EMPIRICAL ANALYSIS OF GLOBAL BOND INVESTMENTS BASED ON FUNDAMENTALS

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Summary

International investments grows steadily. However, the benefits of diversification across markets are more often addressed for stock than for bond portfolios. In the later case, currency volatility cannot be ruled out because interest rate and exchange rate levels of risk are similar. Most studies related to this interesting subject specially in continental Europe give arguments for international diversification based on ex-post efficient frontiers and address the issue of hedging the exchange rate risk. This paper shows how two simple ideas could have helped investor to gain from international diversification ex-ante. It is assumed that real rates in every market tend to revert to a 5 year average and that exchange rate revert to the moving average of purchasing power parity. Portfolio composition of investors based in various currencies are optimized in a mean-variance framework. Empirical study over the last business cycle tend to demonstrate that significant outperformance could have been achieved, with very little increment of risk. Surprisingly investor based in strong currencies had a big incentive to invest in bond markets denominated in weaker currencies, despite the currency depreciation.

Analyse empirique des placements en obligations planétaires basés sur des principes fondamentaux

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Résumé

Les investissements internationaux s'accroissent de façon continue. Les avantages d'une diversification sur plusieurs marchés sont plus souvent soulignés pour les portefeuilles de valeurs que pour les obligations. Dans ce dernier cas, la volatilité des devises ne peut être ignorée du fait que les niveaux de risque sont similaires pour le taux d'intérêt et pour le cours du change. La plupart des études touchant à ce sujet, surtout sur le continent européen, viennent à l'appui d'une diversification internationale fondée sur des frontières ex-post efficaces et mettent en valeur la question de couverture du risque associé au cours du change. Nous démontrerons dans notre exposé la façon dont deux idées simples auraient pu permettre à un investisseur de bénéficier d'une diversification internationale ex-ante. Il y est assumé que les taux réels de chaque marché tendent à revenir à une moyenne de 5 ans et que le cours du change revient à la moyenne changeante de la parité du pouvoir d'achat. La composition d'un portefeuille basé sur diverses devises se trouve améliorée dans le cadre d'une analyse fondée sur la moyenne et la variance. L'étude empirique portant sur le dernier cycle de transactions tend à démontrer qu'une performance nettement supérieure aurait pu être possible, avec un risque très peu accru. Résultat surprenant : l'investisseur misant sur des devises fortes était très encouragé à investir dans des marchés d'obligations libellés en devises plus faibles, en dépit de la dévaluation des devises.

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There has been a tremendous development of international investments over the last few years particularly, by US based institutions. As a result, portfolio managers' trades now account for more than 10 % of the ever growing volumes currency markets (about twice the level of commercial transactions). While it is true that the potential benefits of international diversification are discussed in a very number of papers written both by academics and practitioners (Bruno Solnik, whose book [1] has contributed to the popularization of the concept, has given many references in it. Most of these works concentrate on stock portfolios, for which the level of volatility obviously dominates the currency risk. When it comes to bond portfolios, the literature is scarce and it remains unclear if the arguments of the above are still valid,. Namely that volatilies for most pairs of currencies dominate the risk of ten year governmental bonds. Adding such an amount of uncertainty could potentially destroy the expected benefits of picking an extra yield or of investing on a steeper yield curve in a foreign bond market.

In fact, most of the literature on global bond investments can be divided into two main streams. First, since the pioneering work of Solnik and Noetzlin (1982) numerous papers have demonstrate the ex-post benefits of investing in foreign bonds. More recent studies by Levy and Neusser (1988), Cholerton et al. (1986), Jorion (1989) and Odier and Solnik (1993) update and enlarge the scope of the first study. Making use of Markowitz optimization with ex-post returns, they all arrive at the same conclusions : that international diversification adds a substantial extra return over a purely domestic portfolio for the same level of risk, partial hedging of the currency risk is also worth considering and bonds add value in a global portfolio of equities. Typically a US based investor holding 60 % in SP 500 and 40 % in US Treasuries would have earned 5 % more yearly over the 1978-1988 period if he had optimally diversified his portfolio. Unfortunately, drawing ex-post efficient frontier requires a knowledge of future returns on foreign bonds.

Second, many papers investigate the risks borne by investors in global fixed income portfolio. Risk decomposition is addressed in Beckers (1991) and Dym (1992) and several aspects of currency risk hedging are discussed in Filatov and Rappoport (1992), Hanser and Levy (1991), Leibowitz et al. (1993) and Sorensen et al. (1993). On one hand, the risks can be decomposed into interest rate and currency risks, with an additional cross risk often neglected. On the other hand, one could follow the CAPM idea and look at the beta of a particular foreign bond market relative to some global bond index. Yet, according to Odier and Solnik (1993), the definition of an international benchmark remains an unsolved problem.

