International Portfolio Management, Currency Risk and the Euro

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Abstract

We investigate the impact of currency risk and of the adoption of the euro on international portfolio choices. We use a parsimonous GARCH parametrization to estimate a conditional version of the International Capital Asset Pricing Model and generate out of sample forecasts of assets returns and market and currency risk exposures. We implement out of sample dynamic asset allocation strategies that take advantage of the predictability and time varying nature of both risk exposures and risk premiums. We find that strategies that include equities and currencies significantly outperform strategies that exclude currencies. Further most of the benefits accrue from managing non-EMU currency exposures. This suggests that the portfolio trade-offs for international investors are unlikely to drastically altered by the introduction of the euro.

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The case for international diversification is now well documented. Given the low level of correlation among national equity markets, investors can improve their reward-to-risk ratio by holding assets in several countries (e.g. Solnik, 1974a, Elton and Gruber, 1992, De Santis and Gerard, 1997). In spite of this evidence, investors hold surprisingly little assets outside their home countries (Tesar and Werner, 1995). This reluctance to diversify across borders is often attributed to the fact that, in addition to market risk, international investments are exposed to the risk associated with exchange rate fluctuations.

The presence of this additional source of risk raises several related issues. First, it is important to determine whether exchange risk can be diversified away or systematically affects international assets returns. Second, if currency risk has a systematic component, one needs to establish whether it is a priced factor in international financial markets. Lastly, if exchange risk is priced, it becomes important to measure both the exposure to non–diversifiable currency risk and the compensation that investors can expect from bearing such risk. Obviously, the answers to these questions have direct implications for portfolio and hedging strategies, since any source of risk that is not compensated in terms of expected returns, should be diversified or hedged. Conversely, if currency risk is priced, currencies become an important asset class and international investors need to jointly optimize their positions in equities and currencies. If this is the case, the adoption of the single currency could have a significant impact on international portfolio strategies.

From a theoretical perspective, the international asset pricing model (IAPM) of Solnik (1974b), Sercu (1980) and Adler and Dumas (1983) suggests that, if consumption baskets differ across countries[1], optimal portfolios include currency investments and exchange risk is priced. Recent studies have provided empirical support for the IAPM. Ferson and Harvey (1993) show that an exchange risk factor help predict international equity returns. Dumas and Solnik (1995) conduct a formal test of the model and provide strong evidence that currency risk is priced in international markets. De Santis and Gerard (1998), using a different methodology, show that currency risk premiums are large, economically significant and vary significantly over time as market conditions change.

In this paper, we investigate the impact of currency risk on portfolio performance when expected returns and risk exposures are time varying. We compare the out-of sample risk and return characteristics of several simple dynamic portfolio strategies which combine equity positions with different currency hedging and speculative strategies suggested by theory and practice. We evaluate the potential impact of the adoption of the Euro by comparing the realized performance of implementing the strategies including or excluding the EMU currencies from the eligible assets.

Implementation of the portfolio strategies requires forecasts of the expected returns and the returns covariance matrix for the eligible assets. Most implementations of portfolio optimization use a pure statistical approach to forecast means and variances. For example, Glen and Jorion (1992) and Solnik (1993) use linear filter rules to forecast mean returns, while they use the unconditional sample covariance matrix to forecast variances and covariances.

[1]Differences in consumption baskets arise from differences in consumption opportunity sets which could be due, for example, to differences in preferences or violation of purchasing power parity.

Black (1993) argues that these approaches are suspect due to data mining problems and suggests that one uses the help of theory to develop forecast of mean returns. We choose the latter approach and estimate the IAPM of Adler and Dumas (1983) to forecast mean returns. An added benefit is that the model used to forecast returns is consistent with the optimal portfolio strategies we implement. In De Santis, Gerard and Hillion (1999), we estimate and test the conditional version of the IAPM and assess whether exchange risk premia significantly affect international asset returns from the perspective of German investors. In particular, we find that both the EMU and non-EMU components of the currency risk of asset returns command a statistically and economically significant premium over the 1974-1990 sample period, but that only the non-EMU component remains economically significant after 1990. We conclude that the adoption of the single currency and the subsequent elimination of intra-EMU currency risk is likely to have limited impact on the risk return trade-off available to international investors.

This paper extends the analysis of the impact of currency risk and the adoption of the single currency in a realistic portfolio management setting. We present a simultaneous analysis of the equity markets and one-month eurocurrency deposits of six countries: France, Japan, Netherlands United Kingdom, United States, and Germany, which we select as our country of reference. Our empirical model fully parameterizes the conditional measures of market and currency risks, as well as their prices and allows them to vary over time. It can be used to generate one month ahead forecasts of the risk exposures as well as the premiums for currency and market risks. These forecasts are then used to implement and evaluate out of sample several easily implemented dynamic asset allocation strategies that take advantage of the predictability of the risk premia and risk exposures. We find that overlay currency management strategies yield small and often insignificant benefits. This is not surprising since overlay strategies fail to fully account for the cross-asset correlations. Much larger and significant benefits accrue to strategies that jointly optimize equity and currency positions. Moreover, we find that most of the benefits of currency risk management accrue from managing non-EMU currency risk. Little or no additional benefits arises from managing within-EMU risk. This provides further evidence that the adoption of the single currency is unlikely to drastically affect the portfolio trade-offs for international investors.

This paper is most closely related to the work of Glen and Jorion (1993). In contrast to their work, we focus solely on out-of-sample performance, and choose the perspective of a German investor rather than a US investor. Further, while they use sample averages or simple filter rules to predict future returns, we use the IAPM consistent with our optimal portfolio strategies to forecast mean returns. Lastly, our approach accommodates the time-variation in variances and covariances observed in financial data. Overall, however, our results reinforce their conclusion that "currencies ... appear to play an important role in optimized global portfolios..."

The paper is organized as follows. Section 1 presents the optimal portfolio strategies and the asset pricing model, Section 2 describes the data. The results are presented in Section 3. Section 4 concludes.

1 Portfolio Choice, Currency Risk and Asset returns

For an international investor, the return on any foreign asset varies not only because asset specific risk, but also because of unpredictable fluctuations in exchange rates. The relevance of currency risk can be appropriately evaluated only within the framework of a model of international portfolio choice and asset pricing. This section first reviews the optimal portfolio choice problem of an international investor and discusses how it is affected by currency risk. The dynamic strategies that we investigate are then outlined, and the international asset pricing model used to generate forecasts of expected returns and covariances described.

1.1 Optimal Portfolio Weights for National Investors

Assume that, in each country, investors maximize the expected utility of future (1 period ahead) real consumption and that domestic inflation in nonstochastic.[2],[3] Assume also that PPP does not hold. This implies that any given asset yields different real returns to investors from different countries.[4]The investment opportunity set, available to all investors, consists of the following securities:

- m risky assets that, in our study, correspond to the stock market indices for m different countries.

- n short-term bills that we associate with Eurocurrency deposits in n different currencies.

Obviously, for each national investor, the Eurocurrency deposit denominated in the domestic currency is perceived as a risk-free asset. Therefore, each investor has access to a total of $N = m + n - 1$ risky securities and one riskless asset. Consider a representative investor from a generic country l and let γ_l denote the investor's degree of risk aversion. Also, indicate with μ_l the $(N \times 1)$-vector of expected returns in excess of the risk-free rate on the N risky assets, and with Σ_l the $(N \times N)$-covariance matrix for the risky assets, where the subscript l indicates that returns are measured in the currency of country l. Mean-variance optimization implies the following portfolio allocation

$$\begin{bmatrix} \omega_{l,N} \\ \omega_{l,N+1} \end{bmatrix} = \frac{1}{\gamma_l} \begin{bmatrix} \Sigma_l^{-1}\mu_l \\ 1 - \iota'\Sigma_l^{-1}\mu_l \end{bmatrix} + \left(1 - \frac{1}{\gamma_l}\right) \begin{bmatrix} 0 \\ 1 \end{bmatrix} \tag{1}$$

[2]We focus on the case of a myopic investor who optimizes his portfolio each period without considering the intertemporal dimension of the problem. Obviously, solving of an intertemporal portfolio problem may yield different results (see, for example, Ang and Bekaert, 1999, Campbell and Viceira, 1998, and Das and Uppal, 1999). However, Ang and Bekaert and Das and Uppal find that the optimal intertemporal dynamic strategies deliver very small additional benefits over the period by period implementation of the optimal myopic strategy. The latter is sufficient to capture most of the benefits of the predictabilty and time varying nature of the returns conditional moments.

[3]The model can be solved without the assumption that inflation is nonstochastic. In this case, however, it is hard to disentangle inflation and currency risk. Since the evidence suggests that the volatility of inflation in most developed markets is negligible compared to exchange rate volatility, we proceed with this assumption. This allows us to focus on the empirical relevance of currency risk alone.

[4]Although whether PPP holds in terms of expectations is still controversial, there is ample empirical evidence against PPP in the short-term (see Rogoff, 1995 for a review).

where $\omega_{l,N}$ is the $(N \times 1)$-vector of optimal weights for the N risky assets, $\omega_{l,N+1}$ is the fraction of the portfolio invested in the domestic risk-free asset, and ι is a vector of ones.

The optimal weights in equation (1) deserve further investigation. Consider an investor with a logarithmic utility function, which is equivalent to the assumption that $\gamma_l = 1$. In this case, equation (1) simplifies into

$$\begin{bmatrix} \omega_{l,N} \\ \omega_{l,N+1} \end{bmatrix} = \begin{bmatrix} \Sigma_l^{-1}\mu_l \\ 1 - \iota'\Sigma_l^{-1}\mu_l \end{bmatrix} \tag{2}$$

where $\omega_{l,N} = \Sigma_l^{-1}\mu_l$ is the vector of optimal weights for the N risky assets, and is independent of the currency of denomination. The portfolio $\Sigma_l^{-1}\mu_l$ in equation (2) is common among all investors and is usually referred to as the *universal logarithmic portfolio*.[5]

Our discussion to this point implies that all investors hold a combination of two portfolios: the universal portfolio of risky assets and the domestic risk-free asset. The allocation between the two depends on the degree of risk aversion of each national investor. Specifically, investors exploit the correlation structure for the entire set of available assets and choose an allocation that maximizes the Sharpe-ratio of their portfolio. This result is similar to the standard solution of a portfolio problem in a single market context. However, when investors have access to foreign equity and Eurocurrency markets, the result has a number of additional implications, which can be derived after appropriately partitioning both μ and Σ:[6]

$$\mu = \begin{bmatrix} \mu_s \\ \mu_d \end{bmatrix} \qquad \Sigma = \begin{bmatrix} \Sigma_{ss} & \Sigma_{sd} \\ \Sigma_{ds} & \Sigma_{dd} \end{bmatrix}$$

where the letter s denotes the stock indices and the letter d indicates Eurocurrency deposits. The Eurocurrency deposits can be used to replicate the payoffs of forward currency contracts and, therefore, can be held both for speculative and/or hedging purposes. Define $\Gamma = \Sigma_{dd}^{-1}\Sigma_{ds}$, the $[(n-1) \times m]$ matrix of coefficients from the regression of the equity indices on the Eurodeposits. Also define $\Sigma_{s/d} = \Sigma_{ss} - \Gamma'\Sigma_{dd}\Gamma$, the $(m \times m)$ covariance matrix of the stock returns, conditional on the Eurodeposits. Hence $\Sigma_{s/d}$ is the covariance matrix of fully hedged equity returns. Standard rules from the inversion of a partitioned matrix imply the following result

$$\begin{bmatrix} \omega_s \\ \omega_d \end{bmatrix} = \Sigma^{-1}\mu = \begin{bmatrix} \Sigma_{s/d}^{-1}\mu_s - \Sigma_{s/d}^{-1}\Gamma'\mu_d \\ \Sigma_{dd}^{-1}\mu_d - \Gamma\omega_s \end{bmatrix} = \begin{bmatrix} \Sigma_{s/d}^{-1}(\mu_s - \Gamma'\mu_d) \\ \Sigma_{dd}^{-1}\mu_d - \Gamma\omega_s \end{bmatrix}, \tag{3}$$

where ω_s and ω_d are the vectors of optimal weights for respectively the stocks and the eurodeposits included in the universal portfolio. The first interesting feature of equation (3) is that the optimal choice of ω_s and ω_d should be made simultaneously to exploit the properties of both sets of assets. The equity positions are a function of the covariance of the fully hedged returns and mean equity returns adjusted for the cost of the hedge. The eurocurrency deposits positions have two components. The expression $\Sigma_{dd}^{-1}\mu_d$ is the solution

[5]For a detailed discussion of this result, see Sercu (1980).

