RORY F. KNIGHT

International Asset Allocation: A Swiss Perspective

1.Introduction

International investing has proved to be an extremely risky activity in recent times. The international investor in equities is exposed to two broad categories of risk: local equity market risk and currency market risk. These risk sources have recently exhibited considerable volatility.

The interrelationships among the various equity and currency markets are extremely complex. Professional portfolio managers, nevertheless, require an analytical understanding of these relationships to manage risk adequately when allocating assets internationally.

This article offers an extensive analysis of these relationships to assist practicing portfolio managers who are responsible for the construction and management of international portfolios, in unravelling some of the complexities of their operating domain, viz., the world's equity and currency markets. In addition, the empirical behaviour of the assets in this domain, between January 1980 and December 1987, will be analysed and discussed in order to illustrate the general principles of international asset allocation.

The body of this paper comprises five sections. The next section introduces the concepts of risk and return, followed by two sections on the diversification of risk; currency market risk is addressed and then equity market risk is analysed. The fourth section discusses international asset allocation. The article concludes with a brief summary which includes some portfolio policy recommendations in the light of the empirical and theoretical analysis presented.

Throughout the paper, the numeraire currency is the Swiss franc. The term local currency refers to non-Swiss currency in the context of this paper. A technical appendix to this article formally describes the methods and statistics referred to in the main body of the text.

2.Risk and return: Ex-ante versus ex-post

Consider an investment in the Japanese equity market from the viewpoint of a Yen-based investor. Figure 1 shows the behaviour of the monthly returns on the Tokyo Stock Exchange in local currency between January 1980 and December 1987 [1].

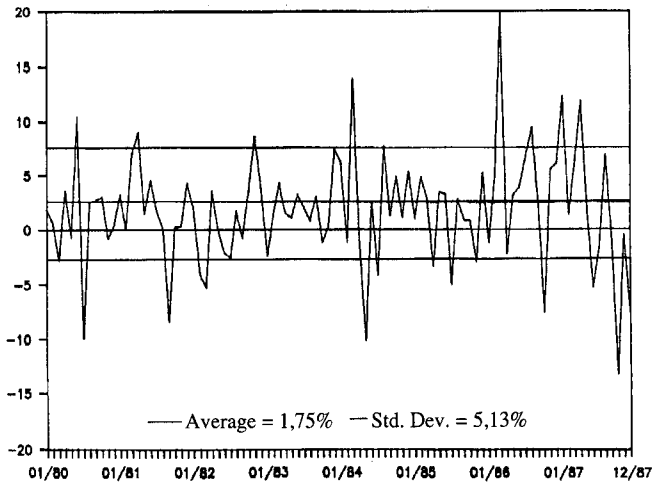


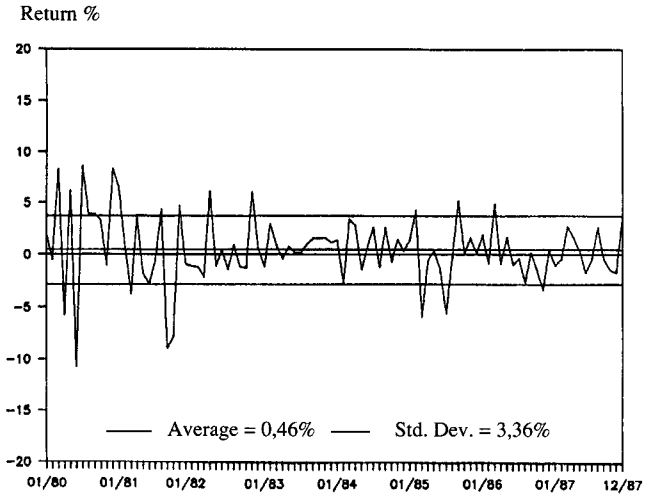
Figure 1: Japanese equity market returns in Yen (January 1980 - December 1987)

During this period, the annualised average monthly return was 20.96% [2]. It will be noticed from Figure 1, however, that the returns varied considerably around this average on a monthly basis. For example, in March 1986 the monthly return on the Tokyo Stock Exchange was a staggering +20.28% while the return in October 1987 was -13.25%. The average within this range was 1,75% as shown in the figure.

The fact that the market has historically fluctuated through such large amplitudes reduces our confidence in making ex-ante estimates.

Ex-post, or after the event, we are able to observe that approximately 66% of the monthly returns on the Tokyo stock market were between -3,38% and +6,88%. Most of the monthly returns, therefore, had a value within 5.13% of the average return. In statistical terms this measure is called the standard deviation of return which is 17.79% on an annualised basis [3]. It is obvious that after the event all that matters is the investment yield. In considering future investments, however, it is necessary to estimate the expected return and to judge the range around this estimate within which the actual future return will fall. A knowledge of the ex-post volatility of returns is, therefore, an important starting point in assessing the ex-ante risks inherent in a particular investment.

Figure 2: Returns on Yen in Swiss Franc (January 1980 - December 1987)



From the viewpoint of a Swiss investor in the Japanese market, Figure 1 captures only part of the ex-post volatility experienced, i.e. equity market risk. The currency market risk is depicted in Figure 2 where the monthly returns on the Yen measured in Swiss franc are plotted over the same interval.

In this case the standard deviation of returns was 3.36% around an average monthly return of 0.46% which on an annualised basis are 11.66% and 5.57% respectively.

As part of his international asset allocation decision, the forward-looking Swiss investor must, therefore, estimate the likely returns to be earned in each equity market in Swiss francs and the associated risk measured by standard deviation of return. In order to transform the estimated return and standard deviation of return of a foreign equity market into his numeraire currency, an international investor, in addition to analysing the equity and local/numeraire currency market separately, must evaluate the relationship between the markets. More specifically, an estimate of return and standard deviation of return in the equity market in local currency and in the local/numeraire currency market must be made. In addition, the likely correlation between these two returns must be estimated.

In our example, the Swiss investor must develop an estimate of the risk and return parameters for both the Tokyo stock market in Yen and the Yen currency market in Swiss franc. The correlation between these two markets must then be estimated.

Table 1 lists the historic values of these risk, return and correlation statistics for 18 equity markets and 17 currency markets. It is clear from Table 1 that although the Tokyo stock market did not outperform all other markets when measured in local currency units, this market did provide the best return per unit risk. Furthermore, the Yen was the only currency to strengthen relative to the Swiss franc on average over this interval. This feature enhanced the ex-post performance of the Tokyo stock market in Swiss franc.