Besides these efforts, Rosenberg (1990) a proposed framework for setting a strategy and Benari (1992) showed that the investment decision and particularly the expected returns on foreign bond relative to

domestic investment cannot be separated from the currency hedging decision, because inflation expectations drives both nominal interest rates and currencies. Kugler and Neusser (1993) also report clear indications of international adjustment in the real interest rates for which they develop an econometric model.

This paper investigates the potential added value of taking into account economic fundamentals when it comes to international bond investments. Starting from the idea of diversification that has already been demonstrated in a mean variance framework, we propose a simple model which incorporates information about inflation and real rates into expected returns. The next section presents this model which is then back-tested for several basis currencies over the past eleven years. We then explore the possible developments of this simple model which could form the basis of a true tactical bond allocation model.

I. THEORY

1) Setting the allocation problem

Let us consider an investor i with a basis currency C_i who invests in long term government bonds B_j denominated in currencies C_j . Returns on bond are simply decomposed in nominal return in currency C_j and currency return if $j \neq i$. Over a unit time interval, say a quarter, this return is :

$$r_{ij} = B_j^{t+1} / B_j^t . C_{ji}^{t+1} / C_{ji}^t - 1$$

where B_j^t denotes bond price denominated in Cj at time t

C_{ji}^t denotes the price at time t of one unit of currency j expressed in numeraire C_i (of course, $C_{ji} = 1/C_{ij}$)

Moreover, if we assume the duration of Bj to be a constant Dj and if Rj denotes the yield to maturity, then :

$$B_j^{t+1} / B_j^t = 1 + R_j^t - D_j (R_j^{t+1} - R_j^t) + \Sigma_j^t$$

where Σ_j^t is a second order term which we neglect in the following

Looking at the return r_i portfolio of investor i whose exposure to bond B_j is w_j, when the currency is not hedged, we find :

$$r_i = \sum_j w_j (1 + R_j^t - D_j (R_j^{t+1} - R_j^j)).C_{ji}^{t+1} / C_{ji}^t - 1$$

The asset allocation can be solved in a Markowitz framework by optimizing the w_j given expected return $E(r_{ij})$ and a covariance matrix for these returns. That is, we look for the solution of :

$$\max_{\{w_i\}} r_i - \lambda var(r_i)$$

where λ is the so called risk aversion.

2) Assessing the expected returns

Optimized portfolio composition depends primarily on expectation of returns , as is well known. Here, we bet on fundamentals and will express them in some "crude" way. There are two terms to assess : the domestic ratio of return for every domestic bond market, and the currency return for every pair of currencies.

Domestic returns are set by assuming that some mean reverting process drives the real returns. More precisely, we suppose that the real rate measured as the long term level rate minus current inflation rate tends to revert to its ex-post five year moving average. For the sake of simplicity we shall also assume that it will revert within a quarter. As a result, forecasted long term market interest rates in three months time are :

$$R^{t+1} = I^t + \overline{RR^t}$$

where $\overline{RR^t}$ is the five year real rate moving average.

Furthermore, we assume that durations bonds are constant across markets and equal to D and we obtain :

$$B_i^{t+1} / B_i^t = 1 + R_i - D\left(I^t + \overline{RR^t} - R_i^t\right)$$

Our model for currencies returns is equally simple. We assume that the currency rates which may diverge from their purchasing power parity (ppp in short) will tend to reach this level at the end of the next quarter. For the sake of consistency we shall again measure ppp with a five year moving average. The forecasted currency level is then :

$$C_{ji}^{t+1} = \left(\sum_{t-T}^{t} C_{ji}^{s} \right) / \left(\sum_{t-T}^{t} I^{s} / J^{s} \right) I^{t+1} / J^{t+1}$$

where I^t and J^t are consumer price indices in market i and j respectively.

Indeed with this equation, ppp holds over a period of lag T ending in t, as can be easily checked.

In the next section, these returns associated with the above simple mean variance optimization will be systematically applied to a variety of basis currencies.