[6]Since we now focus on the universal portfolio, we omit the l subscript from μ and Σ.

to a standard mean-variance problem for the optimal portfolio of eurodeposits only and, therefore, can be interpreted as a purely speculative position in eurodeposits. On the other hand, the expression $\Gamma\omega_s$ reflects the investment in eurodeposits that minimizes the variance of the portfolio, given the position in stocks. In this sense, investors hold eurodeposits for both speculative and hedging purposes.[7]

Two special cases are of interest. First, if the expected excess returns on currency deposits are zero, then the optimal portfolio weights simplify to

$$\begin{bmatrix} \omega_s \\ \omega_d \end{bmatrix} = \Sigma^{-1}\mu = \begin{bmatrix} \Sigma_{s/d}^{-1}\mu_s \\ -\Gamma\omega_s \end{bmatrix}. \tag{4}$$

In this case, the optimal strategy calls for selecting equity portfolio weights based on the equity indices unhedged expected returns but on the covariance matrix of their fully hedged returns. On the other hand the currency position has only a hedging component. Second, if in addition currency risk is fully diversifiable, then $\Sigma_{s/d}^{-1} = \Sigma_{ss}^{-1}$ and $\Gamma = 0$, and the optimal portfolio includes only equity positions. It is also the solution to a standard mean-variance problem for the optimal portfolio of unhedged equity investments.

1.2 Dynamic Portfolio Strategies

We investigate five dynamic strategies: the overall optimum portfolio described in the previous section and four other strategies which correspond to commonly encountered restrictions imposed on investment managers. Our discussion of optimal portfolio choice will help identify the shortcomings of each strategy and the circumstances under which they are optimal. Using the notation introduced in the preceding subsection, the five strategies can be summarized as follows[8].

	Portfolio Position	
Strategy	**Equity**	**Eurodeposit**
1. EO	$\omega_s = \Sigma_{ss}^{-1}\mu_s$	$\omega_d = 0$
2. EO + CH	$\omega_s = \Sigma_{ss}^{-1}\mu_s$	$\omega_d = -\Gamma\omega_s$
3. EO+CH&S	$\omega_s = \Sigma_{ss}^{-1}\mu_s$	$\omega_d = \Sigma_{dd}^{-1}\mu_{td} - \Gamma\omega_s$
4. FHEO	$\omega_s = \Sigma_{s/d}^{-1}\mu_s$	$\omega_d = -\Gamma\omega_s$
5. OPT(E+C)	$\omega_s = \Sigma_{s/d}^{-1}\mu_s - \Sigma_{s/d}^{-1}\Gamma'\mu_d$	$\omega_d = \Sigma_{dd}^{-1}\mu_d - \Gamma\omega_s$

1. Optimal equity only strategy [EO]: In this strategy we take the point of view of a manager whose mandate prohibits her to take direct positions in the currency assets. She

[7] The expression for ω_d is equivallent to the expression for the optimal hedge for a prespecified portfolio derived in Anderson and Danthine, 1981, and as they show, would be valid for any choice of ω_s.

[8] Implicitly the weights in the table assume that the investor has a degree of relative risk aversion of 1. It is a simple matter to scale the portfolio weights of the risky assets by the inverse of the degree of relative risk aversion to get the optimal weights for any level of risk aversion.

optimizes her portfolio holdings over the eligible equity indices only. This strategy is optimal only if the currency risk exposure of the equity investments is fully diversifiable and currency deposits have zero expected excess returns.

2. Overlay currency hedge strategy [EO+CH]: This strategy correspond to the situation where the role of equity portfolio manager is distinct from the role of currency manager. First the equity portfolio manager chooses her optimal equity portfolio weights in the same fashion as in strategy 1. Second, conditional on these equity portfolio weights, the plan sponsor optimally hedges her exposure to currency risk. This implicitly assumes that currency risk commands a zero premium and hence no speculative position in currency assets are allowed. However, the equity allocation is suboptimal since the equity positions are selected without taking into account the correlations between equity and currency assets.

3. Overlay currency hedge and speculative strategy [EO+CH&S]: This strategy is identical to the second strategy in terms of the equity positions, but the currency overlay strategy allows for both optimal hedging and speculation in eurocurrency deposits. The manager can take advantage of the existence and predictability of currency premia. The overall allocation is still suboptimal since the equity positions are selected without taking into account the correlations between equity and currency assets, nor the cost of the hedges.

4. Fully hedged optimal equity portfolio [FHE:] The portfolio manager jointly selects his equity and currency positions to achieve the minimum variance fully hedge equity portfolio. It assumes that currency deposits have zero expected excess returns, and hence that the hedges are costless and that speculative positions in currencies are unnecessary.

5. Unrestricted optimal allocation [OPT(E+C)]: This strategy implements the unrestricted global optimum portfolio strategy. The portfolio weights of equity and currency assets are selected simultaneously, taking into account the covariances between all assets. In particular the equity positions now reflect their covariance with the currency assets and the costs of the minimum variance hedges.

Note that the eurodeposit positions are always determined as a function of the positions in the equity portion of the portfolio. Hence we can evaluate the benefits of overlay strategies for any given portfolio of equities as long as we have estimates of the excess returns on currencies and of the variance covariance matrix of the currency and equity assets considered.[9]

1.3 Asset pricing with currency risk

This section briefly reviews an international asset pricing model which incorporates currency risk as well as market risk and was originally developed by Solnik (1974), Sercu (1980) and Adler and Dumas (1983). Later we estimate a conditional version of the model to generate forecasts of mean returns and covariances.

[9]Jorion and Khoury, 1996, Ch 7, pp, 273-322 provide a lucid and detailed discussion of international portfolio choice and pricing as well as the references to the original contributions to the field.

The model is derived by aggregating the optimal portfolio demands defined in equation (1) across national investors. The assumption that PPP does not hold has two important implications for asset pricing. First. the optimal portfolios defined in equation (1) differ across countries. Second, the equilibrium expected return on any asset includes a premium for market risk and a premium for currency risk in addition to the risk free return, denominated in the reference currency. Market risk is given by the covariance of the asset return with the return on the world-wide portfolio of all traded assets, whereas exchange rate risk, with respect to a given currency, is measured by the covariance of the asset return with the relative change in the corresponding exchange rate. Formally, if the Deutsche Mark (DEM) is used as the reference currency, the model imposes the following pricing restrictions

$$E\left(R_i^{DEM}\right) - R_f^{DEM} = \gamma \; cov\left(R_i^{DEM}, R_M^{DEM}\right) + \sum_{j=1}^{n} \delta_j \; cov\left(R_i^{DEM}, \nu_j^{DEM}\right) \quad \forall i \qquad (5)$$

where R_i^{DEM} and R_M^{DEM} are the DEM denominated return on asset i and the world market portfolio respectively, R_f^{DEM} is the return on the DEM-denominated bill, ν_j^{DEM} is the relative change in the DEM price of currency j, and γ is the world aggregate risk aversion coefficient. The coefficient γ measures the trade-off between the expected return on the asset and its market risk and, for this reason, can be interpreted as the price of market risk. Using the same argument, each coefficient δ_j in equation (5) is usually referred to as the price of exchange rate risk for currency j.

To estimate the model, we focus on two assets for each country: a risky portfolio of stocks obtained from a country index and a short-term deposit, denominated in the local currency, whose returns are measured in the reference currency. Since short-term deposits are riskless when measured in local currency, their only risk component, when measured in the reference currency, is the relative change in the exchange rate between the reference and the local currency. In this sense, the term $cov_{t-1}\left(R_{i,t}^{DEM}, \nu_{j,t}^{DEM}\right)$ which appears in equation (5) can be replaced with the term $cov_{t-1}\left(R_{i,t}^{DEM}, R_{j,t}^{DEM}\right)$ where $R_{j,t}^{DEM}$ denotes the return on the short-term deposit denominated in currency j and measured in DEM.

Equation (5) holds in each period. When new information becomes available, investors may update their beliefs with respect to both expected returns and market volatility. In addition, they may change their attitude toward risk as market conditions change. In light of these issues, we focus on the conditional version of the model. In practice, choosing a conditional specification of the model amounts to specifying how the moments of the asset return distribution change over time. To accommodate these dynamics into the model, we modify the notation in equation (5) as follows. Let $R_{i,t}^{DEM}$ be the DEM-denominated return on asset i between time $t-1$ and time t; also let $E_{t-1}(\cdot)$ and $cov_{t-1}(\cdot)$ denote the expectation and covariance operators, respectively, conditional on the information available at the end of time $t-1$. Equation (5) in its conditional form can now be written as

$$E_{t-1}\left(R_{i,t}^{DEM}\right) - R_{f,t}^{DEM} = \gamma_{t-1} \; cov_{t-1}\left(R_{i,t}^{DEM}, R_{M,t}^{DEM}\right) + \sum_{j=1}^{n} \delta_{j,t-1} \; cov_{t-1}\left(R_{i,t}^{DEM}, R_{j,t}^{DEM}\right) \qquad (6)$$

It is obvious from the equation that the choice of the dynamics for the first and second moments is not independent. Because the asset pricing model postulates a relation between expected returns and covariances among returns, one can freely parameterize only the first or the second moments. Here, we follow the approach of De Santis and Gerard (1997,98) who use a parsimonious multivariate Generalized AutoRegressive Conditional Heteroskedastic (GARCH) in mean specification for the dynamics of the second moments. We make two additional auxiliary assumptions. First we assume that both the price of market risk (γ_{t-1}) as well as all the prices of currency risk ($\delta_{j,t-1}$) can change over time. Second we restrict the price of market risk to always be positive.[10] Details about the empirical methodology are provided in the appendix.

2 Data

We take the perspective of a German investor to perform the estimation and compute the optimal portfolios. We select the six countries with the largest market capitalization: France, Germany, Japan, Netherlands, United Kingdom and United States and for each country investigate both the country equity index and the one month euro-deposit over the period from January 1974 through April 1997. The country indices as well as the value weighted world index are obtained from Morgan Stanley Capital International (MSCI). The one month eurocurrency deposit rates are obtained from the B.I.S., Basel, and from DRI Inc. For the conditionally risk-free rate, we use the one-month eurodeposit rate for the currency of reference, i.e. the DEM. Returns on both equity and eurodeposits are computed in DEM, based on the closing European interbank currency rates from MSCI. Monthly excess returns are computed by subtracting the one month euroDEM deposit rate from the monthly return on each security. Summary statistics of the continuously compounded monthly asset returns are displayed in Table 1.

To describe the investor's information set, we use variables similar to those used in previous research. The instruments include: a constant, the dividend price ratio on the world equity index in excess of the one-month euroDEM rate, the change in the one-month eurodollar deposit rate and the U.S. default premium, measured by the yield difference between Moody's Baa and Aaa rated bonds. In addition to the global variables, we use also one country specific variable to predict changes in currency risk premiums: the difference between the real return on the local short term deposit and the real return on the short term deposit in the reference currency, which we refer to as the real risk-free rate differential. Real returns are computed by deflating local nominal one-month Eurocurrency rates by the change in the local CPI index. Inflation data are from the International Financial Statistics (IFS) database. All variables are used with a one–month lag, relative to the excess return series. Summary statistics of the information variables are displayed in Table 2. The low

[10]This restriction follows from the assumption of investor risk aversion used in deriving the equilibrium return model. See Merton (1980) for the need to impose this restriction when estimating and testing the model empirically.

correlations reported in panel b suggest that the variables included convey non redundant information.

3 Empirical Evidence

3.1 International APM with Time-Varying Prices of Risk

Although this is not the primary focus of the paper, we first briefly discuss the results from estimating the conditional IAPM specified in equation (6) over the whole sample. Parameter estimates as well as summary statistics and diagnostics for the residuals are provided in Table A.1. Summary statistics on the different components of the estimated risk premia as well as a decomposition of risk exposures are presented in Table 3 and Figures 1 and 2. We find strong support for a specification of the international CAPM that includes both world-wide market risk and foreign exchange risk. Second, we find that both the risk exposures and the components of the risk premia vary significantly over time and across markets. Three main results emerge from the evidence:

1. Currency fluctuations induce a systematic source of risk in returns. However, the EMU component is small relative to the non-EMU component (Dollar, Yen and Pound). The most relevant currency risk factor is linked to the US dollar.

2. Currency risk is priced. The EMU currency risk commands a positive but small risk premium. The non-EMU currency risk premium is negative, which suggests that investors are willing to forgo part of their expected returns to hold assets that provide a hedge against currency risk.

3. Currency risk and its impact on returns varies over time as a function of changes in economic conditions and the institutional environment. In particular, the risk exposure of international markets to the EMU currencies has declined while their exposure to non-EMU currencies has increased significantly in the nineties.