It is interesting to note the average return and risk across the two different types of markets. The equity markets averaged 19.93% (excluding Swit-

Table 1: Historic Values of risk, return and correlation for the stock markets (in local currency) and the currency markets.

Country	Equity Market Return $\bar{R}_i$	Equity Market Risk $\sigma(\tilde{R}_i)$	Currency Market Return $\bar{E}_i$	Currency Market Risk $\sigma(\tilde{E}_i)$	Equity/Currency Correlation $p(\tilde{R}_i,\tilde{E}_i)$
Australia	21.06	26.47	-8.43	15.68	0.19
Austria	10.63	19.95	-1.56	5.59	0.06
Belgium	23.74	20.41	-4.54	8.53	-0.11
Canada	12.88	20.97	-4.94	13.07	0.11
Denmark	17.34	19.38	-4.65	5.93	-0.04
France	19.41	21.47	-6.59	6.66	0.08
Germany	13.69	20.37	-1.84	5.41	0.05
Hong Kong	25.63	36.37	-9.21	13.31	0.26
Italy	30.21	29.15	-7.70	6.87	0.12
Japan	20.96	17.79	5.57	11.66	0.07
Netherlands	19.22	20.56	-2.10	5.31	-0.01
Norway	13.10	28.39	-6.15	8.36	0.05
Singapore	10.76	28.98	-2.59	11.58	0.18
Spain	29.92	23.28	-9.29	8.69	0.11
Sweden	30.72	24.13	-7.34	9.89	-0.04
U.K.	23.38	20.69	-5.25	11.76	0.04
U.S.A.	16.12	17.30	-3.74	13.95	0.00
Switzerland	8.98	16.84			
Non Swiss Avg.	19.93	23.27	-4.73	9.54	0.07
Average	19.32	22.92			

Legend:

$\bar{R}_i$ = *The annualised monthly return on equity market i in local currency.*

$\sigma(\tilde{R}_i)$ = *The standard deviation of* R_i.

$\bar{E}_i$ = *The annualised average monthly return on currency i in Swiss franc.*

$\sigma(\tilde{E}_i)$ = *The standard deviation of* E_i.

$p(\tilde{R}_i,\tilde{E}_i)$ = *The coefficient of correlation between* R_i *and* E_i.

Note: All statistics have been estimated on monthly data over the interval of January 1980 to December 1987.

zerland) whereas the currency markets in Swiss franc averaged -4.73%.

Furthermore, the equity markets exhibit more than double the volatility observed in the currency markets. These differences are not really that surprising if one considers the different economic processes generating these return series. The equity market return, on the one hand, reflects an investment return. This return is expected to reflect interest rates and market risk premia. The currency market being only an exchange market, on the other hand, generates "returns" that are an economic artefact. Changes in exchange rates are expected to reflect adjustments to accommodate expected inflation differentials across countries. The magnitude of these adjustments is inevitably less than the nominal equity market returns and the direction of the adjustments may be expected to be positive or negative.

As indicated above, Table 1 shows that over the interval under investigation, the Swiss franc outperformed all currencies except the Yen. Does this mean that any foreign investments made by Swiss investors, other than in Japan, were detrimental to portfolio performance? Prima facie, given the negative returns on all other currencies and given the currency market volatility, one might be tempted to answer this question in the affirmative. In order to answer adequately the question one must investigate in more depth the world equity and currency market structure.

3. Diversifying currency market risk

Let us now consider the net effect on the returns from the Japanese equity market in Swiss franc. The annualised average monthly return was 26.53% (see Table 2). Notice that this is equal to the combined effect of the return on the equity market in local currency (20.96%) and the return on the currency market (5.57%) (see Table 1). Surprisingly, perhaps, the standard deviation of returns (volatility) on the Japanese market in Swiss franc was not 29.45% (17.79 + 11.66), as one may have expected, but only 21.9% (see Table 2). Some risk has been removed. The combination of equity and currency markets has resulted in an element of risk being removed by diversification. In this case, some 65% of the currency risk is removed so that only 35% persists after the transformation of the Japanese equity market returns, in Yen, into Swiss franc. This effect is not peculiar to the Japanese market, in fact, this 65% removal of currency risk is well below the average of 74% as shown in Table 2.

Table 2: Historic values of risk diversification

Country	Market Equity	Risk Currency	Equity/ Currency Correlation	Swiss franc Return	Risk	Currency Risk Removed
	$\sigma(\tilde{R}_i)$	$\sigma(\tilde{E}_i)$	$p(\tilde{R}_i,\tilde{E}_i)$	$\bar{R}_i^{sf}$	$\sigma(\tilde{R}_i^{sf})$	
Australia	26.47	15.68	0.19	12.63	33.26	57%
Austria	19.95	5.59	0.06	9.08	21.06	80%
Belgium	20.41	8.53	-0.11	19.21	21.26	90%
Canada	20.97	13.07	0.11	7.94	25.93	62%
Denmark	19.38	5.93	-0.04	12.70	20.03	89%
France	21.47	6.66	0.08	12.82	23.00	77%
Germany	20.37	5.41	0.05	11.85	21.32	82%
Hong Kong	36.37	13.31	0.26	16.42	41.88	59%
Italy	29.15	6.87	0.12	22.51	30.76	76%
Japan	17.79	11.66	0.07	26.53	21.90	65%
Netherl.	20.56	5.31	-0.01	17.12	21.16	89%
Norway	28.39	8.36	0.05	6.96	29.98	81%
Singapore	28.98	11.58	0.18	8.17	33.11	64%
Spain	23.28	8.69	0.11	20.63	25.70	72%
Sweden	24.13	9.89	-0.04	23.38	25.72	84%
U.K.	20.69	11.76	0.04	18.13	24.19	70%
U.S.A.	17.30	13.95	0.00	12.38	22.22	65%
Swiss	16.84			8.98	16.84	
Non Swiss Avg.	23.27	9.54	0.07	15.20	26.03	74%
Average	22.92			14.86	25.52	

Legend:

$\sigma(\tilde{R}_i)$ = *The annualised standard deviation of the monthly return on equity market i in local currency.*

$\sigma(\tilde{E}_i)$ = *The annualised standard deviation of the monthly return on currency i in Swiss franc.*

$p(\tilde{R}_i,\tilde{E}_i)$ = *The coefficient of correlation between* $\tilde{R}_i$ *and* $\tilde{E}_i$.