II. IMPLEMENTATION OF THE STRATEGY

1°) Data

In this section, we consider investors based in a currency of the G5 countries, investing in their governement bond market or in that of the other four. We shall refer to the USD investor when speaking of a USD based investment in G5 bonds. In order to cope with the different durations of local indices we have built synthetic local bond returns from a long term interest rate series (OECD quarterly series were used), assuming that $D_i = d = 6$ years for every market. Our simulations correspond to hypothetical investors who keep their interest rate exposure constant over time and across markets. However, as discrepancies with bond indices based on capitalization weighted prices of bonds should remain minor and average to almost zero over time, one expects very similar results when using other kind of indices.

We selected a period of eleven years from 1982 to mid 1993 (46 quarters) which correspond approximately to a full business cycle. Nevertheless G5 average interest rate at the beginning of the period was xx although it is now yy. The inflation levels explain by large this difference.

The strategy of each investor was presented in the previous section. Every quarter portfolios are rebalanced according to optimal weights deduced from the new forecasts. We used one hundred portfolios regularly spanning the range of expected returns pertaining to one particular date, number 1 having the lowest variance and thus the lowest return and number 100 having the highest ex-ante return and variances. We recorded the quaterly simulated performances of all the portfolios and ex-post analyzed the annualized mean and standard deviation of the returns in order to draw the dynamic efficient frontiers resulting from the systematic investment process.

2) Dynamic efficient frontiers

We present in this section the results of our investment strategy for every investor belonging to the G5, starting with FRF investors, who happen to be the exception to the rule. The returns of individual G5

markets converted into FRF are plotted in figure 1a along with the dynamic efficient frontier computed as was explained earlier. Our strategy failed to beat the simple buy and hold strategy of the domestic OAT market, which for the period under consideration has achieved an almost 15 % per annum with a 7 % volatility ! Such a return could be beaten with a little increment of risk : the portfolio lying under the arrow turned out to have a 16 % return for a mere 7.4 % volatility. Returns of this portfolio are shown in figure 1b where one can see the benefits of investing in long term bonds at the beginning of the period. These being mainly tied to the disinflation following the second oil shock in the late 70's. Returns were negative for only six out of 46 quarters, a very low number.

Conversely the added value of our strategy for a GBP investor is strikingly high for the total span of risk. With the same volatility as the gilt market, one could achieve an excess return of 4 %. Moreover, even less riskier portfolios (down to 8 % in volatility) offer more attractive returns than the local bond market. Again, the evolution of returns by quarter of portfolios under the arrow is depicted in figure 2b, showing extraordinary high returns especially at the beginning of the period and in Fall 92, when the GBP quit the EMS.

Not surprisingly the DEM investor faced a situation (figure 3a) similar to the FRF investor, although risk taking earned about 5 % more. His local bond market certainly offered the lowest risk during this time period, and going international was not that comfortable, as is shown in figure 3b.

USD and JPY investors have had clear incentives to diversify globally and to apply our strategy : at 1 % to about 2 % one to excess return with the same level of risk ; in addition, 4.5 % and 3 % respectively were achievable with some incremental risk as can be seen in Figure 4a and 5a.

Finally, returns of portfolio indicated by arrows are shown in figure 4b and 5b, where one can observe the impact of the rise and the fall of the USD in 1984 and 1985 on returns. However the almost steady appreciation of the JPY is hardly noticeable, which seems to demonstrate that even investors based in strong currencies should diversify, at least in the G5 bond markets.

3) Comparison of portfolio performances and composition

With the exceptions of the French OAT market which over the period considered outperformed the other four markets as far as mean returns are concerned, and the German Bund market which offered the least risk, international investments following our strategy proved to be more efficient than investment in the local market for the same level of risk and outperformed it when a limited incremental risk is accepted. These results are summarised in Table 1, with returns and volatilities of the portfolios already mentioned, that is local bond and diversified portfolios exhibited in figures 1b - 5 b. Returns here are free of transactions costs, which reduce the outperformance only by some 10's of basis points because of the very high liquidity of currencies and G5 bond markets.

Table 2 gives another perspective also in favor of our strategy. Indeed, in the case of the former portfolios, excess returns and excess risks (tracking errors) over the local bond market and over an international benchmark composed of 40 % USD bonds and 15 % of the four other markets are significant. The information ratio, defined as the mean excess return divided by the excess risk,

summarizes the past benefits of the strategy. Remembering that a 0.5 information ratio is often considered as a standard of high quality, the results show the potential interest of our strategy. which was, for sake of presentation, oversimplified. With an average information ratio of 0.36 (against the local benchmark) and 0.26 (against the international benchmark) there is respectively a 80 % and 87 % probability of outperformance over 10 years !