These results imply that an international asset pricing model which uses only exposure to the world market risk to explain conditional expected returns is misspecified. The tests also reveal the relative economic importance of the different sources of currency risk. The estimation shows that while both EMU and non-EMU currency risk are statistically significant, the economic significance of the non-EMU component is far larger than that of the EMU component. Not surprisingly US $ risk is the most significant source of currency risk.

Our approach provides direct estimates of the conditional second moments and, therefore, of the premium associated with each of the risk factors. The size and dynamics of each premium component vary across markets. However, a number of interesting regularities can be uncovered from the graphs. As an example, Figure 1 displays the decomposition of the total premium in market and currency component for the world index. Figure 2 displays the estimates of the exposure of the world index to the US$ and both EMU currencies exchange rate changes.

Although, over the entire sample, the average premium for currency risk appears to be only a small fraction of the average total premium, over long subperiods, currency premia are usually an economically significant fraction of the total premium. First consider the period prior to 1990. The average values of the aggregate currency premia are large and vary from an average -1.9% for the U.S. index to a positive premium of 1.3% for Japan. During the same period, the estimated premia for market risk are all large and positive. Therefore, the total premia are mostly positive, and rather large. Interestingly the premia associated with non-EMU currency risk is negative for all assets and often significantly larger than the aggregate currency premia. The premia for EMU currency risk are small and mostly positive

Second, consider the last six years in the sample. Negative premia for foreign exchange risk often more than offset a positive market premium, thus generating negative total premia. Although this is partially explained by a decrease in the magnitude of the market risk premia for all assets, it is mostly due a significant increase in the magnitude of the (negative) premia for non EMU currency risk.

Figure 2 illustrates this point as well. Over the whole period, exposure of world index to the USD exchange rate changes was on average 4 times as large as its exposure to FrF risk and 15 times as large as its exposure to Dutch guilder risk. Further exposure to both EMU currencies has declined in the nineties, while average exposure to non-EMU risk has slightly increased. This suggest that although the adoption of the single currency may eliminate the intra-EMU exchange rates as source of return volatility, this may be partially offset by an increase of the exposure of asset returns to non-EMU currency risk.

For the eurodeposits, most of the premium is, not surprisingly, driven by the currency risk component. As one would expect, in this case, the covariances with the market portfolio– which measures the amount of systematic market risk–are small although not negligible. In addition, for each country, the size and dynamics of the currency risk premium in the equity and Eurocurrency market are very similar.

3.2 Portfolio Strategies Implementation

Implementing the dynamic portfolio strategies only requires estimates of the vector of expected excess returns and of the variance covariance matrix of returns for each period. As the model we estimate to test the conditional IAPM is fully parametric, it has the advantage of delivering explicit estimates of all conditional moments required for optimal portfolio management and can be used to generate out of sample forecast of expected returns and covariances. Further it has the added advantage to be consistent with the optimal portfolio strategies we investigate. Lastly, Black (1993) suggests that using a model rooted in theory to forecast expected returns is a way to alleviate the data mining issues plaguing returns predictability studies. The cost is that forecasting power of the approach may be low.

We implement our out of sample investigation as follows. At the beginning of each month t, we estimate the model using the data for month 1 to $t-1$. We use the estimated model to forecast expected returns and covariances for the next month as input in the equations that define the portfolio weights, and generate the optimal asset allocation for the 4 strategies described above. At the end of the month, we measure the realized performance and turnover for each portfolio, reestimate the model using the newly available data, and use the new estimated model to forecast means and covariances and generate a new set of optimal weights for the next month. Since we start this process in January 89 and our sample extends until April 97, this requires 99 estimations of the full model.

We first estimate a set of unconstrained optimal portfolios. Implicit is the assumption that there are no position limits and that transactions costs are negligible. As is common in studies of this types, it generates extreme loadings on some assets. We then compute optimal portfolio weights under realistic portfolio constraints. We impose a no short sale restriction on the equity positions while allowing unrestricted positions in eurodeposits. Note that, according to the model, the optimal portfolio held by investors of the country of reference would include both the optimal portfolio as defined here plus an investment in the country's currency eurodeposit.

The five strategies are implemented for two sets of equity assets and for two sets of currency deposits. In the first implementation, we restrict the equity position to be exclusively invested in the world equity index. For strategy 1 to 3, we further restrict the portfolio to be fully invested in the world equity index. Hence, in this implementation, strategy 1 corresponds to a passive benchmark investment in the world equity portfolio, while that passive benchmark is enhanced through optimal dynamic currency hedging in strategy 2 and through both currency hedging and speculation in strategy 3. In strategies 4 and 5, the positions in world equity index and the eurodeposits are jointly optimized. In a second implementation, the six country equity indices are substituted to the world equity index in our set of eligible assets. In this implementation, the equity positions are determined by the optimizer's algorithm for all strategies.

To investigate the potential impact of the adoption of the single currency on international portfolio performance, we implement the different strategies using two sets of eligible eurocurrency deposits. The first set include all the euro deposits while the second set is restricted to the non-EMU currencies eurodeposits. Comparing the portfolio performance for the two set of currencies allows us to evaluate the marginal cost of excluding EMU-currencies from the menu of investments choices.

3.3 Performance Evaluation

The performance of the different strategies is evaluated on the basis of their average excess returns, standard deviation of excess returns and Sharpe ratio. All portfolio returns are reported in percent per month in excess of the 1 month eurodeposit rate of the currency of reference. We compare the performance of the dynamic strategies to the performance of a strategy of buying and holding the world equity index. In the absence of currency and inflation risk, this would be an appropriate proxy of the market portfolio of risky securities held by all investors. Since we are interested in evaluating the impact of managing currency risk on portfolio returns, this provides a reasonable benchmark[11].

[11]If currency risk is priced, as in the ICAPM presented in section 1, the world market equity portfolio is not the appropriate theoretical benchmark for international portfolio returns. The theoretical benchmark is

To test the significance of the portfolio performance of the dynamic strategies, we use a procedure similar to the one proposed by Solnik (1993). Since the optimal weights are determined at the beginning of each month for the coming month, we can compare the realized excess return of each strategy to the return that an uninformed investor would expect from the same strategy. We assume that the uninformed investor just knows the unconditional mean of the asset returns. We use the data both prior and posterior to the performance period to estimate the sample mean asset returns (see Solnik, 1993 for discussion). Since to conduct t-tests we need the assumption of joint normality, we will further assume that our uninformed investor use the same multi-variate GARCH process to model the time–varying second moments of excess returns.[12] Then the difference between the realized return on the optimal strategy and its uninformed expected return measure the value added of the model used to predict mean returns. Formally

$$R^e_{pt} = \omega'_t R^e_{it} \qquad E_u[R^e_{pt}] = \omega'_t E_u[R^e_i] \qquad \widehat{\sigma}_{pt} = \omega'_t \widehat{\Sigma}_t \omega_t$$

where $E_u[R^e_i]$ is the unconditional mean excess return of asset i. Then the t-statistic for the difference in means is computed as follows

$$t - test = \frac{1}{\sqrt{T}} \times \sum_{t=1}^{T} \frac{(R^e_{pt} - E_u[R^e_{pt}])}{\widehat{\sigma}_{pt}}$$

Alternatively we use a GMM procedure to construct robust Wald tests of the difference between the Sharpe ratios of the different strategies. Unfortunately as the performance period is short, the tests have low power and fail to reject the null of no significant difference in Sharpe ratios in all cases.

3.4 Empirical Results

3.4.1 Portfolio performance

Table 4 describes the performance and turnover of the different dynamic allocation strategies when equity positions can be combined with positions in both EMU and non-EMU currencies eurodeposits. Table 5 reports the performance statistics for the same set of strategies when currency positions are restricted to non-EMU eurodeposits. Note that in all cases, we impose the no short sales constraint on equity positions.[13]

The first rows of Table 4 and 5, report, as a benchmark, the performance of a passive strategy of holding the world equity market index portfolio. It shows that, over the test

a portfolio of all equity assets plus positions in the bills of all countries. However this appropriate theoretical benchmark is neither observable nor easily estimable (see Solnik, 1993, for a discussion of this issue)

[12]As the results will show shortly, the GARCH specification we use does a good job at forecasting the expected volatility of the strategies.

[13]Results for the unconstrained portfolios are available upon request. Although they uniformly generate better performance than the constrained portfolios, it comes at the cost of some unrealistically large long and short positions in some equity assets. Hence we focus our discussion on the more realistic case when equity short sales are not allowed.

period, holding the world index portfolio yields a low realized excess return and high volatility. The performance t-statistic is very close to zero, as the uninformed expected return over the performance testing period is identical to the average excess return on the passive strategy. Two further observations are in order. First, the Tables report, for each strategy, the standard deviation of the strategy's realized excess return as well as the average of the GARCH model monthly forecasted standard deviation. While for the world index, the realized standard deviation was 4.47% per month, the average forecasted standard deviation was 4.53%. Albeit this is a crude measure, it suggests that the GARCH model does a good job at forecasting volatilities. Second, the realized excess return on the world index is 0.06% per month over the 1989-97 performance evaluation period. It is much lower than the world index overall sample average realized excess return of .332% per month reported in Table 1. This indicates that compared to the pre-test period of 1974-1988, international investments have done very poorly in the 1989-1997 test period. This may hamper our ability to detect statistical significant performance enhancements from the strategies investigated.

The table shows also that both overlay strategies, the simple overlay hedge, or the overlay hedge combined with a speculative currency position, yield rather limited benefits in terms of return enhancement and volatility reduction. When combined with a position in the world index, they provide a slight improvement in Sharpe ratios while they result in a degradation of performance when combined with an optimal portfolio of the 6 equity indices.

Next, consider the fully hedged optimal equity strategy. In both panels, it generates negative excess returns and significant negative t-statistics. These results are similar to those provided by Glen and Jorion (1993). This strategy while providing minimum variance hedges, fails to take into account the costs of the hedges when determining the equity positions and thus is clearly suboptimal.

The optimal dynamic strategy which combines both equities and eurodeposits, generates higher excess returns at lower relative risk. In both panels, this strategy yields the highest Sharpe ratios and is the only one to generate a significantly positive performance test statistic (5.71 and 5.98 respectively). For example compared to the passive strategy of holding the world equity index, which has a Sharpe ratio of .014, the dynamic strategy which each month optimally allocate the portfolio between the world equity index and eurodeposits in 5 currencies yields a Sharpe ratio of .05, which is approximately 3.5 times as large. Although the dynamic strategy realized excess returns of .09% per month is 1.5 times larger than the returns of the passive strategy, its volatility is significantly lower at 1.73% per month vs 4.5% per month. This is sharply illustrated in Figure 3, which graphs the cumulative total return on an investment of 100 DEM at the start of the test period for each of the four strategies described in panel a of Table 4. The optimal dynamic strategies achieve a slightly higher total return as the passive strategy over the last 8 years while encompassing significantly lower volatility. The small performance enhancement generated by the dynamic currency overlay strategies is clearly illustrated. This suggests that most of the gain from the dynamic asset allocation strategies arise from taking advantage of the correlation structure between stocks and currency returns as well as of the predictability of currency premia.

Lastly consider the standard deviations of the realized returns of the different strategies and compare them to the GARCH model forecasts. The two numbers are very similar in all cases, except for the optimal portfolios of equity and currencies and for the fully hedged position in the world index. In the latter cases, the strategies forecasted standard deviations are substantially lower than the realized standard deviation. As we will see later, the latter strategies involve positions in currencies often one order of magnitude larger than the positions in equities. This suggests that the GARCH specification we use may not be as good to model the covariance process of currencies as it is for the equities.

Table 5 reports the performance of the 10 strategies when only non-EMU currencies eurodeposits are included in the portfolios, Its purpose is to investigate the impact of excluding EMU currencies from the menu of eligible assets. The results are broadly similar to those reported in Table 4. Surprisingly, for all implemented strategies, the realized returns are higher, the volatilities are lower, and hence the Sharpe ratios are higher when EMU currencies are excluded from the set of eligible assets than when they are included. One interpretation of this evidence is that there is little or no additional economic benefits from including EMU-deposits in our set of hedge assets. On the other hand it may also indicate there are significant estimation costs of including more assets in the model. The larger the model to estimate the more imprecise the estimates and the less reliable the forecasts of means and covariances used in the optimization. Excluding EMU-currencies seems to have little cost in terms of expected returns while yielding significant gains in terms of reducing noise in the estimation. The poorer performance of the larger model could also be a consequence of the choice of currency. The volatility of the DEM/Nl guilder in particular is very low and significantly lower than the volatility of the DEM exchange rates with for other EMU currencies like the Italian lira or the Spanish peseta. Alternatively, the performance difference in Tables 4 and 5 could stem form the inability of the multivariate GARCH model that we use to cope with the possibility currency crisis and sudden realignments within the ERM, a major source of risk for many EMU currencies. This interpretation finds further support in the surprising result that in Table 5, the optimal portfolio formed only of the 6 country equity indices yields a higher 'realized' Sharpe ratio that the optimal portfolio of the equity indices plus the currencies, even though the latter includes more assets[14]. When only equity indices are included, the average forecasted standard deviation is extremely close to the realized standard deviation, while when currencies are added, the forecast underestimates the actual standard deviation.