$\bar{R}_i^{sf}$ = *The annualised average monthly return on equity market i in Swiss franc.*

$\sigma(\tilde{R}_i^{sf})$ = *The standard deviation of* $\bar{R}_i^{sf}$

Note: All statistics have been estimated on monthly data over the interval of January 1980 to December 1987.

This phenomenon is, of course, due to the lack of correlation between a country's equity market and the market for its currency. Table 2 column 3, shows that the average correlation between a country's equity market returns and the returns on the market for its currency measured in Swiss franc was only 0.07. In the case of Belgium, the correlation was, in fact, negative where almost all of the currency risk was removed. The highest correlation between equity and currency market was Australia (0.19) and even in this case, 57% of the currency risk was removed in combination with the stock market.

The analysis presented illustrates the removal of currency risk by diversification. It is useful to distinguish diversification of currency risk from hedging currency risk. The former manages currency risk by exploiting the lack of correlation between the two markets of interest. Whereas the latter requires another position to be taken which is exactly opposite to the position to be hedged. In this case, an amount is borrowed in the foreign country to finance the equity market investment in that country. The borrowing is equivalent to taking a short position in the currency against the long position in the currency implied in the equity investment.

Notice that hedging neutralises a position that continues to be held. Here, neutralise implies that all risks and returns are eliminated. Clearly, if a significant proportion of currency risk is removed via diversification, as suggested in the results, only the residual currency risk requires to be hedged. On average, this residual risk was only 26% of the total currency risk. See STULZ (1987) for a discussion on currency hedging in the context of international portfolio management.

It will be appreciated that if the diversification effect is ignored, an over-hedging may occur.

Traditional concern with the volatility of the currency markets may be misplaced in international portfolio management. The existence of exchange rate variability should not be a major hindrance to international diversification, particularly for the Swiss investor.

4. Diversifying equity market risk

After a careful analysis of the relationships between each foreign country equity market and the currency market of each country relative to the Swiss

franc, our Swiss investor is able to transform his risk and return estimates in local currency into Swiss franc measures (see Appendix). The historic averages for these statistics are given in Table 2.
Notice that the Swiss market was the least volatile on average during the study period. Given that the Swiss equity market may be expected to continue to be the least volatile, what are the incentives for a risk averse Swiss investor to consider international investment? The answer is, of course, that combinations or portfolios of the markets described in Table 2 will have better risk/reward characteristics than any of the individual markets.
Each individual asset's total risk may be conceived of as having an element which is diversifiable on combination with other assets. The proportion of the total risk which is diversifiable will depend on the degree of correlation among the assets to be combined. This is the same principle by which currency risk is diversified (see Section 3).
Consider again an investment in the Japanese equity market by a Swiss investor. Assume our investor has developed expectations of return, risk and correlation equal to the historic averages of these statistics. Table 3 summarises the risk and return parameters for the Japanese and Swiss equity markets and those for the minimum risk portfolio of those two assets. (See Appendix for minimum risk portfolio and two asset portfolio calculations.)
In combining the two markets our Swiss investor is able to increase his expected return by approximately 65% and, at the same time, reduce his risk by approximately 12%. Thus the potentially large benefits from international diversification can be demonstrated. As indicated above, the extent to which country specific risk can be diversified depends on the correlation between the returns on the home country market and the returns on the foreign country market. In our example, a correlation of 0.24 was implied in the minimum risk combination. This represents the historic correlation between the Japanese and Swiss equity market returns in Swiss franc. This diversification principle applies to multi-asset (country) portfolios as well. The calculations become more tedious and require an analysis of the

Table 3: Risk and return parameters for the Japanese and Swiss equity markets

Portfolio	Return $\bar{R}_p^{sf}$	Risk $\sigma(\tilde{R}_p^{sf})$
100% Japan	26.53	21.9
100% Switzerland	8.98	16.84
1/3 Japan 2/3 Switzerland	14.83	14.79

Legend:
$\bar{R}_p^{sf}$ = *The annualised average monthly return on portfolio p in Swiss franc.*
$\sigma(\tilde{R}_p^{sf})$ = *The standard deviation of* $\tilde{R}_p^{sf}$.

Note: All statistics have been estimated on monthly data over the interval of January 1980 to December 1987.

cross-correlations of all the assets in the investment universe. The various formulae for calculating the risk and return characteristics of two asset and multi-asset portfolios are given in the Appendix to this article. A full historic cross correlation matrix for the 18 markets included in this study is reported in Table 6. These results will be discussed in the next section.
In order to estimate the proportion of a country's total risk that is diversifiable, it is useful to compute its correlation with a world market portfolio. In this way, the average correlation of each market with all other markets is measured in summary form.
Table 4 contains statistics measuring the relationship between each market and the Morgan Stanley Capital International World index [4]. Column 1 in Table 4 reports the country Beta for each equity market. This statistic measures the sensitivity of a country's equity market returns to the returns on the world index. The world index is used here to represent the average returns on all markets [5].
Column 2 of the same table reports the correlation coefficient between the return on each equity market and the returns on the world index. Notice that, not surprisingly, the U.S. is highly correlated with the index since the U.S. market constitutes over 40% of the index. The correlation coefficient may be interpreted, in this context, as the proportion of the country specific risk that is not diversifiable

Table 4: Relationships with World index (all data in Swiss franc)

