*)

(*) Denotes that the difference between the two (above) series is statistically significant at a 5% level.
(**) Denotes that the difference between the two (above) series is NOT statistically significant at a 5% level.

The table shows that the average annual returns (in euro)[15] for the unhedged investments in some countries (Sweden and the UK) are higher than the hedged returns (implying that the forward rate tends to be below the future spot rate). In Japan, Switzerland and the US, the opposite occurs; the returns on hedged bonds are higher than those of unhedged bonds (implying that the forward rate tends to be above the future spot rate). However, the differences between hedged and unhedged returns are not statistically significant, implying efficiency in the forward market (euro/foreign currency).

Moreover, a pronounced difference between the risk in the different local markets (expressed in the respective foreign currency) and the risk for the unhedged case for a Dutch investor is evident in the time period. For instance, while the average standard deviation of an investment

[15] The annualized returns are calculated using continuous compounding and the yearly standard deviations correspond to 3.46 times the monthly standard deviations.

in Japanese bonds is 1.59% (in yen), this standard deviation (measured in euro on an unhedged basis) is equal to 11.32%, more than 7 times the risk as measured in the local market (Japan). This difference is also considerable for bond investments in the United States and United Kingdom, where the standard deviation in euro (unhedged) is more than double the standard deviation in the local currency (US dollar and British Pound respectively).

As expected, the hedged returns are less volatile than the un-hedged returns. This risk reduction is statistically significant at the 5% significance level for all the markets considered. The case for hedging is very evident for investments in Japan, United States and United Kingdom, where a Dutch investor can reduce by more than half the risk of its foreign bond investment by fully hedging the currency risk.

In order to make more general statements for a Dutch investor, I analyze 5 strategies explained in Section 3 of this paper. For bond investments, the results are as follows:

Table 4. Average risk and return for different bond strategies for a Dutch investor (1999-2004)

	Return		Risk
Domestic bonds	4.46%		2.71%
Equally weighted foreign currency	3.83%		4.86%
Multi foreign currency	4.55%		8.03%
Hedged equally weighted foreign currency	4.15%		2.35%
Hedged multi foreign currency	5.21%		3.73%

It can be seen that foreign currency bonds (lines 2 and 3) carry a much higher risk than Dutch bonds. It seems that a naïve diversification strategy would have achieved lower volatility during the period than the actual composition of the foreign portfolio. This can be explained by the fact that Dutch pension funds and insurers invest a high percentage of their bond portfolio in two of the most volatile bond markets in the sample: the US and UK bond markets.

When comparing the hedged and un-hedged standard deviations for the equally weighted and multi foreign currency portfolios it can be observed that hedging has a positive impact (statistically significant at the 5% level) in reducing the volatility of these portfolios. For instance, the volatility of the hedged multi foreign currency portfolio (3.73%) is less than half

the volatility of the un-hedged case (8.03%). It is worth noting that a currency diversified and hedged bond portfolio generates a level of risk similar to that of a portfolio containing only Dutch bonds.

4.2 Equity investments

The table shows the risk and returns for an average Dutch pension fund and insurer investing in a single foreign equity market.

Table 5. Risk and return on international investments on equities (1999-2004)

Equities	Jap	Neth	Swe	Swi	UK	US
	Average annual returns (local currency)					
Local	0.96%	-3.27%	4.20%	-1.97%	-1.69%	-1.15%
	Average annual returns					
	Dutch investor (€)					
Unhedged	0.97%	-3.27%	3.55%	-0.96%	-1.11%	-2.29%
Fully Hedged	2.77%	-3.27%	3.47%	-0.05%	-3.15%	-1.31%
	(**)		(**)	(**)	(**)	(**)
	Standard deviation of returns					
Local	16.68%	21.84%	30.37%	15.70%	15.11%	16.60%
	Dutch investor (€)					
Unhedged	22.25%	21.84%	32.47%	14.46%	16.00%	20.05%
Fully Hedged	16.60%	21.84%	30.22%	15.52%	15.07%	16.59%
	(**)		(**)	(**)	(**)	(**)

(*) Denotes that the difference between the two (above) series is statistically significant at a 5% level.
(**) Denotes that the difference between the two (above) series is NOT statistically significant at a 5% level.

Due to the bad situation of the stock market worldwide during the analyzed period the annualized local returns are very low and in several cases negatives (stock markets of the Netherlands, Switzerland, United Kingdom and the US).

The difference between the local and unhedged returns of foreign investments for the Dutch investor gives an idea of the appreciation or depreciation of the euro in the time period analyzed. Thus, the euro depreciated versus the Japanese Yen, Swiss Franc and British Pound since the unhedged returns (in euro) are higher than the domestic returns (in the respective foreign currency) and appreciated versus the Swedish Krona and the US dollar, since the unhedged returns (in euro) are lower than the domestic returns.

There are differences between the un-hedged and fully hedged returns for the Dutch investor, but these differences are not statistically significant.

Analyzing the difference between the risk in the different local markets (expressed in the respective foreign currency) and the risk for the unhedged case for a Dutch investor, it can be seen that this is much smaller than for the case of bonds and for Swiss equities, the standard deviation measured in euro (unhedged) is lower than the standard deviation measured in Swiss Francs. This coincides with Haefliger et. al (2002) findings that couldn't uncover a clear pattern of distinction (from the perspective of several investors) between the risk of domestic and foreign equity investments. In fact, they found that for German and Japanese investors, certain foreign markets had a lower volatility than their respective domestic markets.

