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Global Optimization for Swiss Pension Funds

1. Introduction

Swiss pension funds have developed rapidly in the past ten years, under the BVG/LPP legislation[1]. The assets of Swiss pension funds are now over 300 billions Sfr. Setting investment objectives for the pension assets in line with the liability structure of the pension plan is a major challenge. In this article we attempt to derive principles that should guide the investment strategy of a Swiss pension fund[2]. We show that a Swiss pension fund should engage in extensive international asset allocation. We also show that equity should be a major component of the asset allocation. In the next section, we discuss the various types of pension plans and study the implications in terms of investment objectives. This is only a stylized analysis outlining simple operational principles, as we do not wish to engage here in a full-fledged modelling of pension liabilities. Such a model is firm-specific and requires to take into account the economics of the firm, the age structure of the current and retired workers, technical assumptions used to calculate pensions and allocate reserves to the various beneficiaries of the pension plan, etc. In section 3, we show why an international investment strategy is justified on the basis of risk diversification. In section 4, we develop this argument by looking at the performance of optimal international asset allocations in comparison with purely domestic ones. In sections 5 and 6 we discuss the practical implementation of optimal strategies, taking into account recent developments. Our conclusions are presented in the last section.

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2. Setting investment objectives for a pension fund

A brief reminder on the economics of a pension fund may be useful for some readers. A pension fund is a rather unique and original institution. Its financial risk structure is quite different from that of insurance companies or other financial institutions. It is useful to present in a stylized fashion its function and its balance sheet. A pension fund is an entity that accumulates and invests the contributions received from current workers (and their employer), while paying benefits to retired workers. The liabilities of the pension funds consist of all the benefits that will have to be paid to the contributors in the future. The assets of the pension fund consist of all its investments. The level of liabilities depends on the accumulated contributions but also on assumptions about salary growth, the demography of employed and retired workers, as well as about the return on assets. The calculation of the liability of the pension fund

is performed by actuaries. For example, they use a technical actuarial rate (i.e. an arbitrary interest rate) to determine the amount of annual pension that can be paid to each pensioner based on his share of accumulated capital. This technical rate is often set at, or around, 4%. These liabilities are firm-specific as they depend on the age structure of current and retired employees. Assets can be invested freely, within the guidelines set by the BVG/LPP and Cantonal authorities. Management of these assets is assumed by internal or external portfolio managers. The portfolio manager rightly focuses on the market value of the assets, but some accounting conventions used might (temporarily) distort the book value of the fund[3]. A major question is to determine the optimal investment strategy for the assets of the pension fund given its liabilities and existing investment constraints and regulations. Too often, the asset-side and the liability-side are treated separately by different professionals with different background. Instead, an Asset-Liability Management (ALM) approach ought to be used. A clear assessment of the pension liabilities, and the factors that will affect their future values, should be used to set the objectives of the asset allocation policy. Swiss pension plans can follow two basic models: defined contribution or defined benefit[4]. These two models are fundamentally very different in terms of the implied liabilities and, therefore, in terms of their implications for investment policy.

2.1 defined-benefit plans

In a defined-benefit plan, the future benefits of the pensioner are guaranteed, usually as a percentage of the last salary (or of some average salary). This means that the liabilities of the pension fund are more or less fixed in real terms; there is a significant risk that the invested accumulated contributions will not be enough to cover the obligations of the plan, especially in periods of accelerating inflation. A basic, although oversimplifying, implication is that the return on invested assets should not fall below the rate of wage increase (Golden rule). This must be true over the very long run. It must also hold over short time-periods (one or a couple of years), otherwise, the pension plan will become underfunded (total assets less than liabilities) and potentially bankrupt. The employer will have to cover the deficit. This risk has materialized for numerous US pension plans, but also for some Swiss pension plans. Over the period 1946-89, Swiss wages had an average annual increase of 5.3% compared to an annual inflation rate of 3%; over the same period the average return on Swiss pension assets was estimated to be around 4.5% [5]. Given the guarantee of liabilities assumed by the pension fund, its investment objectives are fairly straightforward in an ALM approach: The primary objective of the investment policy of a defined-benefit plan ought to be to minimize the risk that the return on invested assets will be below the rate of wage inflation affecting the pension liabilities, in any period. In many countries, pension consultants spend a lot of time studying factors affecting the guaranteed liabilities and designing investment strategies that attempt to minimize the risk of under-funding of the plan. While risk minimization can be achieved through cash-flow-matching or immunization techniques using domestic bonds, when benefits are only guaranteed in nominal terms (fixed dollar or franc amounts), the task is quite difficult when the benefits are guaranteed in real terms. Unfortunately, there are no assets which deliver a steady positive real return indexed on wage inflation. For example, the total return (income plus price variation) on Swiss bonds was well below that of wage inflation in 1989 and 1990. So there are no obvious risk-free strategies and, therefore, no certainty to achieve the objective.