The performance of the different strategies including and excluding the EMU currencies are plotted in Figures 3 and 4 for the strategies invested in the world index and in Figures 5 and 6 for the strategies invested in the 6 equity indices. To make Figures 5 and 6 more readable, the returns of all strategies have been scaled to yield the same expected standard deviation. The graphs show clearly that there is little difference between the performance of the dynamic strategies including or excluding EMU-deposits. This indicates that in an international portfolio framework most economically significant currency risk arises from

[14]This is possible because we evaluate the strategies based on their out of sample performance. In terms of expectations though, adding assets increase the expected Sharpe ratio. Indeed, the forecasted expected return over the forecasted standard deviation is higher for the latter strategy than for the former.

non-EMU currencies, namely the US$, the Yen and the Pound. This also would suggest that the adoption of the Euro may yield little benefit or cost to international investors, irrespective of their country of origin.

The graphs also clearly display the failure of our forecasting model during the EMS currency crisis in September and October of 1992. Two strategies perform uniformly badly during that crisis: the overall optimal portfolio of equity and currencies as well as the overlay strategy that includes a currency speculative component. This suggest that although the GARCH specification we use may be appropriate to model equity volatilities and covariances, it is unable to deal with severe disruptions in the currency markets. Introducing asymmetry in the covariance processes along the lines suggested by Kroner and Ng (1998) may alleviate this problem.[15] Note also that when these 2 months are excluded from the performance computations, the Sharpe ratios of the optimal strategy as well as the currency speculative strategy are more than 4 times higher, while the Sharpe ratios of all other strategies are virtually unchanged.

As a final note, we also implemented all the different strategies using the assets unconditional means and covariances computed on the expanding sample of data available at the end of each month as the forecast for next month mean and variances. Although we do not report it here, in all cases the performance of the different strategies was systematically and significantly lower than those reported here using the estimated IAPM. This suggests that although our empirical model puts severe restrictions on our forecasting equations, it provides meaningful information about future means and covariances.

3.4.2 Portfolio weights and turnover

Next we examine the positions and turnover required by the different strategies. The third column in Table 4 and 5 report the average proportion of the total portfolio invested in risky asset. The remainder, one minus this number is the average proportion invested in the risk free asset. The optimal strategies that include all currencies require to have about 125% of one's portfolio invested in risky assets. These numbers drop to an average net short position in risky assets of 3.8% (and 103.8% in the risk free asset) when EMU currencies are excluded. Since all equity positions are restricted to be positive, the overall short position in risky assets stems from short positions in the eurodeposits. The average fraction of total portfolio value traded each month is equal to 99% when EMU currencies are included and drops to 30% of portfolio value per month when EMU currencies are excluded. Hence a large fraction of the trading is concentrated in the EMU currencies positions.

Tables 6 and 7 provide a detailed description of the average positions and turnover for each security under each of the different strategies. For the optimal portfolios of eurocurrency deposits and equity indices, more that 95% of the turnover reflects trading in currencies. This also reflects the small size of the equity positions relative to the eurodeposits positions. The dynamics of the positions are displayed in Figures 7 to 10, which plot the aggregate equity and currency positions for the 4 optimal strategies.

[15] Note however that in the current state of technology, it is nearly impossible to estimate a specification à la Kroner and Ng, 1998, in a system of more that 4 or 5 assets.

The results highlight several other interesting patterns. First, as one goes from a pure currency hedge strategy to a hedge plus speculative strategy the average size of the currency positions increases. Second, for the strategies that include both a hedging and speculative component, the eurodeposit positions are much larger on average than the equity holdings. Similarly, the minimum and maximum portfolio weight for each equity index is always much smaller than those of the euro-currency deposits. For example the optimal dynamic strategy calls for shorting up to 94% of portfolio value worth of guilders in one period, while being long 424% of portfolio value in the same asset in some other period. The largest equity position called for by the optimal strategy is 23.4% in the US market or 42.3% in the world index. Given the short sale restriction for equity indices, it is not surprising to observed that positions in equities are never negative. However it is important to point out that restriction is never binding for the U.S, Japanese and UK equity indices.

Lastly, the plots show that extreme weights are more prevalent when EMU currencies are included that when they are excluded. This is not surprising given that the volatility and risk exposures of these two assets are significantly lower than those of the other assets. Therefore on average one would expect larger positions in these assets and as their risk/reward trade-off changes from period to period, larger transactions as well. Also, one cannot exclude the possibility that the high turnover and position variability observed in this case may be due to greater parameter uncertainty that affects the estimation of larger systems.

When excluding the EMU currencies from the estimation and portfolio optimization, turnover, while still substantial, is more than 70% lower, averaging 30% per month. In this case as well most of the turnover is concentrated in eurodeposits. Given that trading currencies is far less costly than trading equities, this turnover pattern, while not costless, does not seem prohibitive. This suggests as well that most gains from the dynamic strategies can be traced to the predictability of eurodeposits returns. To emphasize, most of the benefits of dynamic trading stem from taking advantage of the predictability of the premia for currency risk. In other words, the returns benefits of following active strategies accrue only if you effectively manage currency risk.

4 Conclusions

We investigate the impact of currency risk on portfolio performance when expected returns and risk exposures are time varying. We compare the out-of sample risk and return characteristics of several simple dynamic portfolio strategies which combine equity positions with different currency hedging and speculative strategies suggested by theory and practice. We evaluate the potential impact of the adoption of the Euro by comparing the realized performance of implementing the strategies including or excluding the EMU currencies from the eligible assets.

To forecast the means and variances needed for implementing the portfolio optimization algorithm, rather than using a pure statistical approach, we use an asset pricing model, the IAPM of Adler and Dumas (1983), which is consistent with the optimal strategies investigated. We estimate a fully parametric specification of the model which allows both prices of risk and risk exposures to be time varying. We generate one month ahead forecasts of expected returns and covariances for six country equity indices and five eurocurrency deposits. We implement and evaluate several dynamic international portfolio strategies which explicitly take advantage of the predictability and time-varying nature of equity and currency premiums and risk exposures. We find that traditional overlay currency strategies yield very limited benefits, whether they are restricted only to hedge an underlying equity portfolio or are allowed to also take speculative positions in the currencies. Further, optimizing fully hedged positions yields negative performance as this strategy fails to take into account the cost of the hedges. However we find that strategies that jointly optimize equity and currency positions significantly outperform overlay strategies or strategies that exclude currencies. Moreover, most of the benefits of these strategies accrue from managing non-EMU currency risk. We conclude that in an international portfolio framework, most economically significant currency risk is associated with the non-EMU currencies, in particular the USD, the Japanese yen and the British pound. This suggests also that the adoption of the euro should have a limited impact on international asset prices, risk and expected returns.

Our results show also that the parsimonious covariance stationary multivariate GARCH specification we use to model the returns covariance process yields good one month ahead forecasts of portfolio volatilities. However, it is unable to deal with severe disruptions in the currency markets. Further research on large scale model which allow for asymmetric volatility and covariances seems warranted in this context.

Our results emphasize the importance of conditional analysis in which risk exposures and risk premia vary over time. Although, on average, the premium for currency risk is smaller than the premium for market risk, an unconditional analysis would fail to detect important regularities in the dynamics of risk premiums and conclude erroneously that currency risk is not an important pricing factor. By the same token, international investors that ignore currency risk and the variability of risk exposures and risk premiums, would fail to achieve the full benefits of risk reduction and return enhancement of optimal portfolio strategies. Even with the advent of the single currency in the European markets, the issue of currency risk will not disappear and will present one of the toughest challenges to portfolio managers in the 21st century. Our approach allows us to take a first step towards meeting this challenge.

Appendix: Empirical Methods

Consider a world with $L+1$ countries, one of which is used to identify the reference currency. For each country, we focus on two assets: a risky portfolio of stocks obtained from a country index (essentially an index fund for the country) and a short-term deposit, denominated in the local currency. To estimate the model, all returns must be translated into the reference currency, here the DEM. For convenience, we organize all asset returns in a vector R_t^{DEM} of dimension $(2L+2)\times 1$. The first $L+1$ elements in the vector include the returns on all the stock indices, the next L elements include the returns on the deposits in the non-reference countries, and the last element includes the return on the world portfolio. If we denote with $r_{i,t}^{DEM}$ the DEM return on asset i, in excess of the return on the DEM-denominated deposit (which is the actual risk-free rate since the DEM is the reference currency), then, dropping the DEM superscript, the system of pricing restrictions in equation (6) can be written as follows

$$
\begin{array}{lll}
E_{t-1}\left(r_{1t}\right) & =\mu_{1t}= & \gamma_{t-1}cov_{t-1}\left(R_{1t},R_{Mt}\right)+\sum_{j=1}^{L}\delta_{j,t-1}cov_{t-1}\left(R_{1t},R_{L+1+j,t}\right)\\
\vdots & & \vdots\\
E_{t-1}\left(r_{L+1,t}\right) & =\mu_{L+1,t}= & \gamma_{t-1}cov_{t-1}\left(R_{L+1,t},R_{Mt}\right)+\sum_{j=1}^{L}\delta_{j,t-1}cov_{t-1}\left(R_{L+1,t},R_{L+1+j,t}\right)\\
E_{t-1}\left(r_{L+2,t}\right) & =\mu_{L+2,t}= & \gamma_{t-1}cov_{t-1}\left(R_{L+2,t},R_{Mt}\right)+\sum_{j=1}^{L}\delta_{j,t-1}cov_{t-1}\left(R_{L+2,t},R_{L+1+j,t}\right)\\
\vdots & & \vdots\\
E_{t-1}\left(r_{2L+1,t}\right) & =\mu_{2L+1,t}= & \gamma_{t-1}cov_{t-1}\left(R_{2L+2,t},R_{Mt}\right)+\sum_{j=1}^{L}\delta_{j,t-1}cov_{t-1}\left(R_{2L+2,t},R_{L+1+j,t}\right)\\
E_{t-1}\left(r_{Mt}\right) & =\mu_{M,t}= & \gamma_{t-1}var_{t-1}\left(R_{Mt}\right)+\sum_{j=1}^{L}\delta_{j,t-1}cov_{t-1}\left(R_{Mt},R_{L+1+j,t}\right)
\end{array}
\tag{A.1}
$$

The first $L+1$ equations in the system are used to price equity portfolios, the next L equations impose pricing restrictions on the currency deposits and the last equation is used to price the world portfolio. In practice, any subset of the equity portfolios can be used if L is too large.[16] On the other hand, all the currency deposits must be included, otherwise some of the currency risk factors would be left out of the pricing equation and the model would be misspecified.

Assume that the total number of assets being used is equal to s, of which the first m are equity indices. With a more compact notation, and adding a disturbance term which is orthogonal to the information available at the end of time $t-1$, the system of equations in (A.1) can be written as follows

$$r_t=\gamma_{t-1}h_{Mt}+\sum_{j=1}^{L}\delta_{j,t-1}h_{m+j,t}+\varepsilon_t \qquad \varepsilon_t|\Im_{t-1}\sim N(0,\Sigma_t) \tag{A.2}$$

where $\Im_{t-1}$ is the set of information available at time $t-1$, Σ_t is the $s\times s$ conditional covariance matrix of asset returns, $h_{m+j,t}$ is the $(m+j)^{th}$ column of matrix Σ_t and h_{Mt} is the last column of Σ_t. Given the order of the equations in (A.1), the $(n+j)^{th}$ column of Σ_t contains the conditional covariances between each asset and the return on the j^{th} currency deposit; in this sense it measures the exposure to foreign exchange risk with respect to currency j. Similarly, the last column of Σ_t includes the conditional covariances between each asset and the market portfolio and, therefore, measures the exposure to market risk.