As expected, the currency hedged returns are less volatile than the un-hedged returns (except for the case of Swiss equities) for the 1999-2004 period. For instance, by hedging a British pound denominated investment, an average pension fund and insurer would have achieved a risk reduction of only 0.93% per annum. However, the risk reduction attained by hedging a foreign currency equity investment is far lower than for the case of foreign currency bonds and more importantly, this risk reduction is not statistically significant.

In order to make more general statements for the Dutch investor, I evaluate several strategies for the case of an equity portfolio. The results are as follows:

Table 6. Average risk and return for different equity strategies for a Dutch investor (1999-2004)

	Return		Risk
Domestic equities	-3.274%		21.842%
Equally weighted foreign currency	0.012%		17.62%
Multiforeign currency	-1.151%		17.86%
Hedged equally weighted foreign currency	0.316%		15.71%
Hedged multi foreign currency	-0.638%		14.64%

Initially, one can see that domestic equities, on average, carry a higher risk than (equally weighted) foreign currency investments and that the difference in terms of risk, between the equally weighted and multiforeign currency portfolios is very small.
When comparing the hedged and un-hedged standard deviations for the equally weighted and multi foreign currency portfolios one can notice that hedging has a positive impact reducing the volatility of these portfolios. For instance, the volatility of the hedged multi foreign currency portfolio (14.64%) is less than the volatility of the un-hedged case (17.86%). However, the decrease in risk through hedging is far lower than for the case of a diversified bond portfolio. Furthermore, the risk reduction achieved through hedging both an equally weighted and a multi-foreign currency portfolio is not statistically significant.[16]

4.3. Using alternative hedge ratios

In the previous sections, a hedge ratio of 100% was the only one considered for all the foreign currencies. This might not be the ideal hedge ratio since this is very much dependent on covariance effects between securities and exchange rate returns that can be time-varying.

From the viewpoint of a risk averse investor the hedged portfolios seemed to be a better choice since both for a multiforeign currency bond or equity portfolio the hedged returns had a lower volatility than the unhedged ones.[17]

In the next table, the average return and risk for a diversified bond and equity portfolios using different hedge ratios: 0, 25, 50, 75 and 100% is presented:

[16] Though the differences seem to be of a significant magnitude, these differences are not statistically significant. Also remember that these are annualized standard deviations and the test is conducted on monthly data.
[17] However, the volatility of a hedged portfolio was statistically indistinguishable from the volatility of a hedged one.

Table 7. Average risk and return estimates for different hedge ratios (1999-2004)

Hedge ratio (%)	Multi foreign currency bonds		
	Return	Risk	% of risk reduction
0	4.55%	8.03%	
25	4.71%	6.10%	-24.1% (*)
50	4.88%	4.43%	-27.4% (*)
75	5.04%	3.44%	-22.3% (*)
100	5.20%	3.73%	8.3% (**)

Hedge ratio (%)	Multi foreign currency equities		
	Return	Risk	% of risk reduction
0	-1.15%	17.86%	
25	-1.03%	16.78%	-6.0% (**)
50	-0.90%	15.85%	-5.5% (**)
75	-0.77%	15.13%	-4.6% (**)
100	-0.64%	14.64%	-3.2% (**)

(*) Denotes that the % of risk reduction is statistically significant at a 5% level.
(**) Denotes that the % of risk reduction is NOT statistically significant at a 5% level.

In the upper part of Table 7, one can see that as the hedge ratio increases by 25%, the percentage of risk reduction is roughly the same, pointing to the benefits (statistically significant) of hedging as much as possible the currency exposure of this bond portfolio. Only when the hedge ratio increases from 75 to 100%, one can observe a risk increase instead of a risk decrease but this increase is not statistically significant[18]. In consequence, this implies that the minimum variance hedge ratio must be in the 75-100% range.[19]

For an equity portfolio, the risk reduction as the hedge ratio increases by 25% is far lower (approx. 3-6% reductions) than for the case of bonds. Moreover, this risk reduction is not statistically significant. Even analyzing increases in the hedge ratio to 50% (for example, from an unhedged equity investment to a 50% hedged), no statistically significant risk reduction is obtained using this strategy. In addition, I cannot reject the null hypothesis of equality of variances of the 5 series, providing evidence that hedging with currency forwards seemed to be a less efficient way (transaction costs must also be taken into account) to reduce risk of this typical and diversified equity portfolio of Dutch pension funds and insurers.

[18] In other words, the risk of a 75% hedged bond portfolio is about the same that of a 100% hedged portfolio.
[19] Indeed the minimum variance hedge ratio in this case is 80%. See appendix B for more details.

Allowing for a hedge ratio larger than 100%, I find that the optimal (minimum variance) hedge ratio for the multi-foreign currency equity portfolio is equal to 135%.[20] This high hedge ratio means that on average, a Dutch investor would enter in a forward transaction to sell 135% of its equity position denominated in a basket of foreign currencies. In other words, each period, the Dutch investor would have to sell forward a larger amount of currencies than presently owned.

For instance, assume the pension fund has a 100 million dollar equity exposure in the US and it wants to liquidate it in the next month. This would mean that the pension fund would enter a forward agreement to sell 135 million dollars (and receive euro) in one month. Since it only has 100 million, the pension would have to buy on the day the forward expires an amount equal to 35 million dollars in the spot market to honor its commitment. So indeed, the pension fund would be speculating that it can get in the future 35 million dollars at a lower rate (euro/dollar) than the one it receives (by selling dollars) in the forward contract.

On a more formal note, this would mean that each time, the investor would be speculating that:

$$F_t > S_{t+1} \tag{11}$$

Where F_t is the forward exchange rate (euro/foreign currency) and S_{t+1} is the future spot rate. This would be a violation of unbiased forward rate hypothesis that asserts that the forward (exchange rate) is a good estimate of the future spot rate (so one cannot expect a systematic undervaluation of the future spot rate, $S_{t+1} < F_t$).