2.2 defined-contribution plans

In all countries, including Switzerland, pension funds have progressively moved towards defined-contribution plans[6] because of the difficulties encountered by defined-benefit plans[7]. In such a system, the contributions are set as a percentage of

the current salary while the future benefits are variable. Future benefits depend on the return on invested assets. This system is less risky for the pension fund and for the employer having to cover its deficit. In a way, the risk is transferred to the employees and pensioners, whose future benefits are uncertain. The level of contributions is set to satisfy some long term objectives expressed in real terms. These long term objectives are often vague and are not contractual guarantees. Minimum objectives[8] are usually quite low and there is no guarantee that the benefits will be indexed on inflation. The minimum rate of contributions capitalization is usually set as a technical rate, often equal to 4%. The income and capital appreciation of invested assets over the value of pension liabilities is used to improve current and future benefits. In the balance sheet of the pension fund, the increase in assets value is directed to various accounting reserves that will serve to raise the benefits paid. Pension funds with a defined-contribution plan carry somewhat less liability risk than defined-benefit plans and can focus on the long term return of invested assets. This ALM analysis suggests a simple objective for the investment strategy: The primary objective of the investment strategy of defined-contribution plans should be to achieve the best long term real return on invested assets. Because excessive fluctuations in annual returns are not desirable given the minimum objectives set in the plan, an acceptable level of return volatility should be selected. Compared to defined-benefit plans, defined-contribution plans should allow somewhat more aggressive investment strategies providing a higher long-term return on assets and, therefore, an easier servicing of pensions. Given the general move towards defined-contribution plans, this article will focus on the investment objective outlined above. As mentioned in the introduction, we will not develop a full-fledged ALM model for a specific pension plan but rather derive some general conclusions that should guide the investment strategy of any pension fund adopting the ALM objectives presented here. We will now show that such an objective requires an extensive international diversification of the investment strategy of a Swiss pension fund.

3. The case for international risk diversification

A preliminary remark is in order. The Swiss bond and stock markets are quite large relative to the size of the economy, but their market capitalization represents only 2% of the world market as shown on Exhibit 1. However Swiss pension fund allocate more than 80% of their assets to domestic investments. One may reflect on the disproportion between the geographic asset distribution of Swiss pension funds and that of the world market capitalizations. The investment strategy of pension funds in other European countries with a funded system (notably the Netherlands and U.K.) tend to be much more international[9].

Besides market size, the major argument for investing internationally is that it increases the profit opportunity while providing risk diversification. It has been repeatedly demonstrated that international diversification reduces the total volatility of the portfolio, i.e. the risk of a large loss in any given quarter or year[10].

The traditional measure of volatility is the standard deviation of return or sigma. It is a well-known

Exhibit 1: Stock market capitalization 1994, Total $ 11.6 Trillions

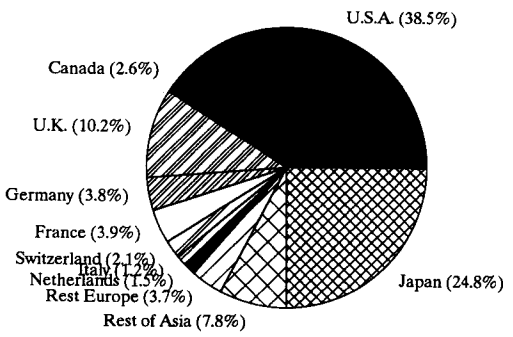
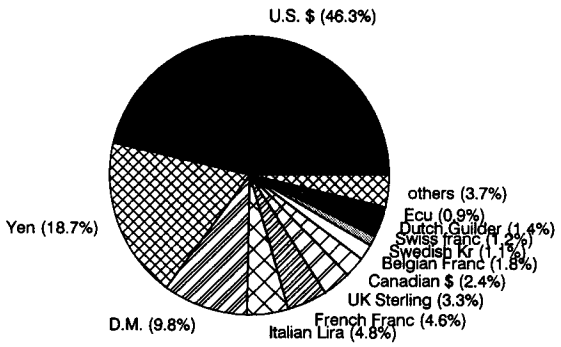


Exhibit 1: Stock market capitalization mid 1994, Total $ 16.3 Trillions



statistical measure of the amplitude of price swings. If we measure sigma in % per year, there is roughly one chance out of six of a shortfall (or negative deviation from the expected return) at least equal to one sigma in any given year. Before developing our argument about international risk diversification, the performance in terms of return and risk of selected major stock and bond markets for the past ten years to Dec. 31, 1993, is given in Exhibit 2. We chose a period of ten years to report long term results; similar conclusions could be reached if we had chosen a period of fifteen or twenty years but we prefer to focus on a more recent period. Some results for the period 1970-1993 are also reported in this article. All calculations are performed in real terms for a Swiss investor. We use a monthly index of Swiss wages[11] as deflator. Thanks to productivity gains, wages tend to rise faster than consumer prices; over this ten-year period, the average yearly wage inflation was 4% per year compared to 3.1% for the CPI inflation. The difference is much larger for the 1970-1993 period; wages grew at an annual rate of 5.5% compared to 4.1% for the CPI. All results reported in this article are based on real Sfr returns, after adjusting for wage inflation.

For each market, we first indicate the annualized average real return calculated in Swiss Franc. This is broken down between: capital gain in local currency, yield and monetary contribution. This last term includes the Swiss wage inflation and currency gains or losses if any. The last two columns give an estimate of the volatility of the markets. We use monthly data to measure the standard deviation of returns in local currency ("risk in LC") and in real Swiss franc ("total risk"). These volatilities are also expressed in per cent per year in real terms.

The Swiss bond market had an average performance of 1.2% in real terms and 5.2% (i.e. 1.2% plus the wage inflation of 4%) in nominal terms. This has been a period of unusually high real interest rates. Over a longer time period, the total return of Swiss bonds, adjusted for wage inflation, is usually close to zero or negative. For the 24-year period since 1970, the real return on Swiss bonds is slightly negative (-0.1% per year). One should not forget that all these figures exclude taxes, transaction costs and management fees. The volatility of the Swiss bond market is only 3.7%, but this reflects partly its illiquidity. The other bond markets have been better performing but also much more volatile over the period; for example the US bond market had an average annual performance of 4.2% in real Sfr; it exhibited a volatility in US$ of 7.6% which compounds to 14.5% in real Sfr, when monetary risks are taken into account. The Swiss stock market had an average real performance of 11.1% with a much higher volatility of 18.3%. This is a traditional result found on any long time-period and any market: stock investments are more risky but tend to provide a sizeable risk premium over the long run, i.e. a higher average return. Here the risk premium of stocks over bonds is equal to 9.9% per year; this makes a large difference when compounded over ten years.