Country	(1) Beta	(2) Correlation	(3) Risk Total	(4) Risk Systematic	(5) Risk Unsystematic	(6) Beta
	β_i	$p(\tilde{R}_i^{sf}, \tilde{R}_w^{sf})$	$\sigma(\tilde{R}_i^{sf})$	$\sigma(\tilde{R}_{is}^{sf})$	$\sigma(\tilde{\varepsilon}_i^{sf})$	βi
				(2)x(3)	(3)-(4)	$4/\sigma(\tilde{R}_w^{sf})$
Australia	1.22	0.65	33.26	21.61	11.65	1.20
Austria	0.32	0.27	21.06	5.61	15.45	0.32
Belgium	0.64	0.53	21.26	11.23	10.03	0.64
Canada	1.20	0.82	25.93	21.21	4.72	1.20
Denmark	0.57	0.50	20.03	10.03	9.99	0.57
France	0.77	0.59	23.00	13.55	9.45	0.77
Germany	0.64	0.53	21.32	11.26	10.06	0.64
Hong Kong	1.24	0.52	41.88	21.92	19.96	1.24
Italy	0.90	0.52	30.76	15.95	14.81	0.90
Japan	0.78	0.63	21.90	13.82	8.08	0.78
Netherlands	0.91	0.76	21.16	15.99	5.17	0.91
Norway	1.01	0.60	29.98	17.89	12.09	1.01
Singapore	1.15	0.61	33.11	20.22	12.89	1.15
Spain	0.70	0.48	25.70	12.40	13.29	0.70
Sweden	0.80	0.55	25.72	14.09	11.63	0.80
U.K.	1.01	0.74	24.19	17.87	6.31	1.01
U.S.A.	1.16	0.92	22.22	20.50	1.72	1.16
Switzerland	0.59	0.62	16.84	10.49	6.35	0.59
Non Swiss Avg.	0.88	0.60	26.03	15.60	10.43	0.88
Average	0.87	0.60	25.52	15.31	10.20	0.87

Legend:

β_i = *The ordinary least squares regression slope coefficient estimated by regressing* $\tilde{R}_i^{sf}$ *on* $\tilde{R}_w^{sf}$.

$\tilde{R}_i^{sf}$ = *The annualised average monthly return on equity market i in Swiss franc.*

$\tilde{R}_w^{sf}$ = *The annualised average monthly return on the Morgan Stanley Capital International World Index in Swiss franc.*

$\sigma(\tilde{R}_i^{sf})$ = *The standard deviation of* $\tilde{R}_i^{sf}$

$\sigma(\tilde{R}_{is}^{sf})$ = *The standard deviation of the systematic return on equity market i relative to the world index, in Swiss franc.*

$\sigma(\tilde{\varepsilon}_i^{sf})$ = *The standard deviation of the unsystematic return on equity market i relative to the world index, in Swiss franc.*

$p(\tilde{R}_i^{sf}, \tilde{R}_w^{sf})$ = *The coefficient of correlation between* $\tilde{R}_i^{sf}$ *and* $\tilde{R}_w^{sf}$.

Note: All statistics have been estimated on monthly data over the interval of January 1980 to December 1987.

within a portfolio with the same constituents as the index. Columns 4 and 5 report the non-diversifiable (or systematic) risk and the diversifiable (or unsystematic) risk respectively. This decomposition of risk into diversifiable and non-diversifiable components provides a useful measure of the degree to which a particular country's risk would be removed if combined with the other countries' in proportion to market capitalisation. The equity market with the least correlation, relative to the world index, is Austria, thus in Swiss franc terms, 73% of Austrian equity market risk would be diversified if the world index represented an actual portfolio. For this reason, it will be shown that Austria is a rather attractive diversification vehicle for Swiss investors.

It will be noted in Table 4 that Columns 1 and 6 are the same. Column 6 demonstrates that Beta may be interpreted as representing the proportion of systematic risk to the world index risk [6]. The implications of the results reported in Table 4 are extremely encouraging for international investors. The benefits of international diversification can be illustrated as follows. In Table 2, it will be noted that the average return and risk in Swiss franc was 14.86% and 25.52% respectively. A portfolio which emulated the world index, however, yielded a return of 15.71% which is marginally higher. The risk of this portfolio, however, was only 17.64%. This represents a reduction in risk of approximately 40%. This reduction is due to the average correlation of 0.60 (see Table 4). That is, on average, 40% of country specific equity market risk was diversifiable [7]. This example illustrates the power of diversification and demonstrates that international diversification reduces risk and does not merely average risk.

Swiss investors were able, on average, to remove 40% of the risk in the world's equity market by investing internationally.

It should now be obvious that effective risk management in international investing requires a careful and on-going analysis of the interrelationships among the world equity markets. In particular, the correlation among equity market returns is an important determinant of the benefits of international diversification.

The full extent to which equity market risk has been diversified may now be examined. On average, the individual equity market returns in local currency had an average standard deviation of 22.92% (Table 1). Finally, in Swiss franc terms, in the context of a world portfolio, the average remaining risk was 15.31% (Table 4, Column 4). Approximately 35% on average of country specific risk, therefore, is diversified despite the volatility introduced by the currency markets.

Prior to proceeding to the next section on international asset allocation, it may be helpful to summarise the effects of currency market risk on international portfolio selection.

In Section 2, it was demonstrated that on average only 26% of currency volatility persisted from a Swiss franc perspective. The currency factor, however, has another more subtle effect at the next stage of diversification, i.e., at the stage where multi-country portfolios are constructed in the investor's numeraire currency. In general, the existence of currency volatility increases the correlation among country equity market returns when measured in a foreign currency. Table 5 sets out the correlation coefficients between each country's equity market and the world index measured in local currency units (Column 2). Column 1 shows the same statistic measured in Swiss franc. Thus a measure of the currency risk induced correlation is developed in column 3. On average, a 26% increase in correlation is observed. This increase naturally reduces the benefits of international diversification [8].

The two currency effects appear to be far less than previously thought. In any event, the benefits of international diversification appear to compensate adequately for the currency disturbance.

Table 5: Correlation with World Index

Country	Correlation with World Index: Swiss franc $p(\tilde{R}_i^{sf}, \tilde{R}_w^{sf})$	Correlation with World Index: Local currency $p(\tilde{R}_i^{Lc}, \tilde{R}_w^{Lc})$	Currency Induced Correlation
Australia	0.65	0.37	77%
Austria	0.27	0.19	37%
Belgium	0.53	0.48	11%
Canada	0.82	0.68	20%
Denmark	0.50	0.45	11%
France	0.59	0.53	12%
Germany	0.53	0.49	9%
Hong Kong	0.52	0.24	118%
Italy	0.52	0.44	17%
Japan	0.63	0.62	1%
Netherlands	0.76	0.74	2%
Norway	0.60	0.53	12%
Singapore	0.61	0.42	44%
Spain	0.48	0.38	28%
Sweden	0.55	0.47	17%
U.K.	0.74	0.64	15%
U.S.A	0.92	0.85	8%
Switzerland	0.62	0.62	0%
Non Swiss Avg.	0.60	0.50	26%
Average	0.60	0.51	24%

Legend:

$p(\tilde{R}_i^{sf}, \tilde{R}_w^{sf})$ = *The coefficient of correlation between the return on equity market i and the return on the Morgan Stanley Capital International World Index in Swiss franc.*

$p(\tilde{R}_i^{Lc}, \tilde{R}_w^{Lc})$ = *The coefficient of correlation between the return on equity market i and the return on the Morgan Stanley Capital International World Index in local currency.*

Note: All statistics have been estimated on monthly data over the interval of January 1980 to December 1987.