Since this kind of speculation (using hedge ratios larger than 1) for pension funds and insurers can be considered atypical and risky, hedge ratios larger than 1 are no longer considered in this paper.

Surprisingly, the decrease in volatility using this minimum variance hedge ratio is not statistically strong to support this optimal hedging since there is no material difference in volatility between this portfolio and an unhedged one.

[20] See Appendix B for more details.

An explanation for the previous results that show, by and large, that by hedging a bond portfolio one can get a significant risk reduction while for an equity portfolio no significant risk reduction can be attained, is found in the next two tables.

Table 8. Decomposition of variance of bond's unhedged returns

Bonds	$s^2 (B_{FC})$	$s^2 (S_{€,FC})$	2 Cov $(B_{FC}, S_{€,FC})$	$= s^2 (R_{€,U})$
Japan	1.95%	103.33%	-5.27%	100.00%
Sweden	34.61%	79.20%	-13.81%	100.00%
Swi	35.04%	54.38%	10.58%	100.00%
UK	15.04%	105.27%	-20.31%	100.00%
US	20.60%	118.35%	-38.94%	100.00%

Table 9. Decomposition of variance of equities' unhedged returns

Equities	$s^2 (B_{FC})$	$s^2 (S_{€,FC})$	2 Cov $(B_{FC}, S_{€,FC})$	$= s^2 (R_{€,U})$
Japan	55.05%	26.57%	18.38%	100.00%
Sweden	86.83%	1.93%	11.24%	100.00%
Swi	115.22%	4.35%	-19.58%	100.00%
UK	89.03%	19.90%	-8.93%	100.00%
US	68.64%	23.66%	7.70%	100.00%

The tables show (using equation 3), the fraction (%) of the un-hedged returns variances measured in euro ($s^2 (R_{€,U})$) of the different foreign bonds and equities that can be attributed to local market asset risk ($s^2 (B_{FC})$), to exchange rate risk ($s^2 (S_{€,FC})$) and to covariance effects between local returns and currency returns (Cov $(B_{FC}, S_{€,FC})$).

A large share of the risk in holding foreign bonds is due to exchange rate risk (third column of table 8, with an average of 92.1%), while risk in the local bond market (second column, with an average of 21.5%) plays a lesser role. In general, covariance effects tend to reduce volatility. However, for equities the opposite occurs, a large portion of the risk investing in foreign equities markets (see table 9) is due to fluctuations in the local stock exchanges (83% on average) while currency risk plays a relative minor role (15.28% on average). On average, covariance effects between equities markets tend to reinforce volatility (positive signs in 3 out of the 5 markets).

Thus, since exchange rate risk manifests more for bonds[21], hedging may be more convenient for these assets while for equities, hedging price (market) risk (for instance, using futures on stock indices) in the foreign markets may be a more efficient strategy than hedging currency risk.

4.4. Mixed portfolios

4.4.1. Static hedging

Table 10 in Appendix C shows the results for the case of static hedging, keeping the portfolio weights (bonds and equities) fixed and optimizing the forward positions to attain the lowest volatility given a rate of return equal to that of the unhedged portfolio. Furthermore, with the restriction of selling short no more than the exposure in the underlying market.

For portfolio 1, the optimization suggests to go short in the currencies of 3 out of the 5 countries: Sweden (with a position equal to 2.31% of the total investment), United Kingdom (14.20%) and the US (14.03%) and to leave the currency exposure unhedged in Japan and Switzerland.

Or equivalently, the optimization suggests using the following hedge ratios: Sweden (h=55%, this corresponds to the fraction invested in the forwards over the amount of the investment in bonds and equities in that country), United Kingdom (h=100%), US (h=20%) and a zero hedge ratio for Japan and Switzerland.

The risk reduction by hedging is very small. In this case, one can obtain a risk reduction of just 0.075% per month.

[21] The fact that foreign bonds tend to be more exposed to currency fluctuations than equities is also noted by Levich et al (1993) 'Bonds are nominal assets, and so they are naturally denominated in some currency. Because foreign bonds represent claims to fixed amounts of foreign currency, and the dollar value of those claims fluctuates with the exchange rate, it is not surprising to find that foreign bond investments are currency exposed. In contrast, equity investments represent claims to real assets, which are not naturally denominated in any currency. Nevertheless, in practice foreign equity investments have behaved as though they are currency exposed'.

For portfolio 2, the optimization suggests to go short in the currencies of 3 out of 5 countries: Japan (with a position equal to 2.10% of the total investment), United Kingdom (5%) and the US (2.70%) and to leave the currency exposure unhedged in Sweden and Switzerland.

Or equally, the optimization suggests using the following hedge ratios: Japan (h=55%), United Kingdom (h=100%), US (h=16%) and a zero hedge ratio for Sweden and Switzerland.

Again, the risk reduction by hedging is very small. In this case, one can obtain a risk reduction of just 0.03% per month.

The bottom of the table reports the test of equality of variance between hedged and unhedged portfolios. These tests just reconfirm the aforementioned; the improvement in performance is not economically (see Sharpe ratios) or statistically significant. Though not shown, these test results coincide with the tests when one uses a uniform hedge ratio for all the currencies involved (without optimization, as in section 4.3), the risk reduction by increasing the hedge ratio (say by 25%) is not statistically significant for these 2 mixed portfolios.

4.4.2. Selective hedging

In this section, a test is performed to see if allowing a time varying hedge ratio (equal to 1 when there is a forward premium and 0 when there is a forward discount) reduces portfolio's variability.