The size of the risk premium (return on stocks minus return on bond) has been unusually large for Swiss stocks over this ten-year period. Over the longer 1970-1993 period, Swiss stocks had a more usual risk premium of 3.5% over Swiss bonds. The performance of other stock markets varies greatly, some are doing better than the Swiss market, other worse. The difference in national performance would have been more shocking if we had reported cumu-

lative return over the tenyear period rather than annualized returns.

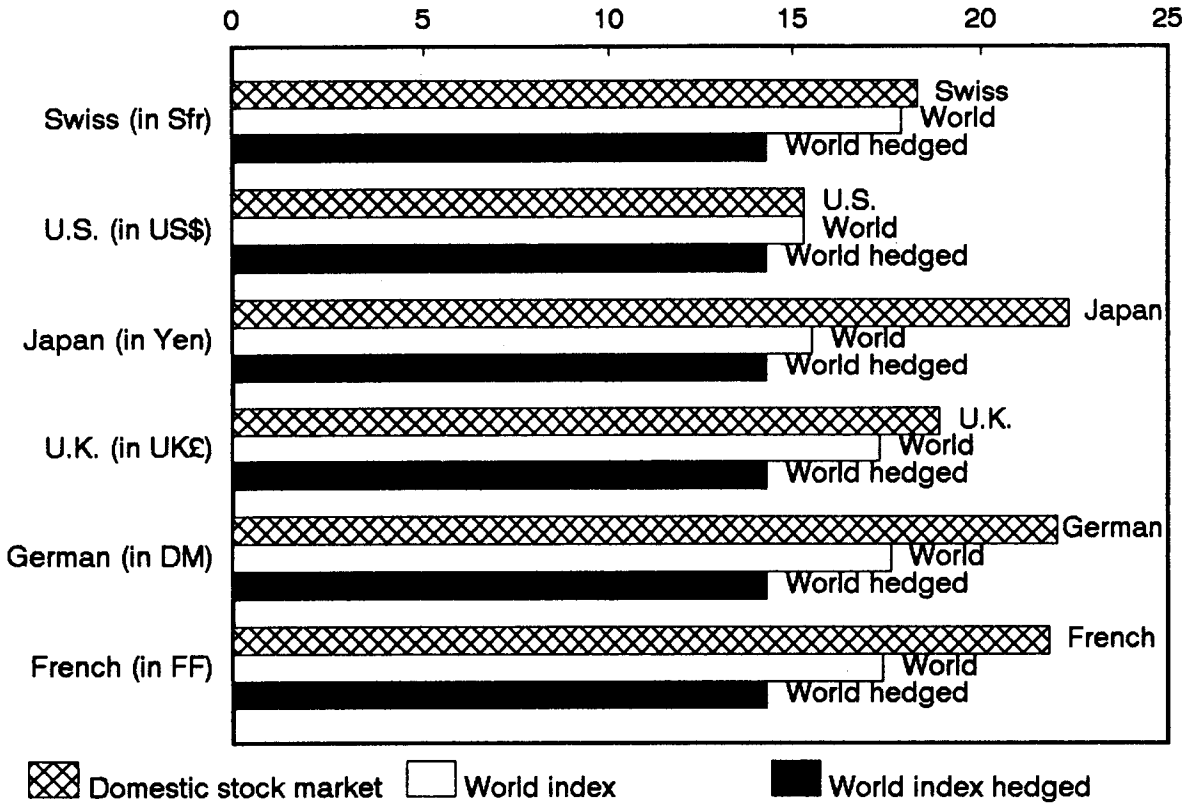
3.1 Risk reduction

The objective of an investment strategy is not to choose a single market based on its return and risk characteristics. The question is not whether any single foreign market, e.g. Japanese stocks, is more or less risky than the Swiss market, but whether including foreign securities in a portfolio increases or reduces the total risk of that portfolio. Although investing abroad means buying some highly volatile markets (e.g. Far Eastern markets, Italy..) and bearing some additional currency risks, it appears that many of these risks get diversified away because of their low correlation; the net result is an international portfolio with an attractive risk/return profile compared to that of a purely domestic Swiss stock portfolio. Actually all foreign stock markets are more volatile than the Swiss stock market, especially when measured in Swiss francs, but the low correlation between national market movements allows to end up with a well diversified international portfolio of similar and even lesser volatility. This risk reduction benefit is illustrated in Exhibit 3. A Swiss investor who had passively invested in the international stock portfolio represented by the World index would have borne a slightly lesser level of risk than that of the Swiss stock market (volatility of 17.9% compared to 18.3% for a Swiss stock portfolio). The volatility of the World stock portfolio would have been further reduced if all invest-

Exhibit 2: Annualized Performance and Risk in % per year, Ten years Dec. 1983-Dec. 1993 Real returns adjusted for Swiss wage inflation