5. International asset allocation

In Section 4, it was argued that there were significant benefits from international diversification. As an example of an internationally diversified portfolio, a world equity market index was analysed. This surrogate portfolio was shown to have an annuali-

sed average monthly return during the study period of 15.71% with a standard deviation of 17.64%.
With a more precise analysis, however, our Swiss investor may be able to construct other portfolios, from among the equity markets available which have superior risk return characteristics.
MARKOWITZ (1959) developed a mathematical method to select efficient portfolios from a defined universe of assets. The required inputs for the Markowitzian portfolio selection are: risk and return estimates (i.e. standard deviation and return) for each asset and the correlation coefficient for each possible pair of assets in the universe. These input statistics, based again on the ex-post measurements, for the 18 equity markets are listed in Table 6.
The Markowitz portfolio selection method was then applied to the data to generate an efficient frontier. An efficient frontier represents that set of portfolios which dominate all other assets or combinations of assets. Dominate in this context means that an efficient portfolio offers the highest return in its risk class, i.e. it dominates or is unambiguously preferred to all other assets and portfolios with the same risk [9].
A sample of five of the portfolios from the efficient frontier generated in the analysis are described in Table 7.
The five portfolios are displayed in order of increasing risk. It is important to observe that it is not possible to determine which of these portfolios is optimal without specifying the investor's risk preferences. This decision is purely subjective and is determined by the investor's degree of risk aversion. Notice that it is only at this stage of the portfolio management process that the risk preferences of the investor are brought into account [10].
The most striking feature of the portfolios in Table 7 is that the Swiss equity market is included in only the least risky portfolio and even then only with a weighting of 1.26%.
Another surprise is that most equity markets are excluded. This is particularly surprising in the case of the U.S. and the U.K. equity markets which have been popular among Swiss investors as off-shore investments.
It appears from the analysis that Japan and Sweden have been the most effective international diversification vehicles for the Swiss investor. These two equity markets were included in all portfolios along the efficient frontier. At the lower risk end of the frontier, the Belgian and Spanish are the next most highly weighted equity markets. Finally, in the lowest risk portfolios, the Austrian and Danish equity markets are included along with the Swiss equity market.
Why is it that some equity markets were completely ignored in the efficient frontier portfolios? The optimisation procedure may be intuitively described as follows. The highest return asset is selected as being efficient, clearly it is the dominant asset in its risk class. Remember that, although some of the

Table 6: Correlation matrix

	Australia	Austria	Belgium	Canada	Denmark	France	Germany	Hong Kong	Italy	Japan	Holland	Norway	Singapore	Spain	Sweden	SWISS	UK	US
Return	12.631	9.078	19.206	7.943	12.695	12.819	11.849	16.423	22.509	26.533	17.117	6.955	8.170	20.627	23.377	8.982	18.125	12.381
Std. Deviation	38.259	21.063	21.259	25.937	20.028	23.002	21.324	41.884	30.763	21.899	21.165	29.977	33.116	25.700	25.720	16.840	24.189	22.226
Correlation coefficients:																		
Australia	1.000	0.162	0.368	0.680	0.339	0.377	0.360	0.527	0.320	0.340	0.472	0.547	0.567	0.406	0.453	0.507	0.599	0.562
Austria	0.162	1.000	0.338	0.238	0.060	0.388	0.490	0.261	0.225	0.038	0.315	0.221	0.106	0.233	0.242	0.428	0.236	0.260
Belgium	0.368	0.338	1.000	0.374	0.304	0.589	0.515	0.326	0.385	0.345	0.539	0.559	0.327	0.321	0.329	0.549	0.503	0.429
Canada	0.680	0.238	0.374	1.000	0.421	0.425	0.373	0.459	0.394	0.333	0.655	0.527	0.548	0.390	0.464	0.556	0.691	0.786
Denmark	0.339	0.060	0.304	0.421	1.000	0.272	0.295	0.308	0.341	0.277	0.423	0.379	0.351	0.253	0.246	0.342	0.363	0.479
France	0.377	0.388	0.589	0.425	0.272	1.000	0.508	0.282	0.478	0.370	0.530	0.539	0.224	0.412	0.346	0.525	0.499	0.475
Germany	0.360	0.490	0.515	0.373	0.295	0.508	1.000	0.388	0.314	0.264	0.624	0.464	0.251	0.340	0.381	0.750	0.420	0.462
Hong Kong	0.527	0.261	0.326	0.459	0.308	0.282	0.388	1.000	0.411	0.262	0.558	0.460	0.530	0.374	0.442	0.468	0.554	0.451
Italy	0.320	0.225	0.385	0.394	0.341	0.478	0.314	0.411	1.000	0.429	0.403	0.236	0.261	0.426	0.412	0.308	0.423	0.379
Japan	0.340	0.038	0.345	0.333	0.277	0.370	0.264	0.262	0.429	1.000	0.347	0.248	0.270	0.363	0.267	0.240	0.344	0.357
Holland	0.472	0.315	0.539	0.655	0.423	0.530	0.624	0.558	0.403	0.347	1.000	0.635	0.461	0.354	0.453	0.668	0.678	0.702
Norway	0.547	0.221	0.559	0.527	0.379	0.539	0.464	0.460	0.236	0.248	0.635	1.000	0.463	0.293	0.472	0.598	0.557	0.551
Singapore	0.567	0.106	0.327	0.548	0.351	0.224	0.251	0.530	0.261	0.270	0.461	0.463	1.000	0.248	0.417	0.357	0.533	0.620
Spain	0.406	0.233	0.321	0.390	0.253	0.412	0.340	0.374	0.426	0.363	0.354	0.293	0.248	1.000	0.323	0.323	0.423	0.388
Sweden	0.453	0.242	0.329	0.464	0.246	0.346	0.381	0.442	0.412	0.267	0.453	0.472	0.417	0.323	1.000	0.495	0.494	0.514
SWISS	0.507	0.428	0.549	0.556	0.342	0.525	0.750	0.468	0.308	0.240	0.668	0.598	0.357	0.323	0.495	1.000	0.532	0.597
UK	0.599	0.236	0.503	0.691	0.363	0.499	0.420	0.554	0.423	0.344	0.678	0.557	0.533	0.423	0.494	0.532	1.000	0.637
US	0.562	0.260	0.429	0.786	0.479	0.475	0.462	0.451	0.379	0.357	0.702	0.551	0.620	0.388	0.514	0.597	0.637	1.000