Table 11 in Appendix D shows the results for the case of this selective (active) hedging, keeping the portfolio weights (stocks, bonds and forwards) fixed and restricting selling short no more than the exposure in the underlying market.

For portfolio 1, the hedging rule produces a slightly higher standard deviation of the portfolio with forwards than for the unhedged one. However this difference (0.09% per month) is not economically nor statically (see bottom of the table) significant.

The trading rule suggests the following average (over the sample period) hedge ratios: Japan (58%), Sweden (50%), Switzerland (53%), United Kingdom (52%) and the US (45%). The interpretation of these average hedge ratios is straightforward; when the average hedge ratio is

above 50%[22], the hedging rule suggest to enter a forward contract more than half of the times (months) and to remain unhedged the remaining. Thus, this applies for the majority of currencies except for the US dollar, where the hedge ratio suggests leaving this exposure unhedged more than half of the months in the sample.

For portfolio 2, the hedging rule produces a slightly higher standard deviation of the portfolio with forwards than for the unhedged one. Again, this difference (0.013% per month) is not economically nor statically (see bottom of the table) significant. The average hedge ratios are the same as for portfolio 1.

However, taking a closer look at the average returns of both investments, one sees a significant improvement when this hedging rule is applied. This is ultimately reflected in higher Sharpe ratios. For example, the Sharpe ratio of portfolio 1 increases by a factor of 9.5 while for portfolio 2, the increase is of a lower magnitude (4.7) but still considerable.

Expanding our analysis to consider a different asset mix for portfolio 2, the most representative of Dutch pension funds and insurers (for instance, considering one portfolio equally invested in bonds and equities and one with a 60% investment in equities and 40% in bonds), the results don't change. Mainly, no significant risk reduction (or variation) is observed when adding forwards to this diversified portfolio; but selective hedging enhances returns at a similar level of risk with a consequent improvement in the Sharpe ratio.

In short, these results suggest that by using selective hedging based on the forward premium, one could have achieved, over the sample period, superior portfolio returns with a level of risk indistinguishable from that of an unhedged portfolio.

[22] Remember that the monthly hedge ratio can only take the value of 0 or 1.

5. CONCLUSION

This paper analyzes the risk reduction effectiveness of currency hedging international portfolios for an average Dutch pension fund and insurer during the period 1999-2004. Several representative portfolios and approaches to hedging are considered. Initially, a portfolio containing only foreign bonds or foreign equities is constructed to test if statically and fully hedging the currency risk of these 2 portfolios is efficient. In addition, several hedge ratios are used (though they are the same for all the different foreign currencies) to get a sense of the optimal hedge ratio of these representative and country diversified portfolios.

Then, the case of mixed portfolios and hedging is analyzed. This analysis is more realistic since a great majority of pension funds and insurers hold both (foreign and euro-denominated) bonds and equities in their portfolios. Two mixed portfolios are analyzed; one that contains exclusively foreign bonds and equities and one that includes both foreign and domestic assets. The asset and country allocation is representative of the holdings of pension funds and insurers during the sample period.

Furthermore, two hedging approaches are tested. The first tries to analyze if optimally adding forwards (imposing some short selling restrictions) to an unhedged portfolio can bring significant risk reductions in these typical portfolios. The hedge ratios are not necessarily the same for the different currencies, however, they remain constant across time (static hedging).

The second approach introduces time variation in the hedge ratios through the information contained in the forward premium. In this case, the currency exposure is hedged only when the foreign currency forward premium is at a premium (selective hedging).

Over the sample period, the tests suggest that by fully hedging a bond portfolio (multi-foreign currency bond portfolio), Dutch pension funds and insurers can obtain a significant risk reduction and a level of risk similar to that of Dutch bonds. However, the risk reduction for an equity portfolio is far lower and it is not statistically significant. Looking at the hedge ratios of these portfolios, the data suggest a (minimum variance) hedge ratio of roughly 80% for a diversified bond portfolio and a hedge ratio above 1 for an equity portfolio. Nonetheless only significant risk reductions are achieved when increasing the hedge ratio (say by 25%) for a bond portfolio. For an equity portfolio the situation is radically dissimilar, no significant risk

reduction is achieved when "normal" hedge ratios are used (between 0 and 1). These results coincide with Haefliger's et al (2002) who claimed that currency hedging should be fully applied to foreign bonds, while foreign equities should be left unhedged or partially hedged.

One can find an explanation for these results decomposing the variance of foreign bond and equities unhedged returns (in euro). The decomposition shows that a large part of the volatility of bond returns is due to currency fluctuations while a large part of the volatility of equities returns is due to price variations (in local currency). This provides some support for hedging currency risk in foreign bond investments and hedging market (price) risk for foreign equity investments.

Moreover, a static hedging strategy and portfolio optimization under short sale constraints for the 2 mixed portfolios didn't produce a significant risk reduction. The results for the selective hedging approach showed similar results when comparing the volatility of an unhedged and hedged portfolio. However, the selective hedging strategy considerably improved the hedged portfolio returns at a level of risk similar to that of the unhedged portfolios.

These results coincide with Statman's (2004) who found that the realized returns and risk of (statically) hedged and unhedged portfolios were virtually identical during 1988-2003 for an American investor. In broad terms, the literature seems to suggest that only when selective hedging is applied (see Glen et al. (1993), De Roon (1997 and 2001) and Morey et al (2001)) portfolio performance can be enhanced; the Sharpe ratio substantially increases. However, few studies incorporate real life constraints such as taxes and transaction costs to see if hedging can boost portfolio performance even after taking into account these costs.