	ANNUAL RETURN %	CAPITAL GAIN %	DIV YIELD %	MONETARY GAIN %	TOTAL RISK %	RISK IN LC %
Bonds						
SWITZERLAND	1.2	-0.2	5.4	-4.0	3.7	3.4
GERMANY	5.7	1.6	7.6	-3.5	6.5	4.5
FRANCE	9.7	4.0	10.5	-4.8	8.0	6.8
NETHERLANDS	6.2	1.9	7.8	-3.5	5.9	3.9
ITALY	9.8	5.5	13.5	-9.3	11.7	8.2
UNITED KINGDOM	3.6	1.2	10.4	-8.1	11.9	7.3
JAPAN	7.8	2.3	5.8	-.04	12.3	6.7
CANADA	3.3	1.6	10.6	-8.9	15.6	7.3
USA	4.2	3.1	9.2	-8.2	14.5	7.6
Stocks						
SWITZERLAND	11.1	12.4	2.7	-4.0	18.3	18.3
GERMANY	10.3	10.0	3.9	-3.6	23.0	21.9
BELGIUM	16.4	14.3	6.0	-3.9	20.6	19.8
FRANCE	14.5	15.6	4.0	-5.1	22.2	21.7
ITALY	8.1	14.0	3.2	-9.1	27.9	25.9
NETHERLANDS	13.1	11.7	5.2	-3.7	17.8	17.1
UNITED KINGDOM	10.7	13.9	5.4	-8.6	21.3	18.9
SWEDEN	7.4	13.6	2.8	-9.0	25.2	25.4
SPAIN	14.3	15.8	6.5	-8.0	26.3	24.4
HONG KONG	26.2	30.4	5.6	-9.8	33.8	29.5
JAPAN	8.6	8.1	0.9	-0.4	26.0	22.3
USA	6.3	10.6	4.0	-8.3	21.4	15.3

Exhibit 3: Stock market risk: Domestic, World, World Hedged, Risk in % per year



ments were fully hedged against currency risk. This argument of international risk diversification is universal and Exhibit 3 also reports the comparison of domestic and international stock risk for nationals of all major countries. Actually a British, German, French or Japanese investor benefits even more from international risk reduction.

The basic reason for this diversification is that all national markets are not fully correlated (synchronized)and there is a good chance that some foreign markets will go up when the Swiss market goes down.

3.2 Correlation

The correlation of the Swiss stock and bond markets with other markets is reported on Exhibits 4 and 5. Again all correlations are calculated using real return, adjusted for wage inflation. The correlation coefficients vary somewhat across countries[12]. The correlation for stocks tend to be around 0.55, which mean that two markets have only 30% (the square of 0.55) of their movements explained by common factors. This figure is even lower for bond markets. Despite media talks monetary variables tend to vary quite independently across countries. This low correlation comes from the fact that national monetary policies are not fully synchronized.

For example the growing Swiss inflation in the late eighties associated with rising Swiss interest rates and a weakening of the franc was not matched in other countries. The relative independence of monetary factors, influencing both currency and interest rate movements, lead to a surprisingly low correlation of the Swiss franc returns on the Swiss and foreign bond markets. Of course the correlation is larger among countries with strong economic and monetary ties. Altogether these correlations are surprisingly low and explain the good risk diversification benefits provided by international investment. Foreign bonds allow to diversify domestic monetary risks.

3.3 Inflation risk

Swiss assets are vulnerable to Swiss inflation risk. When Swiss inflation accelerates, the prices of Swiss assets do not go up accordingly. This has been the painful experience of the eighties in most countries. For example, bond prices tend to go down when inflation (and interest rates) increases. The correlation between Swiss bond returns and inflation is negative and equal to -0.29. This is shown on Exhibit 6. A negative correlation is "bad" as it implies a bad performance on Swiss bonds when inflation is high and, therefore, precisely when pension beneficiaries would like the return on the pension fund to provide for an increase in the

Exhibit 4: Correlation of Swiss stocks 1983-1993, in real Sfr.