Table 7: Five efficient portfolios

	2 Asset Portfolio	Efficient Portolios 1	2	3	4	5
Characteristics:						
Return	14.83	18.75	24.07	25.10	25.71	25.83
Std. deviation	14.79	13.69	17.01	18.18	19.11	19.36
Portfolio weightings:						
Australia	0%	0%	0%	0%	0%	0%
Austria	0%	19.64%	0%	0%	0%	0%
Belgium	0%	11.39%	17.24%	5.90%	0%	0%
Canada	0%	0%	0%	0%	0%	0%
Denmark	0%	18.81%	0%	0%	0%	0%
France	0%	0%	0%	0%	0%	0%
Germany	0%	0%	0%	0%	0%	0%
Hong Kong	0%	0%	0%	0%	0%	0%
Italy	0%	0%	0%	0%	0%	0%
Japan	33%	31.60%	51.63%	64.97%	73.98%	77.74%
Netherlands	0%	0%	0%	0%	0%	0%
Norway	0%	0%	0%	0%	0%	0%
Singapore	0%	0%	0%	0%	0%	0%
Spain	0%	5.42%	7.96%	3.01%	0%	0%
Sweden	0%	11.88%	23.18%	26.12%	26.02%	22.26%
Switzerland	67%	1.26%	0%	0%	0%	0%
U.K.	0%	0%	0%	0%	0%	0%
U.S.A.	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%

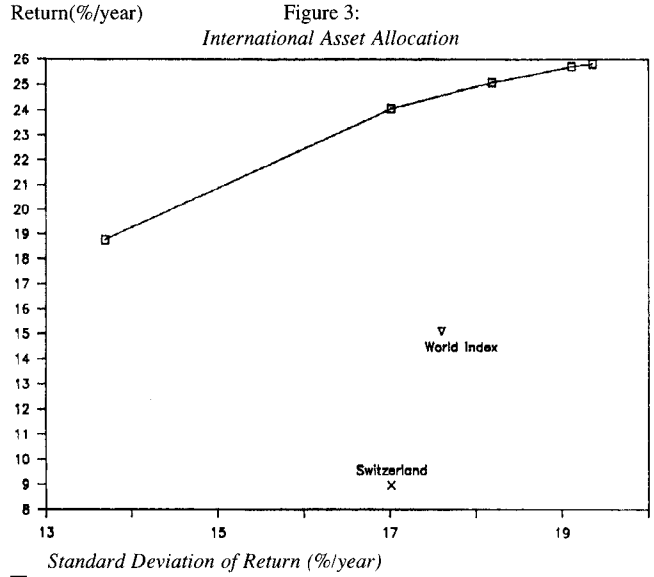
risk of this asset may be diversified when it is combined with other assets, the return of the portfolio will have to be lower. This is so because the return of a portfolio is a weighted average of its constituent assets.

The optimisation procedure then seeks, iteratively, different combinations of assets which cause the maximum reduction of risk relative to the highest return asset for a given marginal reduction in return. Clearly, assets which are highly uncorrelated with one another, which have high returns and low risks will be highly desirable. In the analysis presented here, the Japanese equity market was the highest return asset and, because of its low correlation with all other assets, it was retained throughout the efficient frontier. Any asset that is highly correlated with the others will not be a likely candidate for inclusion in an efficient portfolio since it will not reduce the risk of the portfolio significantly. In contrast to the Japanese equity market, the American, British and Swiss equity markets are highly correlated with the other markets and particularly among themselves. One would not expect, therefore, to have all three included in an efficient portfolio.

The German and Austrian equity markets represent two useful points of reference in this analysis. Notice that the Austrian equity market had a lower return than the German market (see Table 6) and exhibited approximately the same level of risk. Despite the apparent dominance of the Austrian equity market by the German equity market in risk/return terms, the Austrian equity market was selected in preference to the German equity market. The answer to the paradox is, of course, that the Austrian equity market was, on average, much less correlated with all the other assets than the German equity market. Notice that the highest coefficient of correlation between two different equity markets is between the German and Swiss markets (0.75). It is hardly surprising, therefore, that the German equity market is not a very effective diversification medium for Swiss investors.

The results are presented graphically in Figure 3. As a point of reference, the Swiss equity market is included on the risk/return plane depicted in Figure 3. Notice how the efficient frontier dominates the

Figure 3:
International Asset Allocation



individual market and, indeed, the efficient portfolios dominate all assets and other possible combinations of these assets. The world equity market index is also included on this plane [11]. While this index was shown, in the previous section, to provide considerable diversification benefits for Swiss investors, it is clear that by employing sophisticated asset allocation models, the benefits of international diversification can be significantly enhanced [12].

It is unlikely that the portfolios suggested in Table 7 are representative of the portfolios held by Swiss investors, private or institutional.

It is strongly emphasised that the portfolios in Table 7 are not recommended portfolios. These have been generated with historic data - real portfolios should be generated using ex-ante estimates. The fact that, in Table 7, most markets are ignored is, of course, surprising and may be the result of outliers in the observation period. Alternative methods of dealing with this problem have been suggested in the literature. In particular JORION (1985) and (1986) suggests a Bayes-Stein approach for estimating the ex-ante expected returns for use in solving the portfolio problem. Such adjustments are beyond the scope of this paper.