Average compositions of the sample of selected portfolios are reported in table 3. The USD investor has the highest exposure (two third) to his own market and the JPY investor the lowest (3 %). Of course local regulations may prevent investors from having such a high international exposure (here, 55 % on average across investors) but when thinking of today's very low international diversification, one can guess what the future will be ! Not surprisingly over the period the best performer (the French market) is overweighted in the portfolios and the worst (the Japanese market) is underweighted. More interestingly, US bonds are well represented in these portfolios ; this is not only due to the high local demand. Also foreign demand for Japanese bonds should have been very low according to our strategy.

III. FURTHER IDEAS AND COMMENTS

Investing in foreign bond markets was rewarded over the last business cycle. The merits of international diversification has already been demonstrated in numerous studies, but the arguments mainly rely on ex-post efficient frontiers. Therefore results depend primarily on ex-post returns and have limited value added when it comes to future investments. The objectives of the present paper were twofold : first, to show that a shrewd investor could gain ex-ante from international investments, and second, that in the G5 countries, betting on the reaction of bond markets to macro economic fundamentals was worth considering. The two ideas we used in order to assess forecasts of return either on local bond markets or on currencies were simple if not common place : over the long term, first, real interest rates in one country cannot diverge to some average and second, currency rates revert to their ppp levels. The model we chose to express these two basic ideas is oversimplified : we assumed that "long term" level either for real rates or ppp was 5 years and that it takes one quarter for both rates to revert to these average levels. Yet the results are good and information ratios are fairly high (0.36 on average against local benchmarks).

It goes without saying that such a strategy could be refined in a number of ways. For example, hedging the currency risk totally or more conveniently optimal hedges can be included (see the literature mentioned). Yield curve movements and comovements could also be exploited, at the price of additional bets in durations, which were kept constant in the paper. More elaborate econometric models with more inputs as to the fundamentals could also boost the information ratios. Also interesting are the benefits of the strategy of overcoming the inflation risk against local inflation on some "global" inflation measure. Some of these aspects are described in [Quants n° 11] and further research should be devoted to this rather new area of investment, because it pays !

So, the next question is : who pays ? The answer pertains certainly to the period considered where French and US governments have offered attractive rates to foreign investors. Japanese and German bonds on the other hand were not very interesting for foreigners. In this dIsinflation period they started

with lower rates than the other G5 members and thus offered less potential for interest rate decreases, and high market performances.

In spite of a steady appreciation of their currencies Germans and Japanese had better invest abroad ! Is the moral of the story that governments with the weakest currencies have to pay a premium over the expected rate of depreciation ? In other words, do strong currencies have a reputation in face of which the market accepts receiving less ?