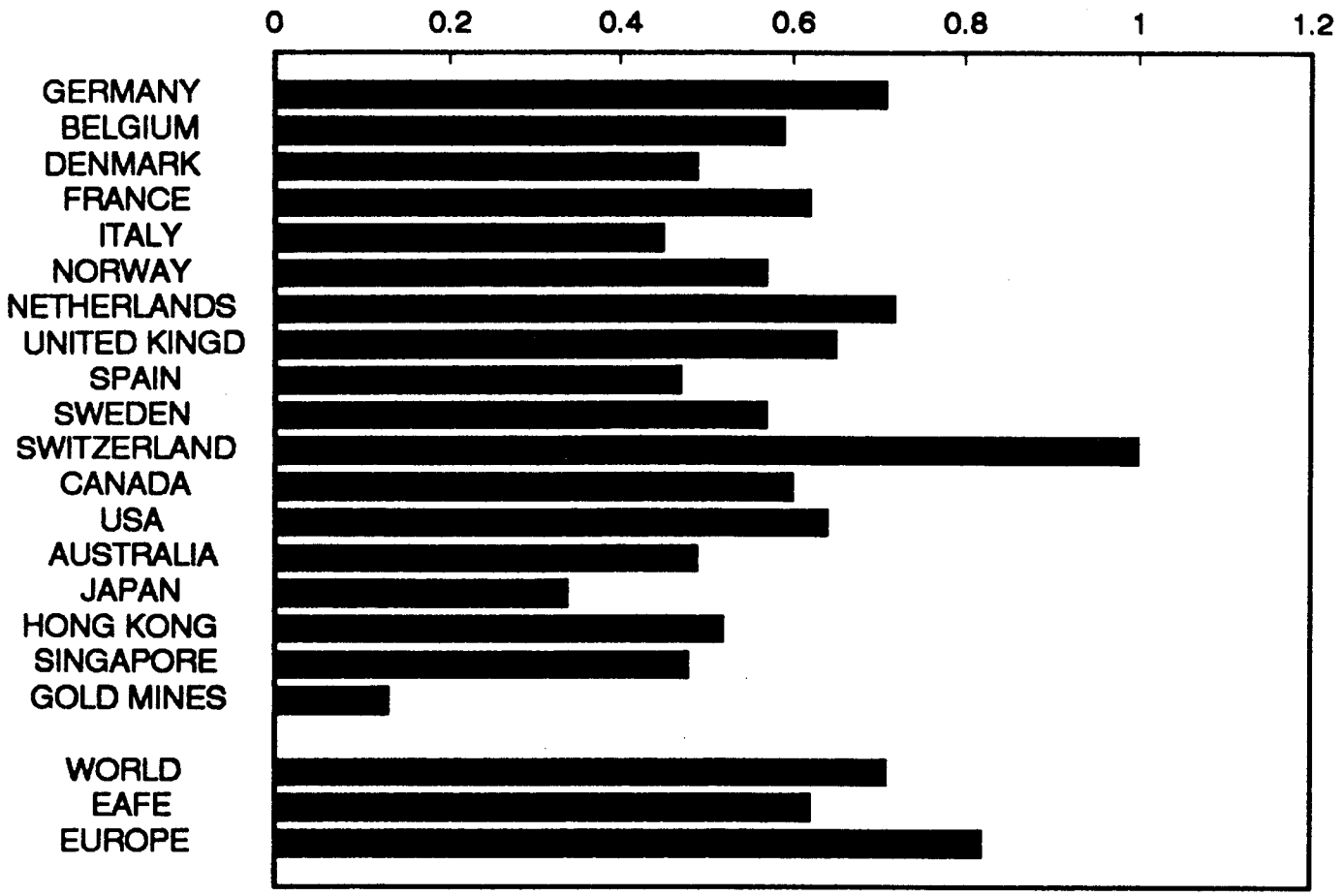
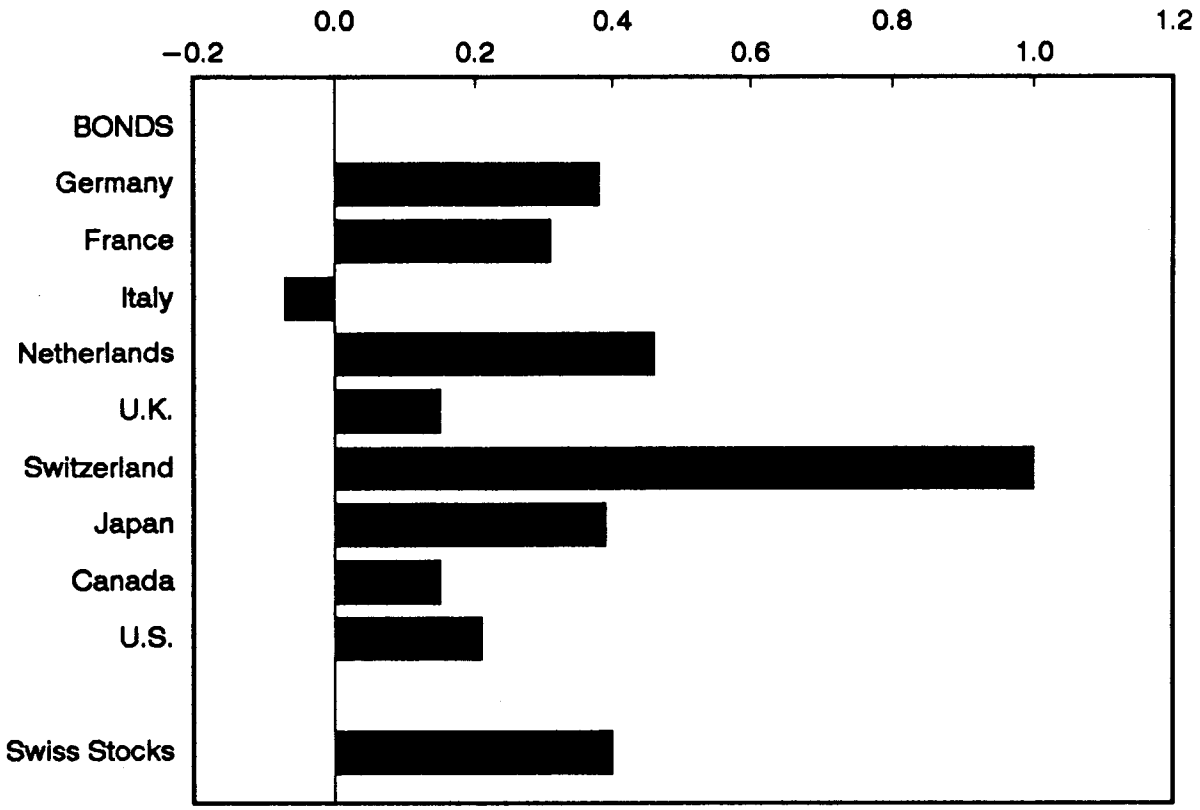


Exhibit 5: Correlation of Swiss bonds 1983-1993, in real Sfr.



benefits to track inflation. The correlation of Swiss stocks and inflation is also negative. This is not the case for foreign investments. A positive correlation between foreign asset returns and Swiss inflation can be explained by the currency factor. When Swiss inflation accelerates, the franc tends to depreciate; the appreciation of the foreign currencies leads to a positive Sfr return on foreign assets. Short-term Swiss interest rates are correlated with inflation. They increase with a rise in inflation. The correlation of the interest rate with inflation is equal to 0.56. The correlation is not equal to one, because of movements in the real interest rate. Clearly, short-term deposits are a good hedge against inflation, while long-term bonds are risky in real terms.