EUN and RESNICK (1988) report the inter-temporal instability of ex-post estimates of risk and return on a subset of the assets studied here, in six month intervals between January 1980 and December 1985. The relative inter-temporal stability of the variance-covariance matrix of international stock index returns is also, however, reported by EUN and RESNICK (1988). Caution should be exercised, therefore, when applying the results in a practical way.

Furthermore, other considerations may constrain investments in certain equity markets, e.g.: [13]

1) Limited size.
2) Lack of liquidity.
3) Lack of information.
4) Taxes biased against foreigners.
5) High transaction costs.
6) Restriction on the repatriation of funds.
7) Personal constraints, e.g. ethically based.

The statistical analysis of the behaviour of the world currency and equity markets, and their interrelationships during an important period of recent history should be the starting point for international asset allocation. Although it is likely that the expected returns and volatility will continuously change, the underlying covariance structure of the markets has been relatively stable [14]. The statistical results offered in this paper may provide, therefore, a useful input for practicing fund managers. The analysis presented in this paper, however, does have a number of important portfolio policy implications for international asset allocation which are discussed in the conclusion.

6. Summary and conclusion

This article reports results which may at first seem surprising but which are fully explainable in the analysis presented. In summary, the results suggest that currency risk has a rather small effect on the risk of an individual foreign equity market. On average, approximately 74% of the currency risk is removed in the case of the world currency markets in Swiss franc.

The major policy recommendation for portfolio managers, in the light of this finding, is that analytical effort should be diverted from estimating short-term exchange rate movements, to investigating the fundamental relationship between exchange rate and equity market movements.

The second finding reported was the extent of the benefits of international diversification in the Swiss case. Relative to a world equity market index, it was shown that on average 35% of a given country's equity market risk could be diversified internationally. This magnitude is encouraging if one considers that it includes any residual currency risk which may persist in the world index when measured in the Swiss numeraire.

A possible policy implication here is that passive investing in equity markets in proportion to their market capitalisation is likely to result in significant risk reduction benefits.

Thirdly, it was shown that historically the Japanese and the Swedish equity markets were the most effective diversification media for the Swiss investor. The American and British equity markets, traditionally favoured by Swiss international investors, appear inferior in a risk/return sense because of their high correlation with most of the world's equity markets.

Tentatively, it is suggested that a reallocation of funds away from the U.S. and the U.K. equity markets toward the Japanese equity market would be advisable.

The final on-going policy recommendation is that fund managers should see the world equity and currency markets in a holistic way rather than as separate parts with structural linkages. These ideas have potentially significant implications for the organisational design and strategy of investment firms and investment departments. Organising these systems into units with regional responsibility may produce a view of the world which obscures the systematic relationships which need to be well understood for effective global asset management.

The results and analysis presented in this article have been based on the developments in modern finance theory which have considerably extended our understanding of the function of capital markets and the role of portfolio management.

The purpose of the article is not to suggest a submission of judgement to mathematical manipulation but rather to provide a way of thinking about the international asset allocation problem. The supplement of professional investment judgement with precise scientific analysis will, of course, provide fund managers a competitive edge in an increasingly competitive industry [15].

Appendix

The Mechanics of International Asset Allocation

1. Data and statistical measures:

This study was based on monthly data for the interval January 1980 through December 1987. Monthly equity returns and currency market returns in U.S. dollar terms were obtained from the Morgan Stanley Capital International perspective, monthly issues.

Return data in U.S. dollars may be transformed into local currency units as follows:

$$\tilde{R}_{it} = \tilde{R}^{\$}_{it} - \tilde{e}_{it} - (\tilde{R}^{\$}_{it} \cdot \tilde{e}_{it}) \quad (1)$$

which is approximated by:

$$\tilde{R}_{it} = \tilde{R}^{\$}_{it} - \tilde{e}_{it} \quad (2)$$

where:

R_{it} = return in period t on the ith equity market in local currency units.

$R^{\$}_{it}$ = return in period t on the ith equity market in U.S. dollars.

e_{it} = change in the value of the local currency unit relative to the U.S. dollar in period t.

$\sim$ denotes a random variable.

The latter transformation was employed in this study.

The standard deviation of returns was computed as follows:

$$\sigma^2(\tilde{R}_i) = \frac{\sum_{t=1}^{T}(R_{it} - \bar{R}_i)^2}{T-1} \quad (3)$$

where:

$\sigma(\tilde{R}_i)$ = the standard deviation of R_i.

R_{it} = the return on the i^{th} equity market in period t, adjusted for dividends.

$\bar{R}_i$ = the average monthly return on the i^{th} equity market over the period t = 1 to T.

T = the number of periods, 96 months in this study.

Standard deviation of monthly returns is annualised by multiplying it by $\sqrt{12}$. The currrency market/ equity market correlation coefficient was computed per (4).

$$p(\tilde{R}_i,\tilde{E}_i) = \frac{Cov(\tilde{R}_i,\tilde{E}_i)}{\sigma(\tilde{R}_i)\sigma(\tilde{E}_i)} \quad (4)$$

where:

$Cov(\tilde{R}_i,\tilde{E}_i)$ = the covariance between $\tilde{R}_i$ and $\tilde{E}_i$.

$\tilde{E}_i$ = the return on the i^{th} currency market in Swiss franc.

$p(\tilde{R}_i,\tilde{E}_i)$ = the correlation between $\tilde{R}_i$ and $\tilde{E}_i$.

2. Transformation of equity market returns in local currency to Swiss franc returns:

$$\tilde{R}_{it}^{sf} = \tilde{R}_{it} + \tilde{E}_{it} + (\tilde{R}_{it} \cdot \tilde{E}_{it}) \quad (5)$$

$$\tilde{R}_{it}^{sf} = \tilde{R}_{it} + \tilde{E}_{it} \quad (6)$$

$$\sigma^2(\tilde{R}_i^{sf}) = \sigma^2(\tilde{R}_i) + \sigma^2(\tilde{E}_i) + 2Cov(\tilde{R}_i,\tilde{E}_i) \quad (7)$$

where:

$\tilde{R}_{it}^{sf}$ = return in period t on the i^{th} equity market in Swiss franc.

Other expressions are as previously defined.

3. Risk and return measures on two country portfolios:

$$\tilde{R}_p^{sf} = W_i\tilde{R}_i^{sf} + W_j\tilde{R}_j^{sf} \quad (8)$$

where:

W_i = proportion of portfolio in the i^{th} equity market.