Certain reservations should be made about the methodology and results of this paper. Some results can be period specific (e.g. the minimum variance hedge ratio, since correlations between assets and exchange rates can change over time and also the forward positions in the optimization exercise). In addition, the results in section 4, in most of the cases are average results that might sometimes hide the fact that some years (see Statman (2004) in the literature review) currency hedging may be a superior strategy than partially or not hedging at all[23].

[23] Nonetheless one can argue that pension funds and insurers have a long-term investment horizon, in which currency hedging has been shown to be not very efficient at reducing volatility.

Furthermore, the results referred to static and selective hedging of the mixed portfolios are in-sample or ex-post results, the optimal portfolio weights are only revealed after the fact. Therefore a remaining question is whether these results hold when the investment choices are based only on prior information (out-of-sample approach). However, it is unlikely that these significantly affect the practical consequences of this analysis.

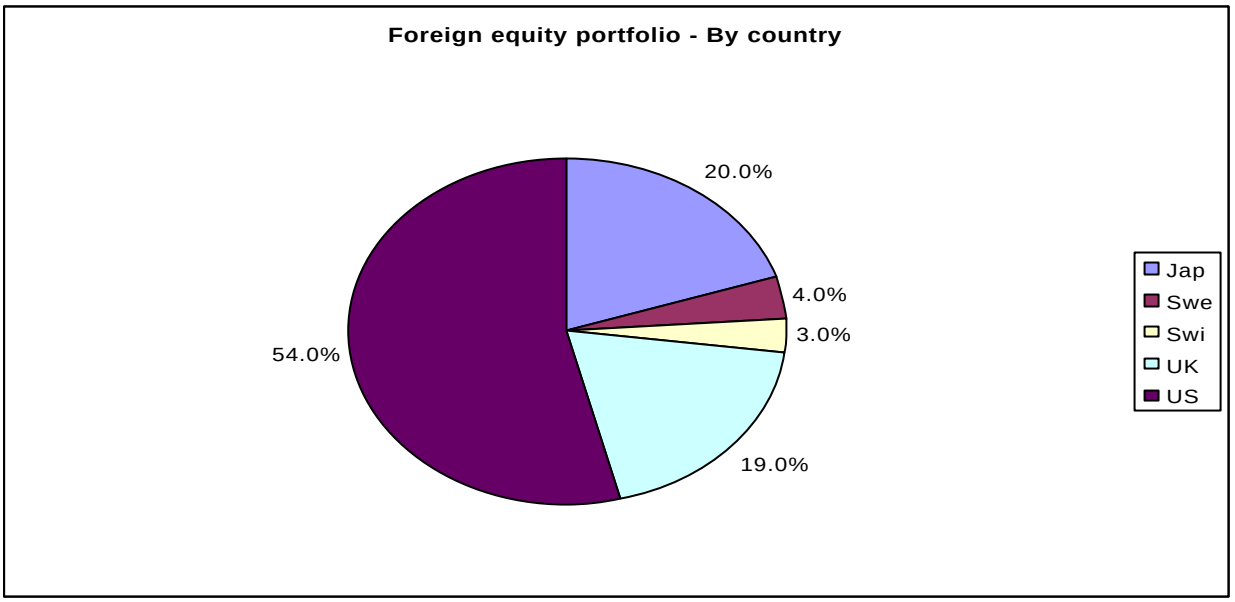
Finally, in terms of further research, it would be of interest to extend this study to consider additional (both in-sample and out-of-sample) selective hedging strategies, for instance, to hedge only when the forward premium is "large" (e.g. above a moving average) or when the foreign currency spot rate is above its Purchasing Power Parity value (since this would suggest a falling spot rate) to gain a deeper understanding of the risk reduction benefits (if any) of selective hedging. Additionally, one can use univariate or multivariate generalized autoregressive conditionally heteroscedastic (GARCH) models to derive hedge ratios as in Brooks et al. (2002).

Some survey work may also be of interest to discover what pension funds and insurers are actually doing, if anything about currency hedging[24]. This issue will continue to be an important one, as many of the countries in the sample experience volatile exchange rate movements.

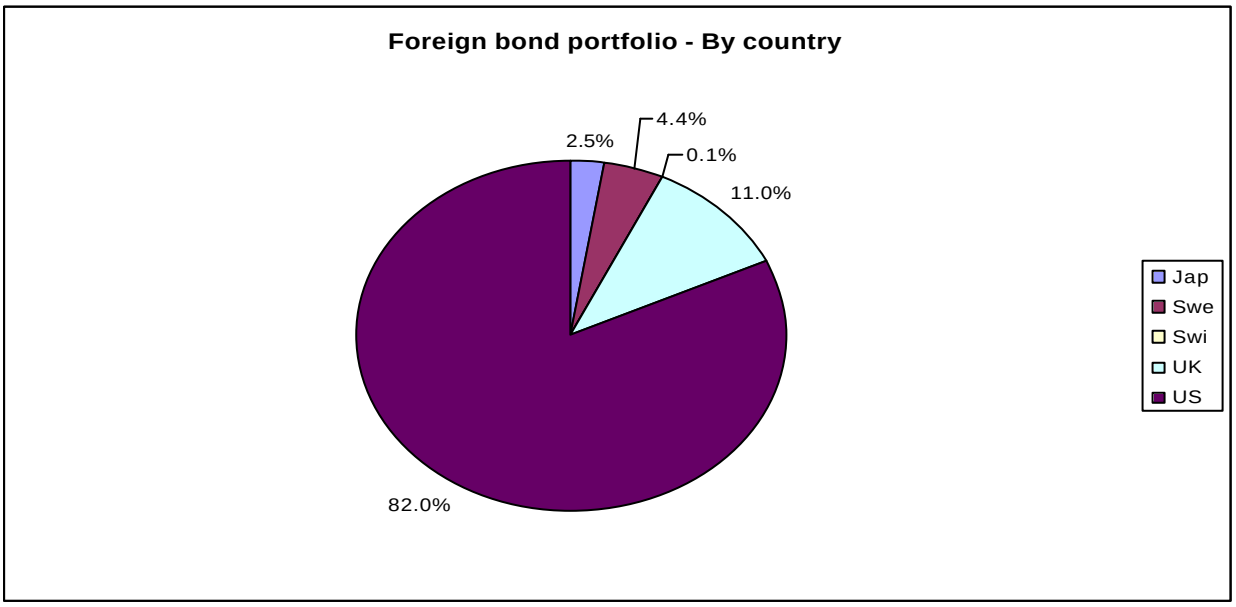
[24] For a survey of the use of derivatives by non-financial listed firms see Bodnar, Gordon M. et al (2001).