3.4 Currency risk

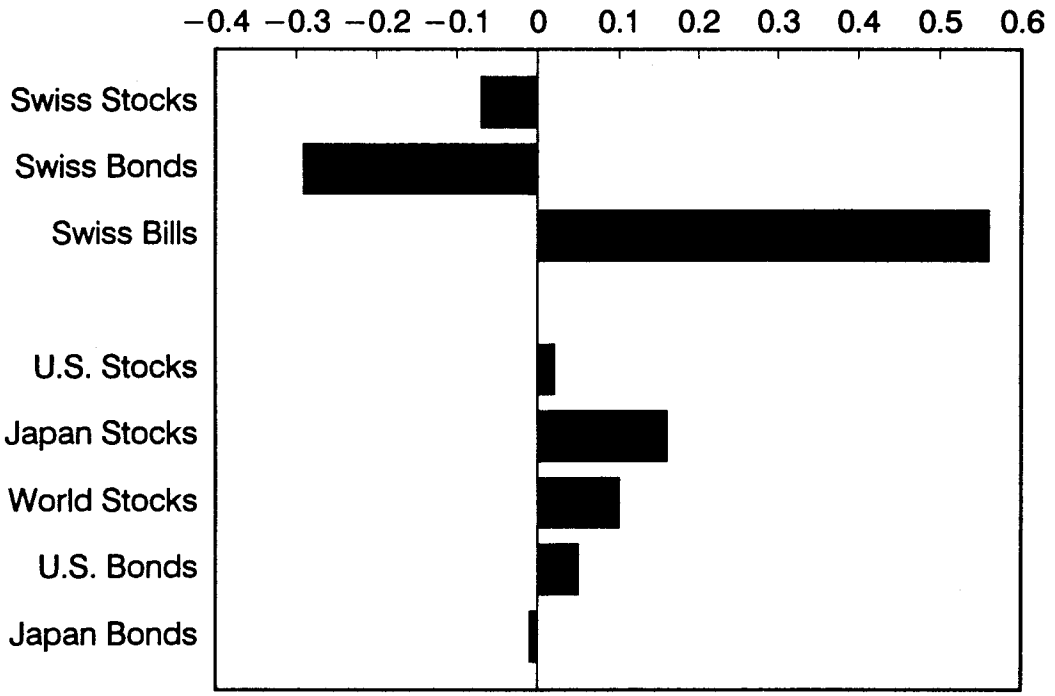
Currency risk is a large component of the total risk of a bond investment. For example we can see on Exhibit 2 that monetary risk makes up about 45% of the Sfr. volatility of an investment in U.S. bonds; the volatility in U.S. dollars is 7.6% while it goes up to 14.5% for a Swiss-based investor measuring risk in real Sfr. Clearly the contribution of currency risk depends on the currency considered and is much lower for a German bond than for a Yen bond. Currency risk is a smaller, but significant, component of the total risk of a stock investment. For example the volatility of the U.S. stock market increases from 15.3%, when measured in US$, to

21.4% when measured in real Swiss francs. Again the contribution of currency risk varies with the countries considered and is very small for Germany and a few other countries. This currency risk gets partly diversified away in a diversified international portfolio, but the risk of an appreciation of the Swiss franc against all or most currencies remains. Currency risk contributes about 20% of the volatility of the World stock index as can be seen in Exhibit 3.

In the last section of this study, we will show that the importance of the monetary factor fluctuates widely over time. This means that monetary factors should be studied with great care and that they should be an important variable in the formulation of the global investment policy. It also implies that an active currency hedging policy could be valuable.

One should not forget that the objective of an optimal investment policy is not to minimize risk but to optimize the risk-adjusted performance of the fund. A systematic policy of complete currency hedging would eliminate the contribution of currency risk on the total risk of the portfolio, but would also affect the return of that portfolio. A short position in a forward currency contract is equivalent to going short in the foreign currency and long in the domestic currency; hence one has to pay the short-term interest rate differential between the two currencies. This is often stated by saying that the forward currency basis (premium or discount) is equal to the interest rate differential. In general, Swiss short-term interest rates tend to be quite low compared to interest rates in other currencies. Hence a systematic full currency hedge for Swiss investors costs the annual interest rate differential but allows to eliminate the depreciation of the foreign currency. A selective currency-hedging strategy is an integral part of active asset allocation[13].

Exhibit 6: Correlation of Swiss inflation and markets, 1983-1993



4. Efficient asset allocation

We will now study the advantage, in terms of potential return and risk reduction, of a global asset allocation strategy that encompasses Swiss bonds and stocks as well as foreign bonds and stocks.

4.1 Efficient bond allocations

So far we have mainly been concerned with the risk diversification advantage of passive international diversification. But another major advantage of global asset allocation is to provide better profit opportunities and hence improve the risk/return trade-off. This is illustrated here by looking at the optimal asset allocations over the past ten years. Swiss pension funds are mostly invested in bonds and we will first study the advantage of diversifying by adding foreign bonds to a Swiss bond portfolio. In Exhibit 7, we provide the optimal international bond asset allocations for different risk levels[14] for the period 1983-1993. Each asset or portfolio is represented by one point on this graph. As noted above the Swiss bond market has a risk of 3.7% and a total real return of 1.2%. Other bond markets are more volatile. By combining the various national bonds we get diversified portfolios whose return and risk can be calculated since we know the returns and covariances of all the assets. The well known idea popularized by the 1990 Nobel prices Markowitz and Sharpe, is that any investor will build a portfolio trying to obtain the best performance while attempting to minimize the risk of loss. This leads to selecting asset allocations that lie in the top-left part of the Exhibit. The best achievable risk/return trade-offs, the efficient asset allocations, lie on the efficient frontier. As can be seen on Exhibit 7, international diversification of a pure Swiss bond portfolio would have greatly enhanced the return on a bond-only portfolio without a large increase in risk. Actually, an international bond portfolio with the same risk level as a purely Swiss bond portfolio (risk of 3.7% per year) would have achieved an annualized total return of 3.7% compared to 1.2% for Swiss bonds. This difference in real performance is considerable if we compound it over ten years, especially since transaction costs and management fees have not been considered. With a slight increase in total risk the increase in return is huge; for example, an efficient bond portfolio with a risk of 5% has an annual real return of 6.5%.