W_j = proportion of portfolio in the j^{th} equity market.

$$\sigma^2(\tilde{R}_p^{sf}) = W_i^2\sigma^2(\tilde{R}_i^{sf}) + W_j^2\sigma^2(\tilde{R}_j^{sf}) + 2W_iW_jCov(\tilde{R}_i^{sf},\tilde{R}_j^{sf}) \quad (9)$$

$$W_i^* = \frac{\sigma^2(\tilde{R}_j^{sf}) - Cov(\tilde{R}_i^{sf},\tilde{R}_j^{sf})}{\sigma^2(\tilde{R}_i^{sf}) + \sigma^2(\tilde{R}_j^{sf}) - 2Cov(\tilde{R}_i^{sf},\tilde{R}_j^{sf})} \quad (10)$$

where:

W_i^* = proportion of funds in the i^{th} equity market allocated to the minimum risk portfolio.

$W_j^* = 1 - W_i^*$

$\tilde{R}_p^{sf}$ = return on portfolio p in Swiss franc.

$\tilde{R}_j^{sf}$ = return on j^{th} equity market in Swiss franc.

4. World market model statistics:

$$\tilde{R}_{it}^{sf} = \alpha_i + \beta_i\tilde{R}_{wt}^{sf} + \tilde{\varepsilon}_{it}^{sf} \quad (11)$$

where:

$$\beta_i = \frac{Cov(\tilde{R}_i^{sf},\tilde{R}_w^{sf})}{\sigma^2(\tilde{R}_w^{sf})} \quad (12)$$

$$\sigma(\tilde{R}_{is}^{sf}) = p(\tilde{R}_i^{sf},\tilde{R}_w^{sf})\sigma(\tilde{R}_i^{sf}) \quad (13)$$

$\sigma(\tilde{R}_{is}^{s})$ = the standard deviation of the systematic return on the i^{th} equity market relative to the world index measured in Swiss franc.

α,β = ordinary least squares regression coefficients.

$\tilde{R}_{wt}^{sf}$ = the return on the world equity index measured in Swiss franc in period t.

$\tilde{\varepsilon}_{it}^{sf}$ = error term or unsystematic return.

$$\sigma^2(\tilde{R}_i^{sf}) = \sigma^2(\tilde{R}_{is}^{sf}) + \sigma^2(\tilde{\varepsilon}_i^{sf}) \quad (14)$$

5. Risk and return measures on multi-country portfolios:

$$\tilde{R}p^{sf} = \sum_{i=1}^{N} W_i\tilde{R}_i^{sf} \quad (15)$$

$$\sigma^2(\tilde{R}_p^{sf}) = \sum_{i=1}^{N} W_i^2\sigma^2(\tilde{R}_i^{sf}) + \sum_{i=1}^{N}\sum_{\substack{j=1 \\ j\neq i}}^{N} W_iW_jCov(\tilde{R}_i^{sf},\tilde{R}_j^{sf}) \quad (16)$$

$$Cov(\tilde{R}_i^{sf},\tilde{R}_j^{sf}) \approx$$

$$Cov(\tilde{R}_i,\tilde{R}_j) + Cov(\tilde{E}_i,\tilde{E}_j) + Cov(\tilde{R}_i\tilde{E}_i) + Cov(\tilde{R}_j,\tilde{E}_i) \quad (17)$$

N = number of countries in portfolio.

Notation as previously defined.

6. Markowitz portfolio selection:

The efficient frontier is derived using the algorithm suggested by Markowitz:

$$\text{Minimise: } -\lambda\sum_{i=1}^{N} W_i \tilde{R}_i^{sf} + \sum_{i=1}^{N}\sum_{j=1}^{N} W_i W_j \text{Cov}(\tilde{R}_i^{sf}\tilde{R}_j^{sf}) \quad (18)$$

for all possible values of λ from zero to infinity subject to:

$$\sum_{i=1}^{N} W_i = 1$$

Footnotes

[1] The stock market data used in this study were obtained from the monthly issues of Morgan Stanley Capital International perspective, published by Morgan Stanley, Geneva.

[2] All stock market returns are adjusted for dividends.

[3] Standard deviation in monthly return is multiplied by the square root of 12 to annualise the measure.

[4] The Morgan Stanley Capital International World index is an arithmetic average value weighted index of 1,300 stocks from 21 different countries.

[5] For a description and discussion of the linear market model which is used to estimate beta, see SHARPE (1964).

[6] The world index had an annualised average monthly return of 15.71% with a standard deviation of 17.64%.

[7] The average return on the equity markets in Swiss franc per Table 2 does not equal the return on the world index because the former is an unweighted average whereas the latter is a value weighted average.

[8] See EUN and RESNICK (1988) for a discussion of the currency factor in portfolio analysis.

[9] The portfolio selection model proposed by MARKO WITZ essentially via an iterative optimisation proce dure seeks out the combination of assets which minimises the risk of a portfolio for a given return. The appendix formally specifies the general form of the model used. Many computerised versions of this model are commercially available.

[10] Certain investors may wish to introduce certain constraints on the available asset set prior to generating the efficient frontier. Clearly, in such cases preferences are introduced at an earlier stage.

[11] No particular significance regarding world market efficiency and/or international capital asset pricing should be attached to the fact that the world equity market index is not on the efficient frontier. Firstly, the data used are ex-post and the world asset pricing model would need to be specified ex-ante. Secondly, the index may not be an adequate proxy for all the assets in the world (see ROLL (1977)). Thirdly, even if the first two disclaimers were met, it is by no means obvious that investors consuming in different currencies would be induced to hold the same market portfolio (see SOL NIK (1974) and STULZ (1981)).

[12] It is important to observe that the risk/return plane shown in Figure 3 is unique to the Swiss investor in that the risk and return measures for all assets are in Swiss franc. The portfolio viewed in the numeraire of other countries could, therefore, be quite different.

[13] It is a relatively straight forward matter to incorporate these constraints into the methods here applied.

[14] See SHAKED (1985) who suggests that as the invest ment horizon increases, the correlation structure beco mes more stable.

[15] This paper has drawn extensively on the international finance literature, not all of which has been acknowledged. In order to remedy this, the reader is referred to SOLNIK (1988) for an extensive review of the literature in international investments.

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