APPENDIX A

-Composition by country of the multi foreign currency equity portfolio



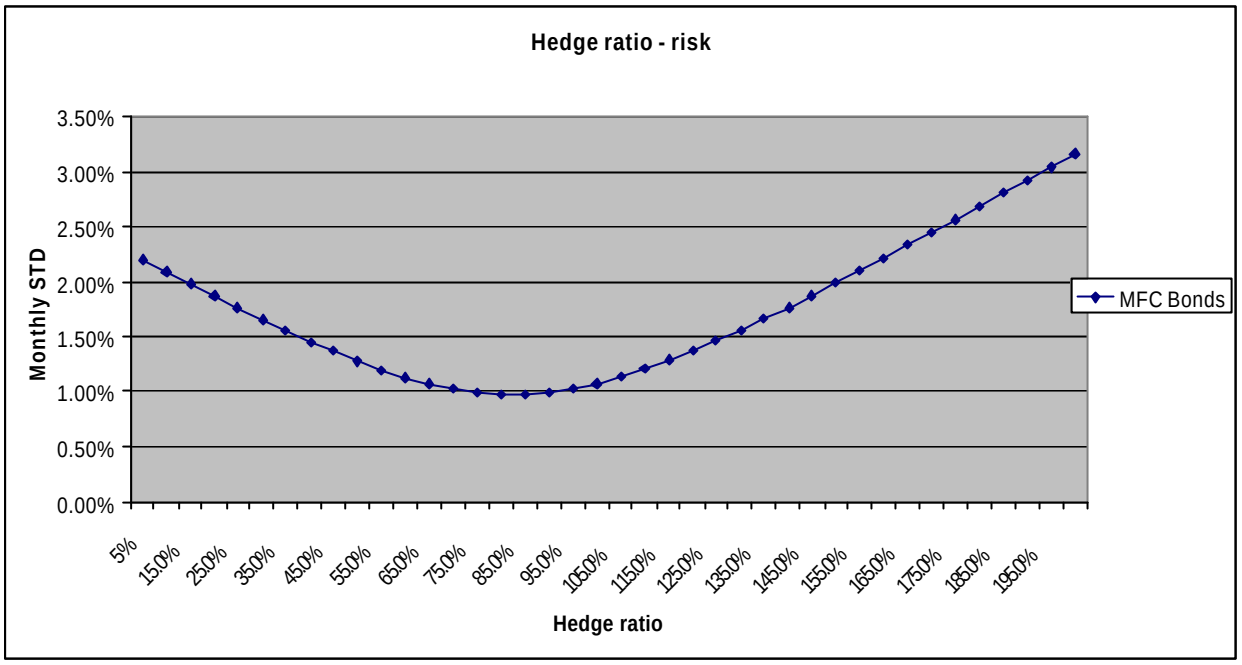
-Composition by country of the multi foreign currency bond portfolio