To complete the specification of the model, we use the GARCH-in-Mean process implemented in De Santis and Gerard (1997, 98). First, the conditional second moments are modeled according to a diagonal GARCH process in which the variances in Σ_t depend only on past squared residuals and an autoregressive component, while the covariances depend

[16] If too many securities are eliminated, information on cross–correlations is lost and tests of the asset pricing restrictions imposed by the model have less power.

upon past cross–products of residuals and an autoregressive component (see, for example, Bollerslev, Engle and Wooldridge (1988)). Second, the system is assumed to be covariance stationary so that the process for the Σ_t matrix can be written as follows

$$\Sigma_t = \Sigma_0 * (\iota\iota' - \mathbf{aa}' - \mathbf{bb}') + \mathbf{aa}' * \varepsilon_{t-1}\varepsilon_{t-1}' + \mathbf{bb}' * \Sigma_{t-1}. \tag{A.3}$$

where Σ_0 is the unconditional variance–covariance matrix of the residuals, ι is an $s \times 1$ vector of ones, a and b are $s \times 1$ vectors of unknown parameters and $*$ denotes the Hadamard (element by element) matrix product.

Under the assumption of conditional normality, the log–likelihood function can be written as follows

$$\ln L(\Psi) = -\frac{Ts}{2}\ln 2\pi - \frac{1}{2}\sum_{t=1}^{T}\ln|\Sigma_t(\Psi)| - \frac{1}{2}\sum_{t=1}^{T}\varepsilon_t(\Psi)'\Sigma_t(\Psi)^{-1}\varepsilon_t(\Psi) \tag{A.4}$$

where Ψ is the vector of unknown parameters. Since the assumption of conditional normality is often violated when using financial time series, we estimate the model and compute all our tests using the quasi–maximum likelihood (QML) approach proposed by Bollerslev and Wooldridge (1992).

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Table 1: Summary Statistics and Volatility Decomposition of Asset Excess Returns

Monthly Deutsche mark (DEM) returns on the equity indices of six countries and the value-weighted world index are from MSCI. The eurocurrency one-month deposit rates for the French franc, Dutch guilder, DEM, Japanese yen, British pound and U.S. dollar are from DRI Inc and the B.I.S. Excess returns are obtained by subtracting the euroDEM one-month rate. All returns are continuously compounded and expressed in percentage per month. The sample covers the period January 1974 through April 1997 (280 observations).

Panel a: Summary Statistics

	Mean	Std. Dev.	Skew.	Weights[a]
U.S.	0.370	5.59	-0.77**	0.35
Japan	0.311	6.40	-0.13	0.31
France	0.363	6.42	-0.30*	0.03
Germany	0.407	5.12	-0.82**	0.04
Netherl.	0.752	4.81	-0.53**	0.02
U.K.	0.518	7.14	0.02	0.11
EurF	0.141	1.25	-0.68**	
EurN	0.030	0.54	-0.22	
Eur£	0.385	6.08	0.12	
Eur$	0.001	3.41	0.18	
EurY	0.076	3.02	0.31*	
World	0.332	4.61	-0.84**	1.00

* and ** denote statistical significance at the 5% and 1% levels. [a]As of December 31, 1990.

Panel b: Unconditional Correlations of r_{it}

	Jpn.	Fr.	Ger.	Nl.	U.K.	EurF	EurN	Eur£	Eur$	Eur¥	Wrld
U.S.	.321	.473	.374	.667	.564	.178	.064	.568	.609	.240	.884
Jpn.	1	.337	.255	.372	.346	.113	.066	.141	.214	.566	.664
Fr.		1	.508	.549	.529	.287	.040	.087	.126	.146	.591
Ger.			1	.606	.391	-.046	-.067	.083	.099	.019	.480
Nl.				1	.661	.077	.055	.231	.282	.148	.747
U.K.					1	.257	.168	.082	.250	.202	.696
EurF						1	.348	.183	.275	.282	.188
EurN							1	.026	.120	.081	.094
Eur£								1	.420	.358	.416
Eur$									1	.442	.506
Eur¥										1	.386

Table 2: Summary Statistics of the Information Variables

The information set includes the world dividend price ratio in excess of the one-month euroDEM rate (XDPR), the one month change in the US Term Premium (ΔUSTP), the change in the one-month eurodollar deposit rate (ΔEuro$), the U.S. default premium (USDP), and the difference between the local currency one month eurodeposit real return and the real return on the one month euroDEM deposit (FRRD, NRRD, £RRD, $RRD, ¥RRD). The world dividend yield is the DEM denominated dividend yield on the MSCI world index. The U.S. term premium is the yield difference between the T-bond or T-note with maturity closest to 10 years and the 3 month T-bill. The U.S. default premium is the yield difference between Moody's Baa and Aaa rated bonds. The real return on one month eurodeposits is equal to the difference between the quoted nominal deposit rate and the previous month change in consumer price index. Inflation rates are obtained from the IFS database. The sample covers the period January 1974 through April 1997 (280 observations).

	Mean	Median	Std. Dev.	Min.	Max.
XDPR	-0.241	-0.197	0.213	-0.944	0.177
ΔUSTP	0.008	-0.012	0.553	-1.717	2.982
ΔEuro$	-0.002	-0.005	0.112	-0.544	0.553
USDP	1.177	1.095	0.473	0.560	2.690
$RRD	-0.015	-0.034	0.370	-0.987	0.959
¥RRD	-0.086	-0.050	0.666	-3.113	1.473
FRRD	0.115	0.118	0.407	-1.098	2.324
NRRD	0.015	0.041	0.495	-1.477	2.051
£RRD	0.026	0.120	0.631	-2.995	2.642

	Correlations							
	XDPR	ΔUSTP	ΔEuro$	USDP	$RRD	¥RRD	FRRD	NRRD
ΔUSTP	-0.114	1						
ΔEuro$	-0.068	-0.330	1					
USDP	0.005	0.116	-0.127	1				
$RRD	0.185	-0.086	0.013	0.308	1			
¥RRD	0.098	-0.076	0.059	0.159	0.340	1		
FRRD	-0.086	0.005	0.011	0.065	0.464	0.280	1	
NRRD	-0.006	-0.054	-0.094	-0.027	0.391	0.447	0.446	1
£RRD	-0.051	-0.157	0.046	-0.050	0.212	0.300	0.367	0.350

Table 3: Estimated Average Risk Premiums

The table reports the average of the estimated risk premiums over the overall sample period, the subperiod prior to June 90, and the difference between the average premium before and after June 90. The total risk premium is measured as the sum of the market risk premium and the aggregate currency premium. The currency premium is the sum of the premium associated with the EMU currencies, i.e., French franc and Dutch guilder, and the premium associated with the non-EMU currencies, i.e., British pound, U.S. dollar and Japanese yen. All estimates are reported in percent per year. Newey-West standard errors in parenthesis.

Panel a: Equity indices

	U.S.	Jap.	Fr.	Ger.	Nl	U.K.	Wrld
				Total Premiums			
Overall	5.72	6.34	7.62	3.25	5.13	9.55	6.33
	(1.46)	(1.10)	(0.87)	(0.58)	(0.82)	(1.23)	(1.19)
Pre-90	9.71	9.06	9.93	4.53	7.82	12.14	9.48
	(1.53)	(1.25)	(0.94)	(0.69)	(0.91)	(1.45)	(1.28)
ΔPost-90	-13.6	-9.29	-7.86	-4.35	-7.00	-8.84	-10.75
	(1.92)	(1.44)	(1.11)	(0.77)	(1.11)	(1.79)	(1.60)
				Market Premiums			
Overall	8.46	6.30	6.36	4.09	6.10	9.06	7.70
	(1.14)	(0.77)	(0.84)	(0.52)	(0.83)	(1.40)	(1.03)
Pre-90	10.94	7.76	8.11	5.19	7.84	11.79	9.84
	(1.39)	(0.98)	(1.04)	(0.63)	(1.02)	(1.77)	(1.27)
ΔPost-90	-8.45	-4.99	-5.97	-3.78	-5.94	-9.32	-7.31
	(1.42)	(1.03)	(1.07)	(0.66)	(1.05)	(1.80)	(1.30)
				EMU Currency Premiums			
Overall	1.22	1.03	2.06	-0.39	0.37	1.82	1.07
	(0.26)	(0.24)	(0.33)	(0.11)	(0.15)	(0.50)	(0.23)
Pre-90	1.28	1.10	2.08	-0.31	0.27	1.81	1.07
	(0.36)	(0.33)	(0.46)	(0.15)	(0.21)	(0.71)	(0.32)
ΔPost-90	-0.21	-0.23	-0.09	-0.26	0.37	0.03	-0.01
	(0.39)	(0.39)	(0.49)	(0.16)	(0.23)	(0.74)	(0.35)
				Non-EMU Currency Premiums			
Overall	-3.95	-0.99	-0.79	-0.48	-1.34	-1.34	-2.44
	(0.64)	(0.60)	(0.21)	(0.09)	(0.23)	(0.62)	(0.47)
Pre-90	-2.51	0.21	-0.26	-0.36	-0.92	-1.47	-1.44
	(0.67)	(0.72)	(0.20)	(0.10)	(0.23)	(0.81)	(0.50)
ΔPost-90	-4.93	-4.07	-1.79	-0.31	-1.42	0.45	-3.43
	(1.16)	(0.88)	(0.39)	(0.22)	(0.48)	(1.14)	(0.86)

Table 3 (continued)

Panel b: Eurocurrency deposits

	Eur$	Eur¥	EurF	EurN	Eur£
Total Premiums					
Overall	0.26	1.47	1.42	0.13	1.66
	(0.82)	(0.72)	(0.27)	(0.14)	(0.48)
Pre-90	2.38	3.30	1.69	0.11	1.45
	(0.84)	(0.78)	(0.37)	(0.19)	(0.63)
ΔPost-90	-7.23	-6.22	-0.94	0.05	0.70
	(1.31)	(0.97)	(0.41)	(0.19)	(0.87)
Market Premiums					
Overall	2.80	1.86	0.38	0.13	1.63
	(0.34)	(0.25)	(0.05)	(0.03)	(0.23)
Pre-90	3.55	2.37	0.50	0.18	2.09
	(0.40)	(0.30)	(0.06)	(0.04)	(0.28)
ΔPost-90	-2.57	-1.74	-0.40	-0.16	-1.59
	(0.43)	(0.31)	(0.07)	(0.04)	(0.29)
EMU Currency Premiums					
Overall	1.14	1.01	1.36	0.12	0.72
	(0.15)	(0.16)	(0.30)	(0.13)	(0.19)
Pre-90	1.03	0.96	1.45	0.07	0.59
	(0.20)	(0.23)	(0.43)	(0.19)	(0.26)
ΔPost-90	0.38	0.19	-0.31	0.16	0.46
	(0.22)	(0.24)	(0.43)	(0.19)	(0.27)
Non-EMU Currency Premiums					
Overall	-3.67	-1.40	-0.32	-0.12	-0.69
	(0.67)	(0.62)	(0.10)	(0.04)	(0.49)
Pre-90	-2.19	-0.03	-0.25	-0.14	-1.23
	(0.73)	(0.72)	(0.12)	(0.05)	(0.64)
ΔPost-90	-5.05	-4.67	-0.24	0.05	1.83
	(1.17)	(0.92)	(0.16)	(0.06)	(0.84)

Table 4: Out of Sample Performance of Dynamic Portfolio Strategies - All currencies included.

The portfolios are obtained by performing mean variance optimization using the beginning of month out of sample forecasts of expected returns and covariance matrix generated by the estimated IAPM model. Two variant of 5 basic strategies are implemented. (1) Passive investment in the world index [PW] or optimal equity only portfolio [EO]. (2) Strategy one plus an optimal overlay currency hedge [PW+CH or EO+CH]. (3) Strategy two with an added optimal currency speculative [PW+CH&S or EO+CH&S]. (4) Optimal fully hedged equity portfolio [FHWO or FHEO]. (5) Unrestricted optimal portfolio of equity and eurocurrency deposits[OPT(W+C) or OPT(E+C)]. For all strategies we rule out short positions in equities. Col 2 reports average monthly realized excess return of each strategy, with their standard deviation in parentheses. Col.3. reports the average uninformed expected return of the strategy and in parenthesis, the average of the model forecast of the monthly standard deviation of the strategy Col. 4 reports the t-test on the mean difference between mean realized return and unconditional expected return of the strategy, and the strategy's Sharpe ratio in brackets. Col 5 reports the average fraction of total portfolio invested in risky assets and, in brackets, the average total turnover. Col 6 reports the average realized total return of the strategy, and its standard deviation in parentheses. All figures are reported as continously compounded rates in percent per month.