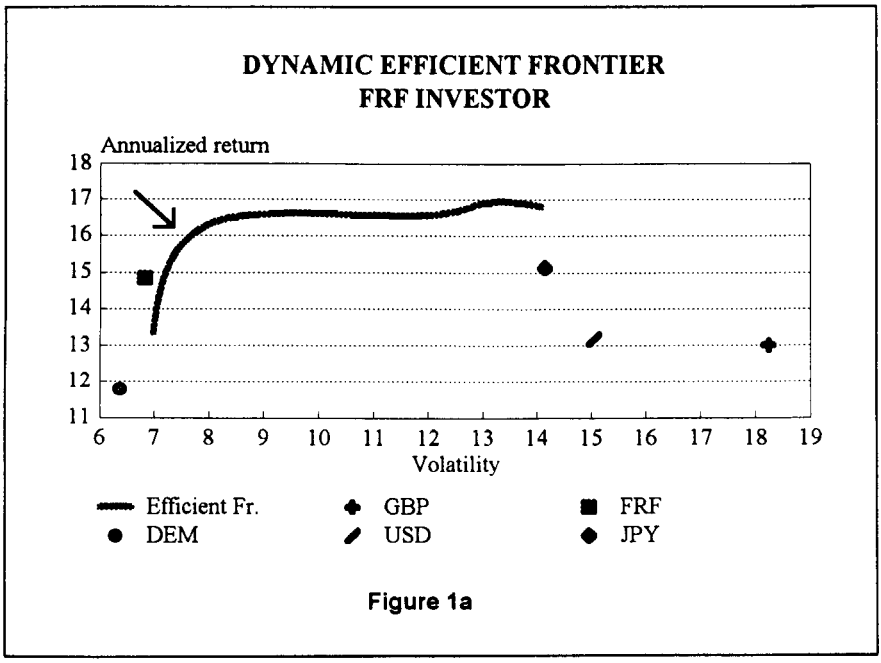

Figure 1a

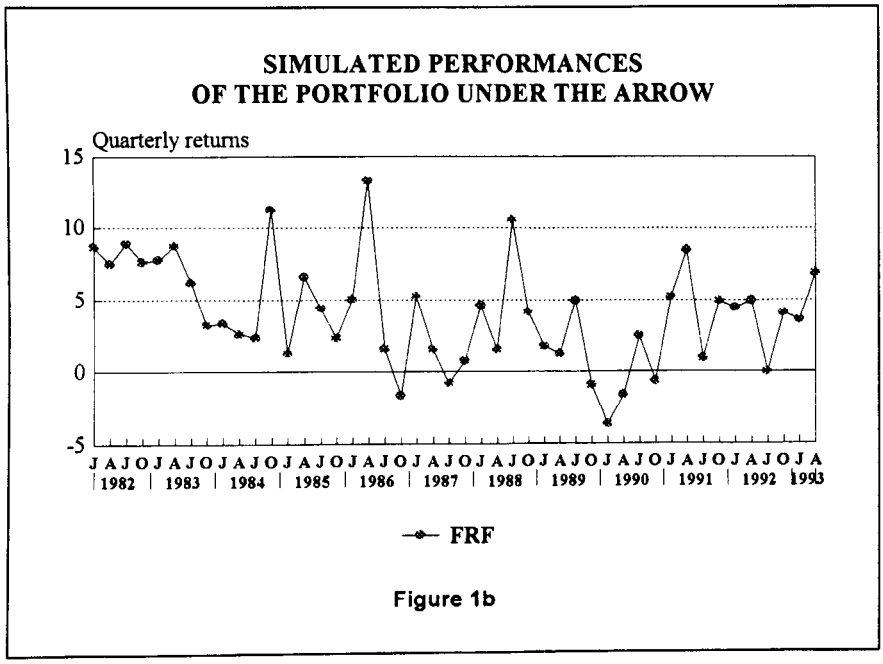

Figure 1b

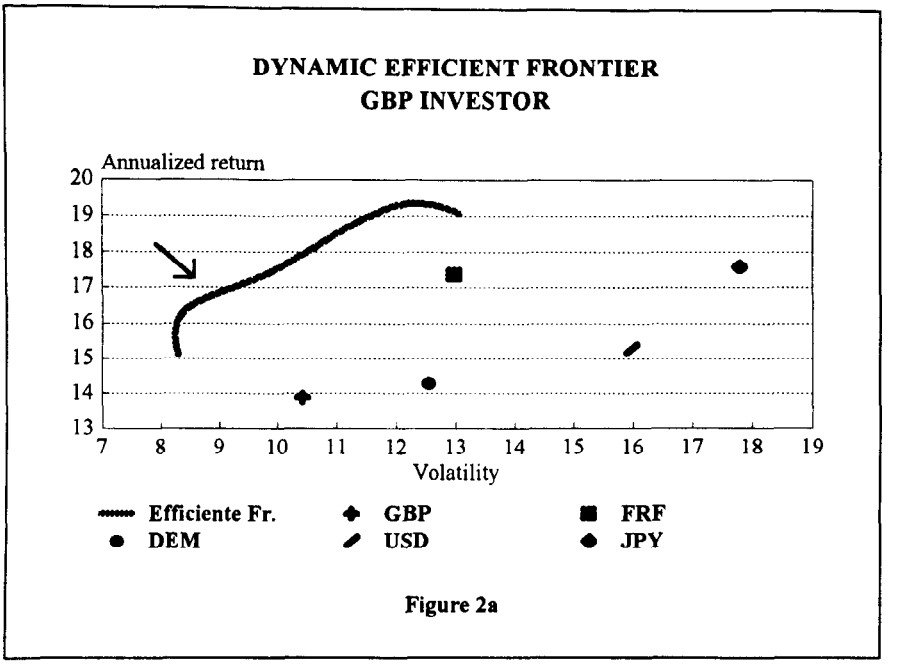

Figure 2a

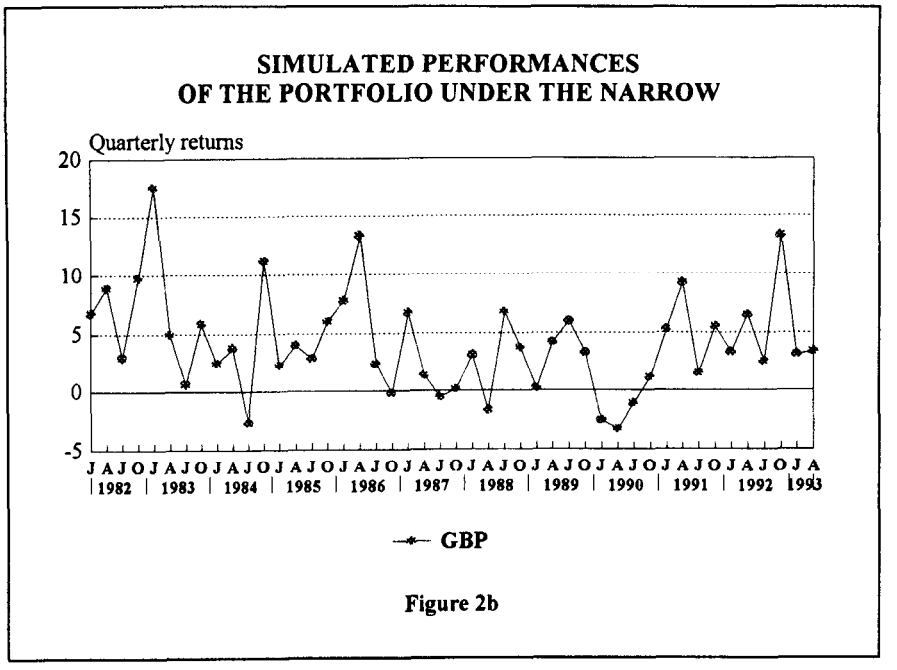

Figure 2b

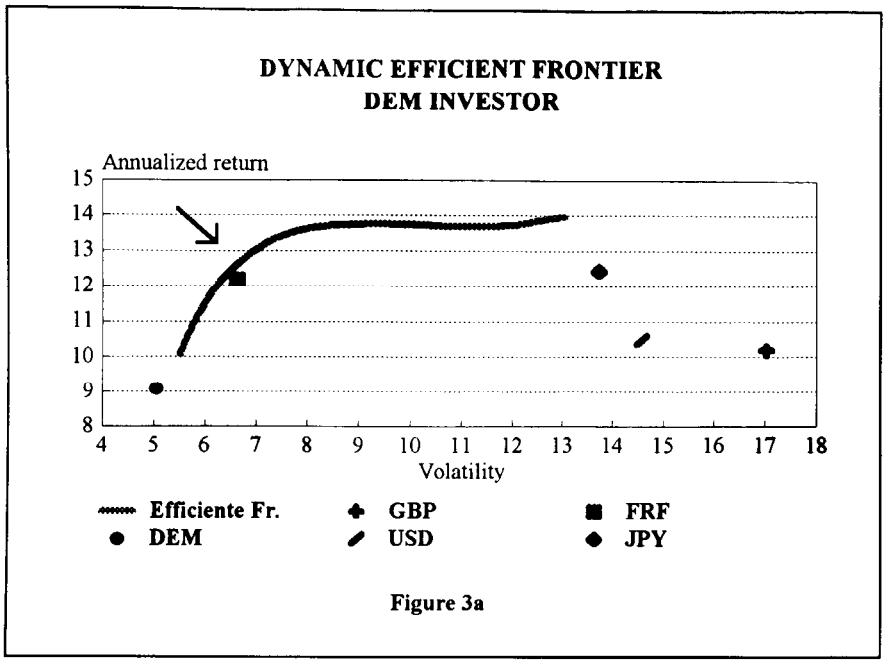

Figure 3a

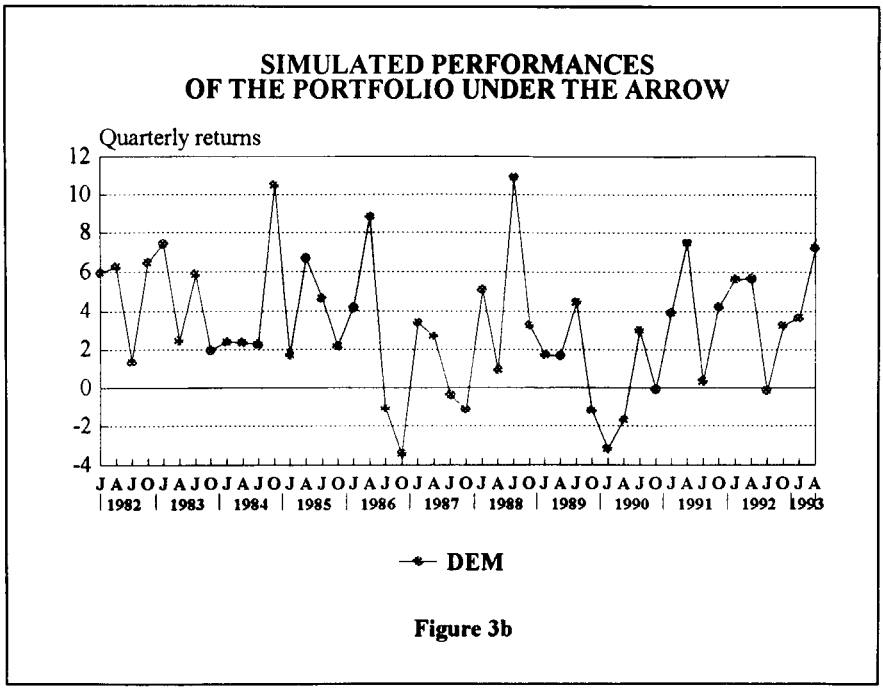

Figure 3b

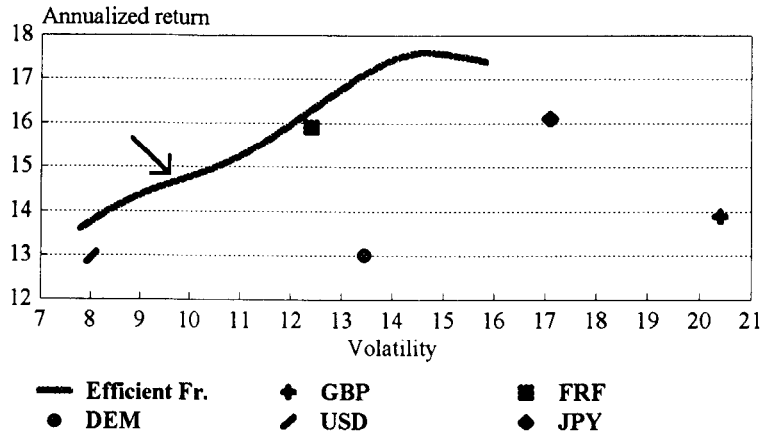

Figure 4a

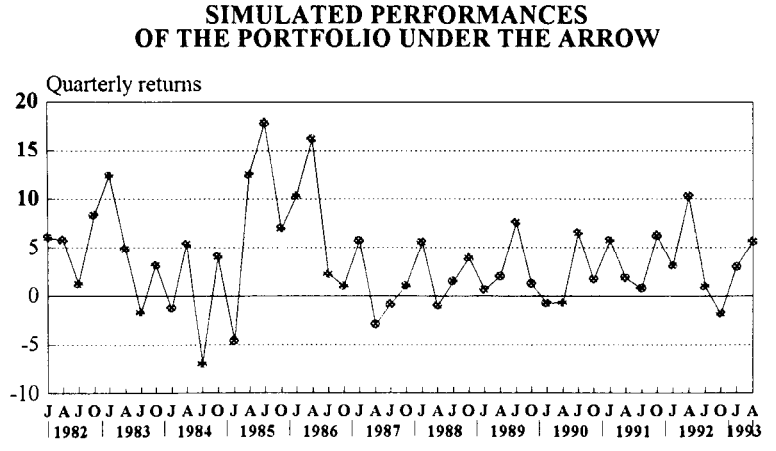