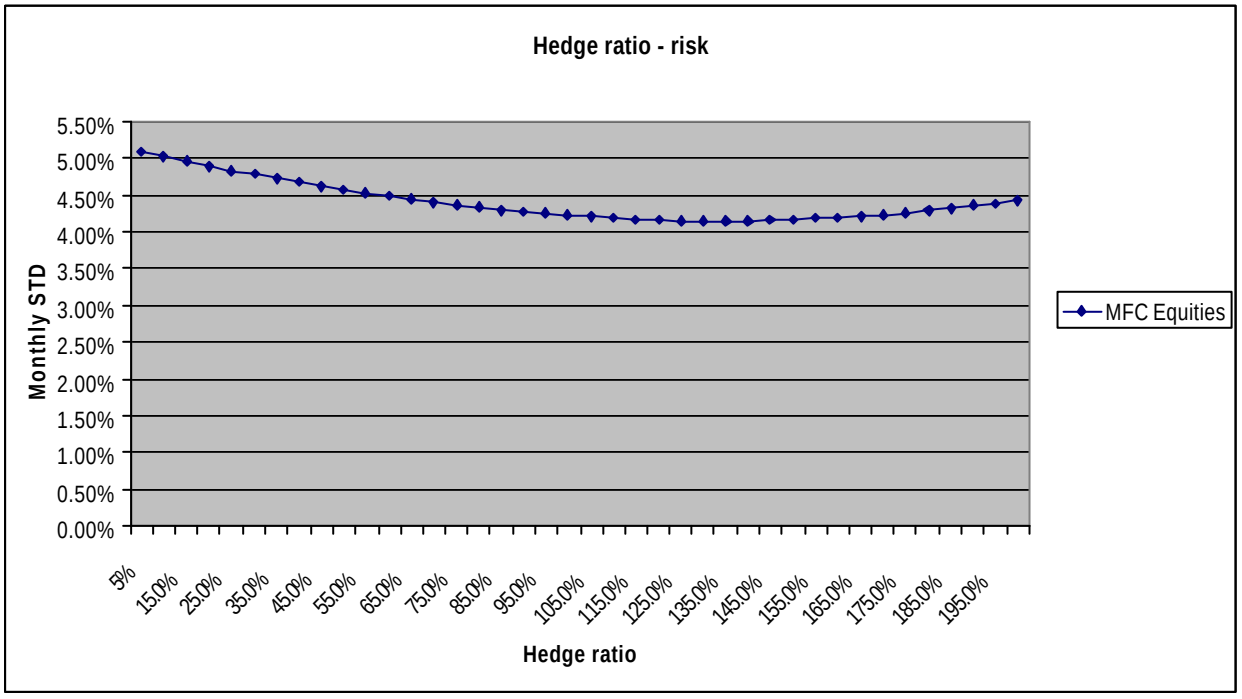
Source: De Nederlandsche Bank

APPENDIX B

-Optimal hedge ratio for a multi-foreign currency bond portfolio



-Optimal hedge ratio for a multi-foreign currency equity portfolio



APPENDIX C

Table 10. Static hedging. Optimal mixed portfolios with short selling restrictions.

	Portfolio 1	Portfolio 1 and forwards	Portfolio 2	Portfolio 2 and forwards
Mean (pm)	0.123%	0.123%	0.085%	0.085%
Standard deviation (pm)	2.865%	2.790%	2.000%	1.970%
Sharpe ratio	0.043	0.044	0.042	0.043
Observations	65	65	65	65
Positions				
Bonds				
Japan	1.50%	1.50%	0.60%	0.60%
Netherlands	0.00%	0.00%	53.40%	53.40%
Sweden	2.60%	2.60%	0.30%	0.30%
Switzerland	0.10%	0.10%	0.00%	0.00%
United Kingdom	6.60%	6.60%	0.60%	0.60%
United States	49.20%	49.20%	5.10%	5.10%
Equities				
Japan	8.00%	8.00%	4.40%	4.40%
Netherlands	0.00%	0.00%	18.00%	18.00%
Sweden	1.60%	1.60%	0.80%	0.80%
Switzerland	1.20%	1.20%	0.40%	0.40%
United Kingdom	7.60%	7.60%	4.40%	4.40%
United States	21.60%	21.60%	12.00%	12.00%
Total	100.0%	100.0%	100.0%	100.0%
Forwards				
Japan		0.00%		-2.10%
Sweden		-2.31%		0.00%
Switzerland		0.00%		0.00%
United Kingdom		-14.20%		-5.00%
United States		-14.03%		-2.70%
Hedge ratios				
Japan		0.00		0.42
Sweden		0.55		0.00
Switzerland		0.00		0.00
United Kingdom		1.00		1.00
United States		0.20		0.16
Test of equality of variance				
Optimal with forward				
vs. Unhedged				
F-statistic (64,64 DF)		1.054		1.030
p-value		0.417		0.453

(*) Significant at the 5% level

APPENDIX D

Table 11. Selective hedging. Mixed portfolios with short selling restrictions.

	Portfolio 1	Portfolio 1 and forwards	Portfolio 2	Portfolio 2 and forwards
Mean (pm)	0.123%	1.210%	0.085%	0.396%
Standard deviation (pm)	2.865%	2.955%	2.000%	2.013%
Sharpe ratio	0.043	0.410	0.042	0.197
Observations	65	65	65	65
Positions				
Bonds				
Japan	1.50%	1.50%	0.60%	0.60%
Netherlands	0.00%	0.00%	53.40%	53.40%
Sweden	2.60%	2.60%	0.30%	0.30%
Switzerland	0.10%	0.10%	0.00%	0.00%
United Kingdom	6.60%	6.60%	0.60%	0.60%
United States	49.20%	49.20%	5.10%	5.10%
Equities				
Japan	8.00%	8.00%	4.40%	4.40%
Netherlands	0.00%	0.00%	18.00%	18.00%
Sweden	1.60%	1.60%	0.80%	0.80%
Switzerland	1.20%	1.20%	0.40%	0.40%
United Kingdom	7.60%	7.60%	4.40%	4.40%
United States	21.60%	21.60%	12.00%	12.00%
Total	100.0%	100.0%	100.0%	100.0%
Forwards				
Japan		-9.50%		-5.00%
Sweden		-4.20%		-1.10%
Switzerland		-1.30%		-0.40%
United Kingdom		-14.20%		-5.00%
United States		-70.80%		-17.10%
Average Hedge ratios				
Japan		0.58		0.58
Sweden		0.50		0.50
Switzerland		0.53		0.53
United Kingdom		0.52		0.52
United States		0.45		0.45
Test of equality of variance				
Portfolio with forwards				
vs. Unhedged				
F-statistic (64,64 DF)		1.064		1.013
p-value		0.402		0.479

(*) Significant at the 5% level

REFERENCES

Abken, Peter A. and Milind M. Shrikhande (1997), "The role of currency derivatives in internationally diversified portfolios", Economic Review, Federal Reserve Bank of Atlanta, 34-59.

Bodnar, Gordon M., Abe de Jong and Victor Macrae (2001), "The impact of institutional differences in derivatives usage: a comparative study of US and Dutch firms", ERIM Report Series Research in Management, Erasmus Research Institute in Management.