Strategy	$\overline{R_p^e}$ (s.d)	UE(R_p^e) ($E[\widehat{\sigma_p}]$)	t-test [Sharpe]	$i'\overline{\omega_s}$ [Avg.Turn]	$\overline{TR_p}$ (s.d)
Panel a: World index and all eurodeposits					
1. PW	0.062	0.062	0.50	1.000	0.620
	(4.474)	(4.528)	[0.014]	[0.000]	(4.449)
2. PW + CH	0.066	0.189	-1.94	0.873	0.624
	(3.594)	(3.780)	[0.018]	[0.346]	(3.577)
3. PW +CH&S	0.084	0.212	-1.96	1.176	0.642
	(3.613)	(3.801)	[0.023]	[0.450]	(3.595)
4. FHWO	-0.028	0.005	-6.39	0.024	0.530
	(0.193)	(0.116)	[-0.145]	[0.096]	(0.270)
5. OPT(W+C)	0.085	0.068	5.705	1.250	0.643
	(1.725)	(1.473)	[0.050]	[0.999]	(1.725)
Panel b: Country indices and all eurodeposits					
1. EO	0.013	0.002	0.548	0.047	0.571
	(0.284)	(0.252)	[0.046]	[0.033]	(0.343)
2. EO + CH	-0.006	0.001	-5.51	0.093	0.552
	(0.219)	(0.221)	[-0.027]	[0.177]	(0.282)
3. EO + CH&S	0.013	0.021	-1.71	0.396	0.571
	(0.458)	(0.453)	[0.028]	[0.285]	(0.486)
4. FHEO	-0.006	0.001	-5.676	0.115	0.553
	(0.296)	(0.295)	[-0.019]	[0.251]	(0.330)
5. OPT(E+C)	0.092	0.075	5.98	1.259	0.650
	(1.726)	(1.473)	[0.053]	[0.993]	(1.727)

Table 5: Out of Sample Performance of Dynamic Portfolios Strategies - Only non-EMU currencies included.

The portfolios are obtained by performing mean variance optimization using the beginning of month out of sample forecasts of expected returns and covariance matrix generated by the estimated IAPM model. Two variant of 5 basic strategies are implemented. (1) Passive investment in the world index [PW] or optimal equity only portfolio [EO]. (2) Strategy one plus an optimal overlay currency hedge [PW+CH or EO+CH]. (3) Strategy two with an added optimal currency speculative [PW+CH&S or EO+CH&S]. (4) Optimal fully hedged equity portfolio [FHWO or FHEO]. (5) Unrestricted optimal portfolio of equity and eurocurrency deposits[OPT(W+C) or OPT(E+C)]. For all strategies we rule out short positions in equities. Col 2 reports average monthly realized excess return of each strategy, with their standard deviation in parentheses. Col.3. reports the average uninformed expected return of the strategy and in parenthesis, the average of the model forecast of the monthly standard deviation of the strategy Col. 4 reports the t-test on the mean difference between mean realized return and unconditional expected return of the strategy, and the strategy's Sharpe ratio in brackets. Col 5 reports the average fraction of total portfolio invested in risky assets and, in brackets, the average total turnover. Col 6 reports the average realized total return of the strategy, and its standard deviation in parentheses. All figures are reported as continously compounded rates in percent per month.

Strategy	$\overline{R_p^e}$ (s.d)	UE(R_p^e) ($E[\widehat{\sigma_p}]$)	t-test [Sharpe]	$i'\overline{\omega_s}$ [Avg.Turn]	$\overline{TR_p}$ (s.d)
Panel a: World index and non-EMU eurodeposits					
1. PW	0.062	0.062	0.404	1.000	0.620
	(4.474)	(4.477)	[0.014]	[0.000]	(4.449)
3. PW +CH	0.069	0.199	-2.119	0.019	0.628
	(3.574)	(3.727)	[0.019]	[0.069]	(3.556)
3. PW +CH&S	0.094	0.209	-1.91	0.010	0.652
	(3.607)	(3.744)	[0.026]	[0.107]	(3.587)
4. FHWO	-0.026	0.006	-4.841	0.001	0.532
	(0.200)	(0.124)	[-0.131]	[0.051]	(0.274)
5. OPT(W+C)	0.103	0.088	11.24	-0.036	0.661
	(1.693)	(1.313)	[0.061]	[0.295]	(1.687)
Panel b: Country indices and non-EMU eurodeposits					
1. EO	0.018	0.005	8.483	0.045	0.576
	(0.247)	(0.234)	[0.073]	[0.033]	(0.309)
2. EO + CH	0.013	0.007	4.405	0.004	0.571
	(0.195)	(0.204)	[0.067]	[0.063]	(0.270)
3. EO + CH&S	0.037	0.027	9.214	-0.005	0.597
	(0.439)	(0.408)	[0.085]	[0.099]	(0.464)
4. FHEO	0.015	0.009	6.409	0.001	0.573
	(0.266)	(0.266)	[0.056]	[0.087]	(0.274)
5. OPT(E+C)	0.108	0.089	11.16	-0.038	0.666
	(1.696)	(1.313)	[0.064]	[0.296]	(1.689)

Table 6: Portfolio Weights - Out of Sample Dynamic Strategies Including all Currencies.

This table reports the average portfolio proportions invested in the different assets for the 10 portfolio strategies examined in Table.4 For the unconstrained optimal strategies we also report maximum and minimum weights as well as average portfolio turnover per month over the sample period. All figures are reported in percent.

Panel a: World index and all eurodeposits

	Wrld	Eur$	EurY	EurF	EurD	Eur£
1. PW	100.00					
2. PW+CH	100.00	-47.64	-27.21	-6.95	94.99	-25.92
3. PW+CH&S	100.00	-55.80	-28.44	-3.25	124.98	-19.90
4. FHWO	3.14	-1.60	-0.69	-0.62	2.97	-0.81
5. OPT(W+C).	3.49	-34.34	-5.77	14.18	124.26	23.17
Min.	0.55	-90.16	-57.42	-99.00	-93.69	-88.66
Max.	42.28	34.36	52.22	159.11	424.72	114.31
Turn.	0.96	10.64	8.72	15.36	53.47	10.49

Panel b: Country Indices and all eurodeposits

	U.S.	Jap.	Fr.	Ger.	Nl.	U.K.	Eur$	EurY	EurF	EurD	Eur£
1. EO	0.27	1.14	1.15	0.30	0.42	1.39					
2. EO+CH	0.21	0.93	0.87	0.23	0.28	1.04	-0.04	-1.15	-2.29	-2.39	-1.29
3. EO+CH&S	0.21	0.93	0.87	0.23	0.28	1.04	-1.49	-0.36	5.09	4.01	0.42
4. FHEO	0.69	1.70	1.19	0.30	0.31	2.15	-0.73	-1.85	-5.35	16.62	-3.51
5. OPT(E+C)	1.77	0.97	0.13	0.10	0.12	0.39	-34.40	-5.90	13.72	125.70	23.32
Min.	0.28	0.14	0.02	0.00	0.02	0.05	-90.13	-57.15	-105.89	-93.27	-88.09
Max.	23.35	11.45	0.96	1.23	0.89	5.47	34.41	51.61	158.93	425.00	114.32
Turn.	0.50	0.26	0.03	0.03	0.03	0.11	10.67	8.70	15.46	52.96	10.46

Table 7: Portfolio Weights - Out of Sample Dynamic Strategies Including only non-EMU Currencies.

This table reports the average portfolio proportions invested in the different assets for the 10 portfolio strategies examined in Table 5. For the unconstrained optimal strategies we also report maximum and minimum weights as well as average portfolio turnover per month over the sample period. All figures are reported in percent.

Panel a: World and non-EMU eurodeposits

	Wrld.	Eur$	EurY	Eur£
1. PW	100.00			
2. PW+CH	100.00	-47.65	-26.44	-24.00
3. PW+CH&S	100.00	-54.91	-27.74	-16.36
4. FHWO	3.38	-1.74	-0.69	-0.89
5. OPT(W+C).	3.94	-30.99	-6.15	29.59
Min.	1.13	-83.12	-50.08	-73.28
Max.	29.73	21.89	38.02	111.12
Turn.	0.90	10.35	7.09	11.10

Panel b: Country Indices and non-EMU eurodeposits

	U.S.	Jap.	Fr.	Ger.	Nl.	U.K.	Eur$	EurY	Eur£
1. EO	0.39	1.04	0.39	0.75	0.43	1.52			
2. EO+CH	0.39	1.04	0.39	0.75	0.43	1.52	-0.47	-1.13	-2.52
3. EO+CH&S	0.39	1.04	0.39	0.75	0.43	1.52	-7.83	-2.41	5.24
4. FHEO	0.66	1.25	0.44	0.85	0.32	2.29	-0.79	-1.35	-3.53
5. OPT(O+C)	2.02	1.13	0.09	0.10	0.14	0.48	-31.13	-6.32	29.72
Min.	0.61	0.31	0.01	0.00	0.00	0.13	-83.11	-50.32	-75.41
Max.	16.35	8.06	0.56	0.66	0.71	5.33	21.82	38.06	111.06
Turn.	0.47	0.25	0.02	0.03	0.03	0.12	10.36	7.08	11.09

Table A1: Quasi-Maximum Likelihood Estimates of the Conditional International CAPM with Time-Varying Prices of Risk.

Estimates are based on monthly Deutsche mark denominated continuously compounded returns from January 1974 through April 1997. Data for the country equity indices and the world portfolio are from MSCI. One-month eurocurrency deposit rates are from DRI Inc and the B.I.S. Each mean equation relates the asset excess return r_{it} to its world covariance risk $cov_{t-1}(r_{it}, r_{mt})$ and its currency risk $cov_{t-1}(r_{it}, r_{5+c,t})$. The prices of risk are functions of a number of instruments, z_{t-1}, included in the investors' information set. The instruments include a constant, the world index dividend yield in excess of the one-month euroDEM rate (XDPR), the change in the one month eurodollar rate (ΔEuro$), the U.S. default premium (USDP), the one month change in U.S. term premium (ΔUSTP), as well as the difference between the 1 month real rates for the local currency eurodeposits and the euroDEM deposit (Loc RRD).

$$r_{it} = \gamma_{t-1} cov_{t-1}\left(r_{it}, r_{mt}\right) + \sum_{k=1}^{5} \delta_{k,t-1} cov_{t-1}\left(r_{it}, r_{6+k,t}\right) + \varepsilon_{it}$$

where $\gamma_{t-1} = \exp(\kappa_m' z_{t-1})$, $\delta_{k,t-1} = \kappa_k' z_{t-1}$ and $\varepsilon_t | \Im_{t-1} \sim N\left(0, H_t\right)$. The conditional covariance matrix H_t is parameterized as follows

$$H_t = H_0 * \left(\iota\iota' - \mathbf{aa}' - \mathbf{bb}'\right) + aa' * \varepsilon_{t-1}\varepsilon_{t-1}' + bb' * H_{t-1}$$

where * denotes the Hadamard matrix product, **a** and **b** are 12× 1 vectors of constants and ι is an 12× 1 unit vector. Robust standard errors are reported in parentheses.

Panel a: Parameter Estimates

	Const		XDPR		ΔEuro$		USDP			
κ_m	-4.80	(1.38)	2.82	(2.16)	-2.58	(1.07)	1.33	(.752)		
	Const		ΔUSTP		ΔEuro$		USDP		Loc RRD	
κ_{FFr}	.136	(.180)	-0.013	(.077)	.426	(.548)	-.039	(.173)	-.117	(.167)
κ_{Nl}	.482	(.352)	0.491	(.191)	.525	(1.11)	-.367	(.260)	.389	(.190)
$\kappa_{£}$	.150	(.073)	0.034	(.042)	.475	(.216)	-.116	(.059)	-.049	(.041)
κ_{Y}	-.070	(.078)	-0.072	(.049)	-.160	(.257)	.064	(.064)	.050	(.036)
$\kappa_{\$}$	-.076	(.062)	0.018	(.039)	.249	(.188)	.041	(.051)	.107	(.050)

	U.S.	Jap.	Fr.	Ger.	Nl.	U.K.	Eur$	Eur¥	EurF	EurN	Eur£	Wrld
a_i	.191	.165	.117	.308	.160	.221	.228	.206	.349	.216	.097	.180
	(.033)	(.031)	(.034)	(.055)	(.034)	(.033)	(.045)	(.039)	(.095)	(.030)	(.037)	(.029)
b_i	.960	.978	.989	.348	.959	.961	.805	.869	.891	.975	.993	.964
	(.013)	(.009)	(.008)	(.285)	(.012)	(.014)	(.079)	(.050)	(.070)	(.008)	(.018)	(.011)

Table A1 (continued)

Panel b: Specification Tests

Null Hypothesis	χ^2	df	p-value
Is the price of market risk constant? $H_0 : \kappa_{m,j} = 0 \quad \forall j > 1$	11.084	3	0.011
Are the prices of currency risk equal to zero? $H_0 : \kappa_{k,j} = 0 \quad \forall k, j$	58.871	25	0.000
Are the prices of currency risk constant? $H_0 : \kappa_{k,j} = 0 \quad \forall k, j > 1$	47.194	20	0.001
Are the prices of currency risk of EMU countries equal to zero? $H_0 : \kappa_{k,j} = 0 \quad \forall j, k = 1, 2$	20.092	10	0.028
Are the prices of currency risk of non–EMU countries equal to zero? $H_0 : \kappa_{k,j} = 0 \quad \forall j, k = 3, 4, 5$	32.075	15	0.006