Figure 4b

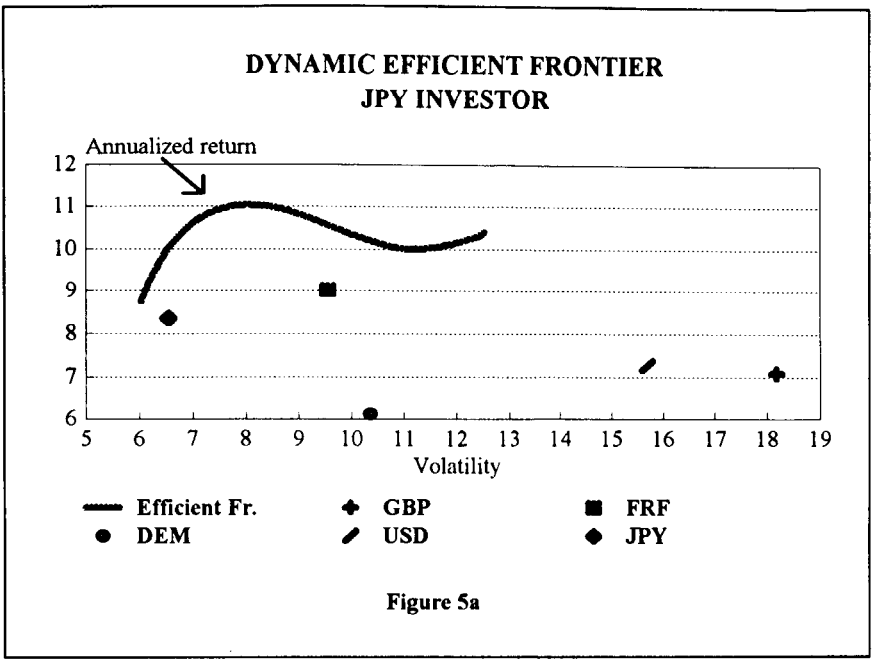

Figure 5a

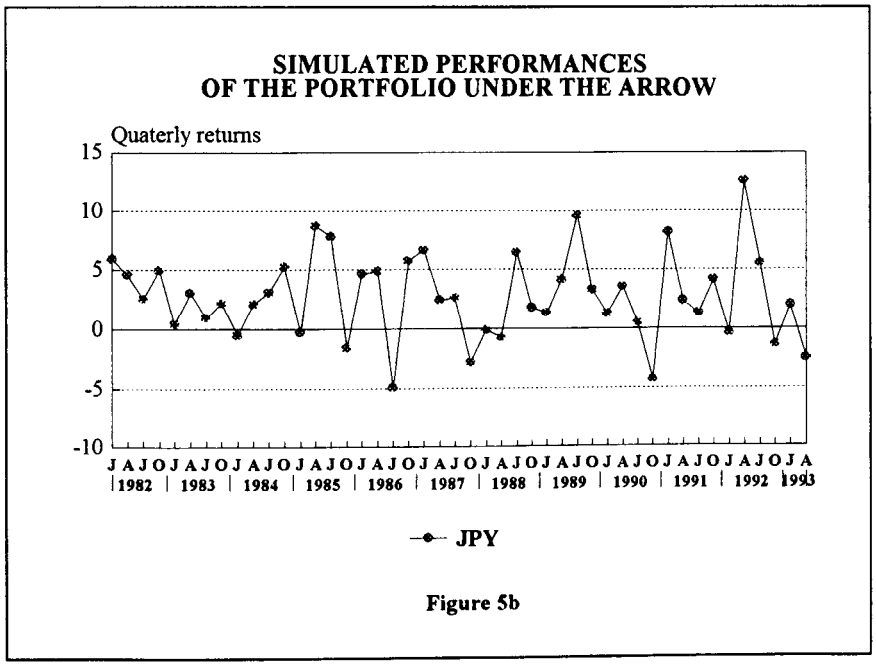

Figure 5b

Investor	Local return	Local risk	Global return	Global risk
FRF	14.84	6.83	**16.02**	**7.40**
GBP	13.88	10.43	**16.72**	**8.77**
DEM	9.09	5.05	**12.94**	**6.63**
USD	12.96	8.03	**14.77**	**10.11**
JPY	8.35	6.55	**11.06**	**7.24**

Table 1

Investor	FRF	GBP	DEM	USD	JPY
Excess return					
/Local benchmark	1.18	3.19	3.85	1.81	2.70
/Internat. benchmark	2.54	1.14	2.16	0.75	1.47
Tracking Error					
/Local benchmark	4.32	11.14	5.24	8.26	8.90
/Internat. benchmark	5.72	6.97	5.76	7.15	7.07
Information ratio					
/Local benchmark	**0.27**	**0.29**	**0.73**	**0.22**	**0.30**
/Internat. benchmark	**0.44**	**0.16**	**0.38**	**0.11**	**0.21**

Table 2

Markets \ Investor	FRF	GBP	DEM	USD	JPY	Total
FRF	**40.8**	**10.3**	**29.5**	**17.5**	**1.9**	100.0
GBP	**17.1**	**51.6**	**8.8**	**16.8**	**5.7**	100.0
DEM	**32.8**	**11.6**	**39.3**	**14.4**	**1.9**	100.0
USD	**18.9**	**12.3**	**1.1**	**66.2**	**1.5**	100.0
JPY	**38.6**	**13.1**	**1.1**	**17.2**	**30.0**	100.0
Total	148.2	98.9	79.8	132.1	41	

Table 3

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