Brooks, Chris, Olan T. Henry and Gita Persand (2002), "The effect of asymmetries on optimal hedge ratios", Journal of Business, Vol. 75, No. 2, 333-352.

Bugar, Gyongyi and Raimond Maurer (2001), "International equity portfolios and currency hedging: the viewpoint of German and Hungarian investors", Johann Wolfgang Goethe-Universitat Frankfurt am Main. Working paper 67, 1-26.

Conover, W. J., M. E. Johnson and M. M. Johnson (1981), "A Comparative Study of Tests for Homogeneity of Variance with Applications to the Outer Continental Shelf Bidding Data", Technometrics 23, 351–361.

De Roon, Frans A. (1997), "Essays on testing for spanning and on modelling futures risk premia", Center for Economic Research, Tilburg University.

De Roon, Frans A., Theo E. Nijman and Bas J.M. Werker (2001), "Currency hedging for international stock portfolios: the usefulness of Mean Variance Analysis", Center for Economic Research, Tilburg University, 1-34.

Eun, Cheol S. and Bruce G. Resnick (1988), "Exchange rate uncertainty, forward contracts, and international portfolio selection", The Journal of Finance, Vol. 43, 197-215.

Glen, Jack and Philippe Jorion (1993), "Currency hedging for international portfolios", The Journal of Finance, Vol. 48, No.5, 1865-1886.

Haefliger, Thomas, Urs Walchli and Daniel Wydler (2002), “Hedging currency risk: does it have to be so complicated”, 1-36.

Levich, Richard M. and Lee R. Thomas (1993), “Internationally diversified bond portfolios: the merits of active currency risk management”, NBER Working Paper No. 4340, 1-35.

Levich, Richard M (2001), International Financial Markets, Prices and Policies, Second Edition.

Morey, Matthew R. and Marc W. Simpson (2001), “To hedge or not to hedge: the performance of simple strategies for hedging foreign exchange risk”, Journal of Multinational Financial Management 11, 213-223.

Pension Verzekeringskamer (2004), “Financial assessment framework-Consultation document”, Apeldoorn, October.

Sener, Tulin (2004), “Hedging for global equity investing”, The Journal of American Academy of Business, Cambridge, 159-166

Statman, Meir (2004), “Hedging currencies with hindsight and regret”, unpublished manuscript, Santa Clara University, 1-11

Previous DNB Working Papers in 2005

No. 27 **Jan Marc Berk and Beata K. Bierut**, On the optimality of decisions made by hup-and-spokes monetary policy committees
No. 28 **Ard H.J. den Reijer**, Forecasting dutch GDP using large scale factor models
No. 29 **Olivier Pierrard**, Capital Market Frictions, Business Cycle and Monetary Transmission
No. 30 **Jan Willem van den End and Mostafa Tabbae**, Measuring financial stability; applying the MfRisk model to the Netherlands
No. 31 **Carin van der Cruijsen and Maria Demertzis**, The Impact of Central Bank Transparency on Inflation Expectations
No. 32 **Allard Bruinshoofd, Bertrand Candelon and Katharina Raabe**, Banking Sector Strength and the Transmission of Currency Crises
No. 33 **David-Jan Jansen and Jakob de Haan**, Were verbal efforts to support the euro effective? A high-frequency analysis of ECB statements
No. 34 **Riemer P. Faber and Ad C.J. Stokman**, Price convergence in Europe from a macro perspective: Product categories and reliability
No. 35 **Jan Kakes and Cees Ullersma**, Financial acceleration of booms and busts
No. 36 **Wilko Bolt and David B. Humphrey**, Public Good Aspects of TARGET: Natural Monopoly, Scale Economies, and Cost Allocation
No. 37 **Piet van Gennip**, Loan extension in China: a rational affair?
No. 38 **Joël van der Weele**, Financing development: debt versus equity
No. 39 **Michael Hurd and Susann Rohwedder**, Changes in Consumption and Activities at Retirement
No. 40 **Monica Paiella and Andrea Tiseno**, Stock market optimism and participation cost: a mean-variance estimation
No. 41 **Monika Bütler, Olivia Huguenin and Federica Teppa**, What Triggers Early Retirement? Results from Swiss Pension Funds
No. 42 **Günther Fink and Silvia Redaelli**, Understanding Bequest Motives – An Empirical Analysis of Intergenerational Transfers
No. 43 **Charles Grant and Tuomas Peltonen**, Housing and Equity Wealth Effects of Italian Households
No. 44 **Philipp Maier**, A 'Global Village' without borders? International price differentials at eBay
No. 45 **Robert-Paul Berben and Teunis Brosens**, The Impact of Government Debt on Private Consumption in OECD Countries
No. 46 **Daniel Ottens and Edwin Lambregts**, Credit Booms in Emerging Market Economies: A Recipe for Banking Crises?
No. 47 **Jaap Bikker and Michiel van Leuvensteijn**, An exploration into competition and efficiency in the Dutch life insurance industry
No. 48 **Paul Cavelaars**, Globalisation and Monetary Policy
No. 49 **Janko Gorter**, Subjective Expectations and New Keynesian Phillips Curves in Europe
No. 50 **Ralph de Haas and Ilko Naaborg**, Does Foreign Bank Entry Reduce Small Firms' Access to Credit? Evidence from European Transition Economies
No. 51 **Ralph de Haas and Ilko Naaborg**, Internal Capital Markets in Multinational Banks: Implications for European Transition Countries
No. 52 **Roel Beetsma, Massimo Guiliodori and Franc Klaassen**, Trade Spillovers of Fiscal Policy in the European Union: A Panel Analysis
No. 53 **Nicole Jonker,** Payment Instruments as Perceived by Consumers – A Public Survey