4.2 Global allocations

The second question is whether stocks help improve the risk adjusted performance of global asset allocations. The question addressed here is not whether one should prefer portfolios made up solely of bonds or solely of stocks but rather whether stocks should be added to a bond portfolio and follow a global investment strategy. Exhibit 8 gives the efficient frontier for a global asset allocation allowing for bonds and stocks, foreign and domestic. No investment constraints other than no short-selling are applied; no currency hedging is included. To keep the figure readable, we do not plot individual bond and stock markets but only the Swiss bond and stock indices as well as the BVG/LPP index. Their relative position is conform to the theory. Swiss bonds had a low risk over the period and low performance. Over the long run riskier stock investments are compensated by a risk premium. Here the Swiss equity risk premium has been equal to 9.9% per year. This is a very large number. The optimal global asset allocations on the efficient frontier strongly dominate Swiss investments. An efficient global portfolio with the same risk level as Swiss stocks has a real return of 18.4% compared to 11.1% for domestic stocks. Conversely, a performance equal to that of the Swiss stock market (11.1% annualized) could have been achieved with one third of the risk. A domestic portfolio of Swiss stocks and bonds tend to have half the performance of that of an international efficient allocation with the same risk level. We also reproduce on Exhibit 8 the efficient international frontier when we only invest in bonds (same as Exhibit 7). Clearly stocks bring a strong contribution in terms of risk/return

trade-off to a bond portfolio since the bond-only efficient frontier is strongly dominated by the global efficient frontier. Investing in stocks is a good way to achieve superior performance for reasonable levels of risk.

4.3 Nominal vs. Real optimization

In theory, the asset allocation optimization should be conducted in real terms. In practice, the use of nominal returns does not make much difference. The reasons are obvious. The difference between the real and nominal return on each asset or portfolio is equal to the inflation rate[15]. So the excess returns are identical whether measured in real or nominal returns. Inflation uncertainty does affect the variances and correlations of assets in a more complex and selective way. However the variance of inflation is very small compared to the variances of the asset prices and of the exchange rates. So the covariances measured in nominal terms are not very different from those measured in real terms. The figures drawn in Exhibits 7 and 8 are almost identical to those obtained from an optimization conducted on nominal returns (except that the returns axis is augmented by 4%, the average inflation rate). The only difference in the efficient allocations is that Swiss bonds are less attractive in real terms than in nominal terms. Given this limited difference and

Exhibit 7: Efficient frontier, bonds only 1983-1993, in real Sfr.