Panel c: Summary Statistics and Diagnostics for the Residuals

	U.S.	Jap.	Fr.	Ger.	Nl.	U.K.	Eur$	Eur¥	EurF	EurN	Eur£	Wrld
Avg(r_{it})	0.37	0.31	0.36	0.41	0.75	0.52	0.00	0.08	0.14	0.03	0.13	0.33
Avg($\widehat{\epsilon}_{it}$)	-0.11	-0.22	-0.27	0.14	0.32	-0.28	-0.02	-0.05	0.02	0.02	-0.01	-0.20
RMSE	5.55	6.27	6.39	5.11	4.76	7.12	3.34	2.98	1.22	0.51	2.63	4.53
R^2_m [a]	2.62	1.75	0.59	0.54	2.57	2.15	0.06	0.65	0.03	-0.91	-1.18	3.79
R^2_{m+c} [b]	1.63	3.92	1.00	0.56	2.23	0.68	3.61	2.67	4.53	10.46	3.54	3.38
Kurt.[c]	3.60*	1.39	1.82*	3.51*	4.20*	4.08*	0.81*	0.10	3.64*	1.89*	1.87*	4.12*
B-J[d]	171*	21.3	43.1*	162*	211*	197*	7.64$^+$	2.39	220*	48.3*	42.0*	221*
$Q_{12}(z)$[e]	0.73	0.75	0.50	0.35	0.16	0.72	0.67	0.42	0.35	0.39	0.20	0.41
$Q_{12}(z^2)$[e]	0.96	0.71	0.16	0.03	0.93	0.85	0.64	0.60	0.78	0.56	0.94	0.99
EN-LM[f]	0.90	0.12	0.29	0.88	0.55	0.18	0.40	0.12	0.19	0.23	0.03	0.87
Likelihood Function:						-7574.67						

[a] Pseudo-R^2 when market risk is the only pricing factor; [b] pseudo-R^2 when both market and currency risk are pricing factors; [c] equal to zero for the normal distribution; [d] Bera-Jarque statistic for normality; [e] p–values for Ljung-Box statistic of order 12; [f] p–values of Engle-Ng test for the predictability of conditional second moments using the instruments.

$^+$and * denote statistical significance at the 5% and 1% levels.

Figure 1a: Total risk premium decomposition - World index

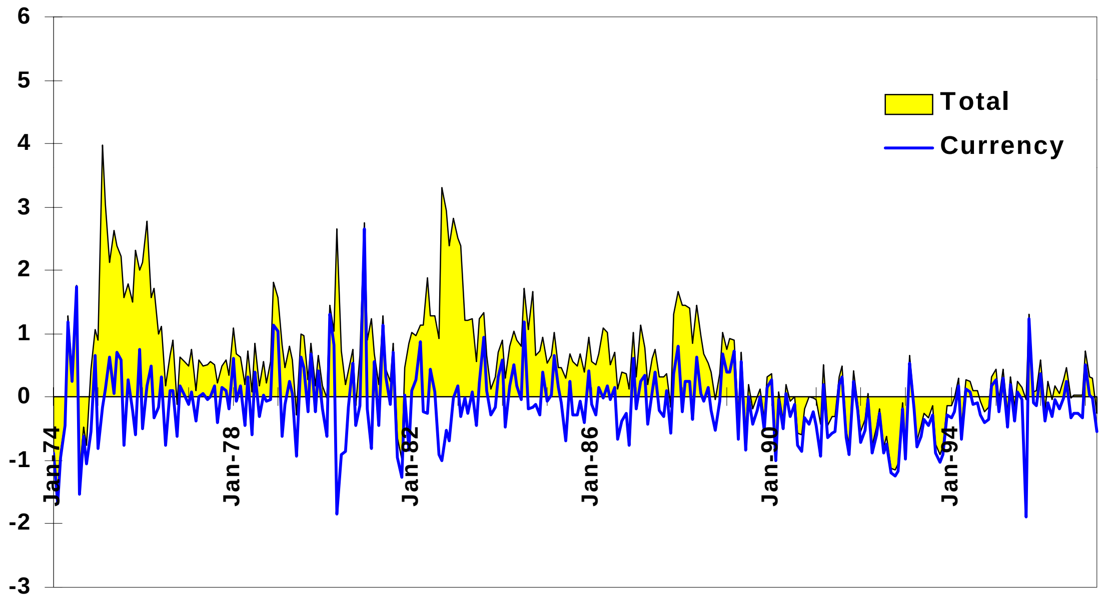

Figure 1b: Currency risk premium decomposition - World index

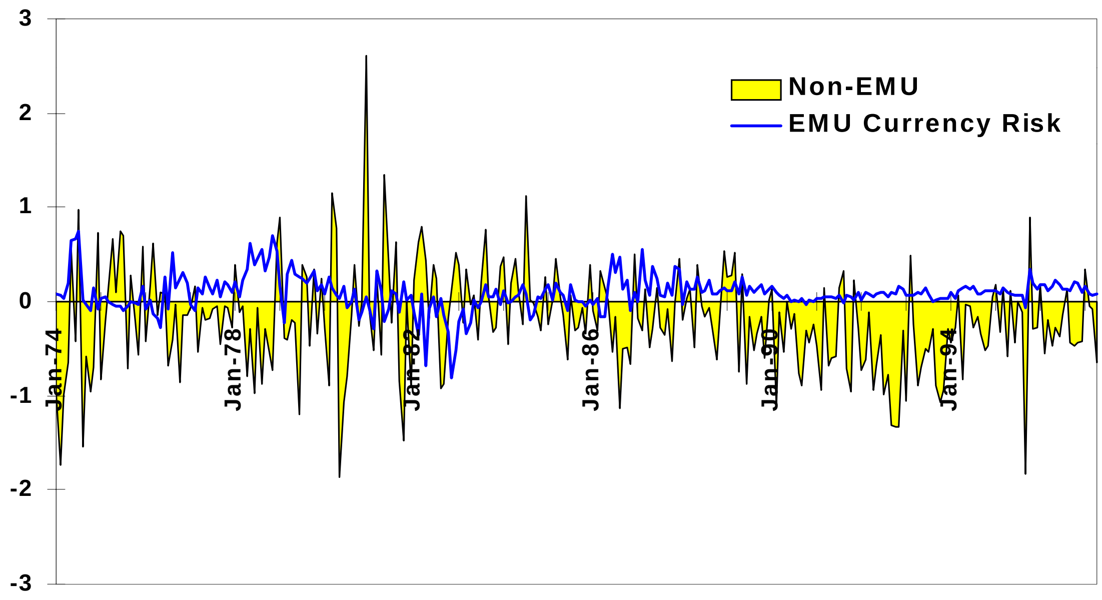

Figure 2: World equity index currency risk exposures

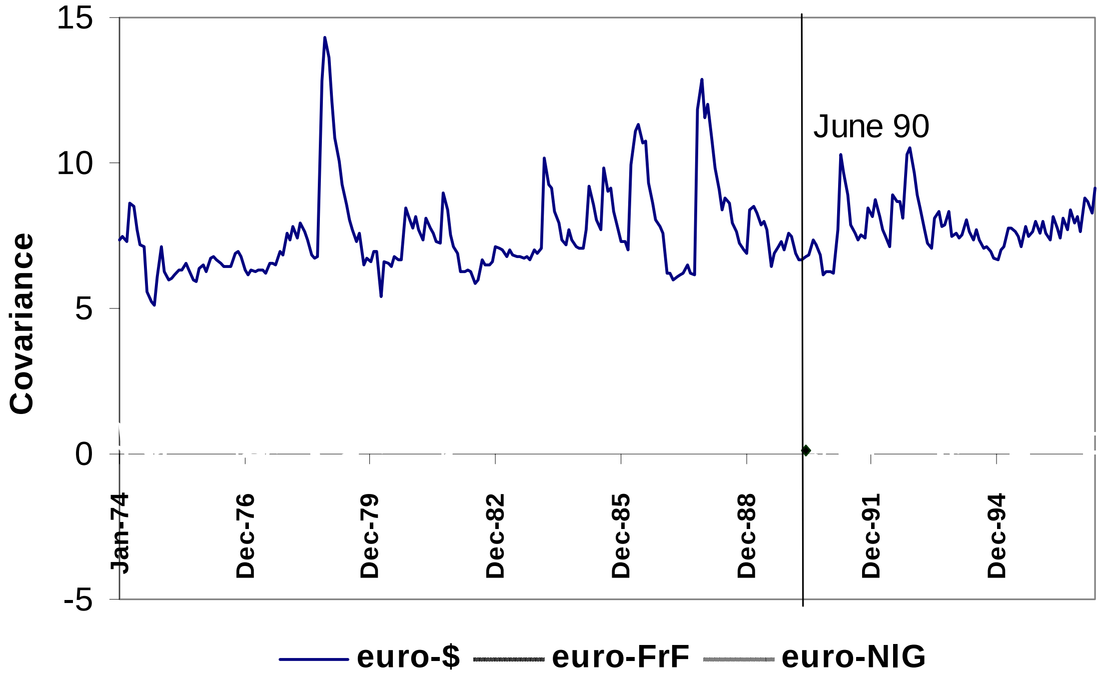

Figure 3: Dynamic strategies performance
World index and all eurocurrency deposits

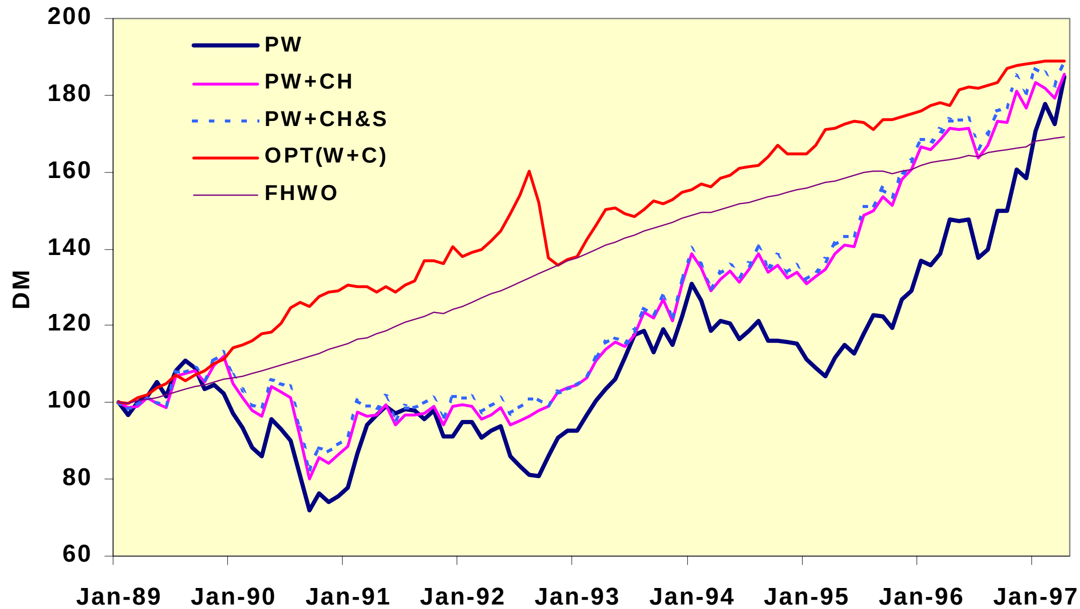

Figure 4: Dynamic strategies performance
World index and non-EMU eurocurrency deposits

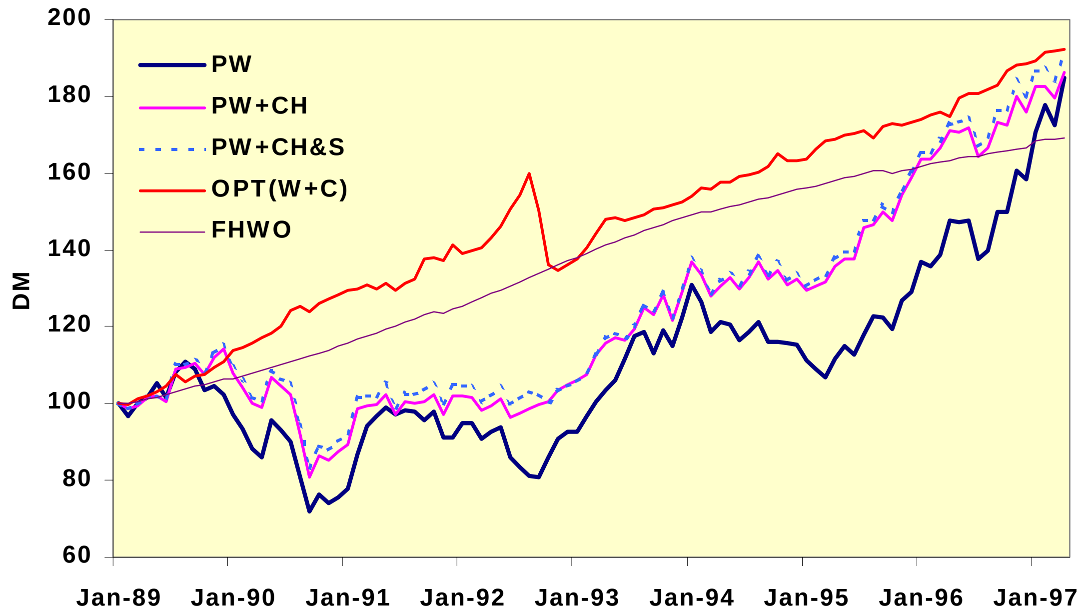

Figure 5: Dynamic strategies performance
6 equity indices and all eurocurrency deposits

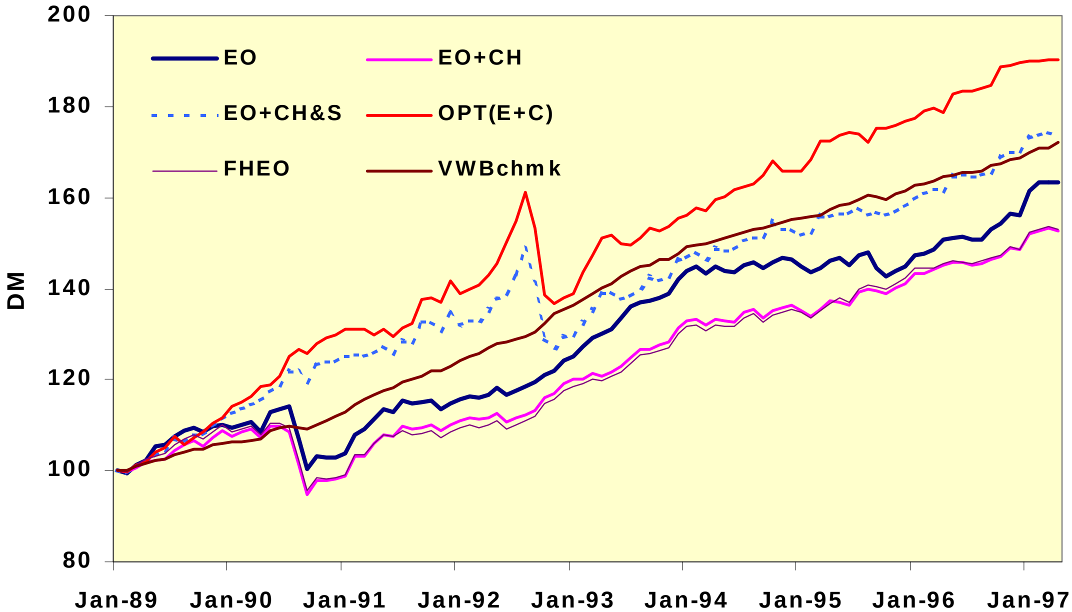

Figure 6: Dynamic strategies performance
6 equity indices and non-EMU eurocurrency deposits

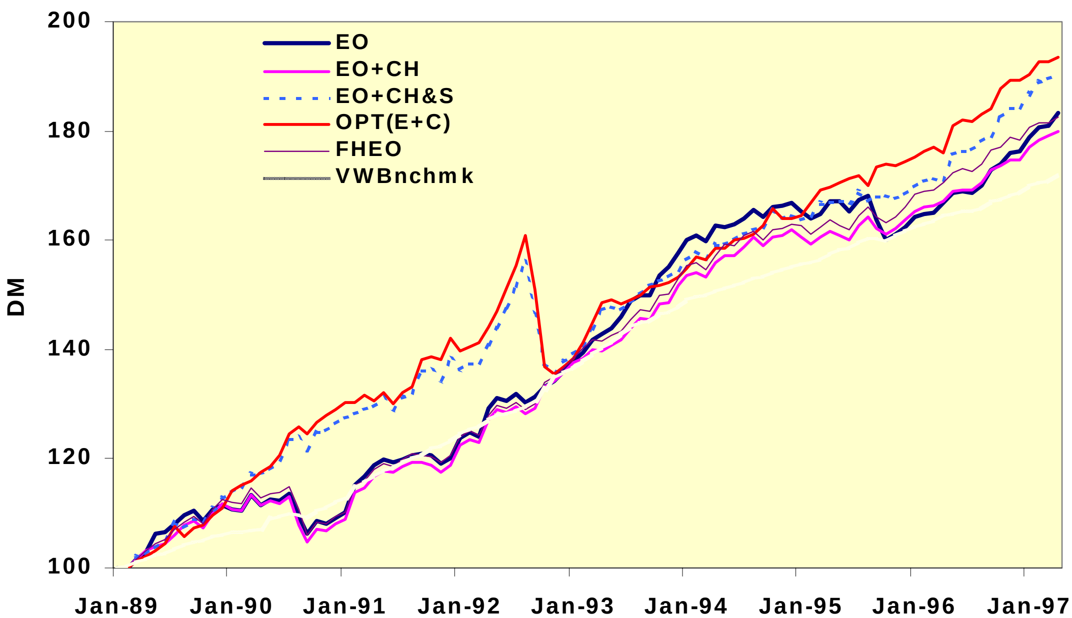

Figure 7: Portfolio Fractions Invested in Risky Securities
World index and all eurocurrency deposits

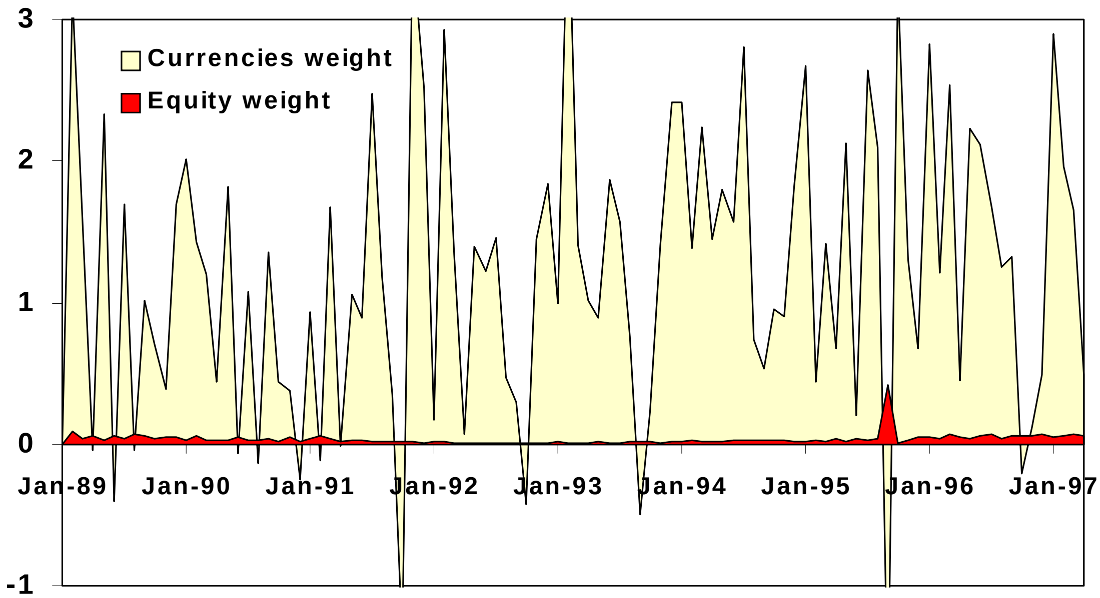

Figure 8: Portfolio Fractions Invested in Risky Securities
World index and non-EMU eurocurrency deposits

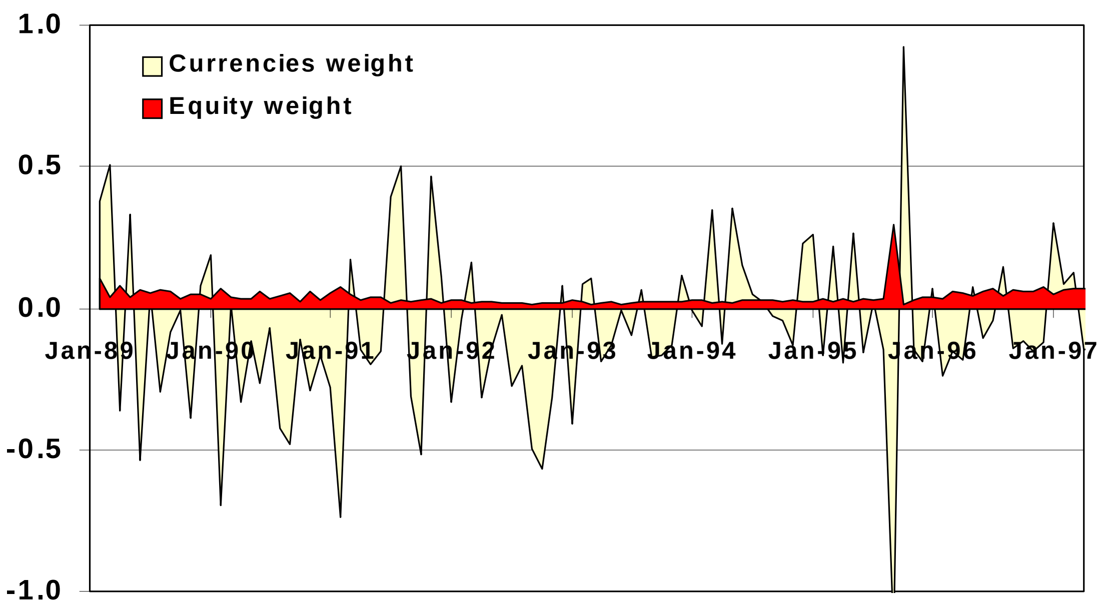

Figure 9: Portfolio Fractions Invested in Risky Securities
6 equity indices and all eurocurrency deposits

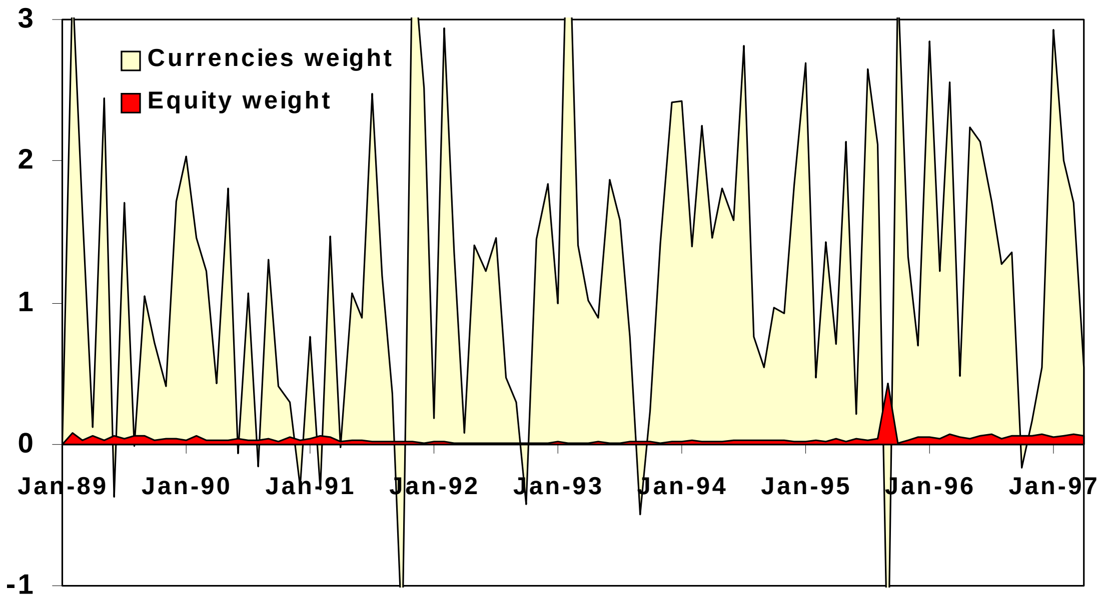

Figure 10: Portfolio Fractions Invested in Risky Securities
6 equity indices and non-EMU eurocurrency deposits