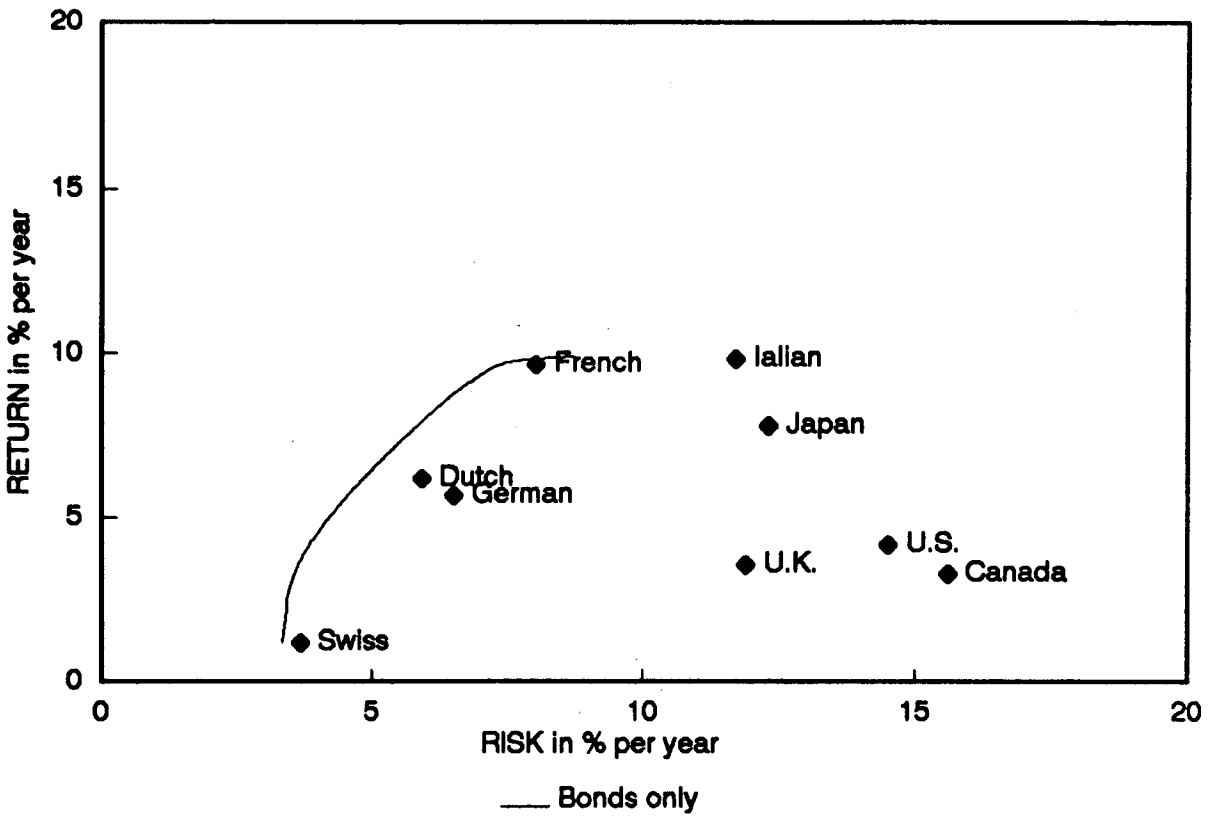
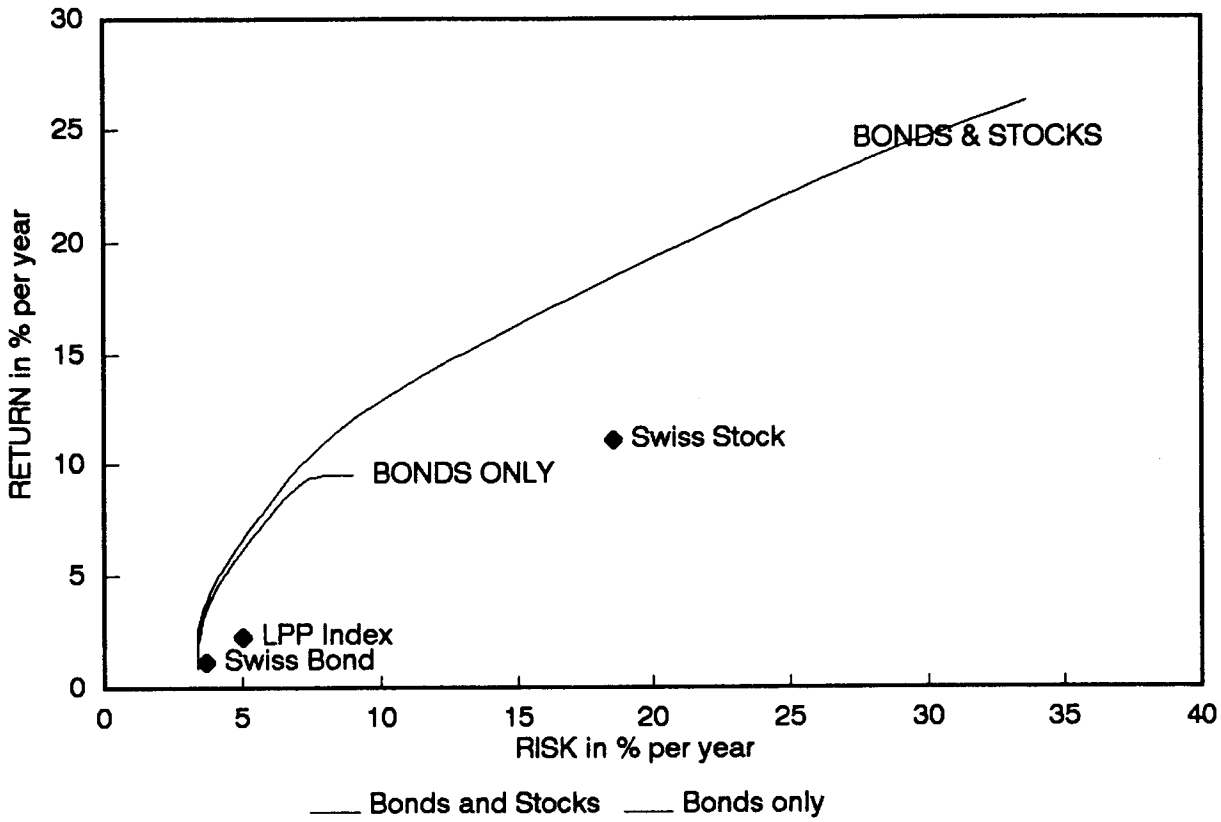


Exhibit 8: Efficient frontier, bonds and stocks, 1983-1993, in real Sfr.



the fact that monthly figures for wage inflation are hard to obtain on a timely basis, money managers conduct the optimization in nominal terms.

4.4 Pension liabilities and efficient asset allocation

We have demonstrated here the large potential in terms of risk-adjusted performance of international asset allocation for a Swiss pension fund. The basic conclusions are 1) that stocks should be extensively introduced to provide a return in excess of wage inflation and 2) that the fund should be diversified internationally to reduce the total risk of the portfolio. Conclusions are derived from a study of the past ten years but similar results would hold for a longer time period. These lessons from the past are very useful to derive implications for a long term asset allocation strategy. The asset allocation strategy was kept constant over the whole period; the performance could be further improved by allowing tactical revisions of the asset allocation over time and selective currency hedging. Hence a pension fund would typically proceed in two steps. First a strategic asset allocation will be set for the long-run; this is typically done by assigning to the money manager a passive benchmark as an objective for the next few years. Second the manager will actively deviate from this strategic benchmark to adapt to changes in the environment and to the risk and return characteristics of the assets.

As mentioned in section 2, a pension fund should choose an efficient asset allocation with a risk level that is acceptable given its liabilities. The choice of the acceptable risk tolerance is a major determinant of the fund's investment strategy. If we look simultaneously at assets and liabilities, several types of risks confront a pension fund. We can mention at least three:

- *liquidity risk:* In the short-run, a pension fund may not have enough cash to meet its obligatory payments.
- *balance sheet risk:* Following adverse market movements, total assets valued at their market prices might be insufficient to cover the actuarial liabilities. Technically the fund will show a deficit. Actuaries will play with reserves and accounting valuation conventions to reduce this risk, which must still be taken into account in the investment strategy. While such a deficit should, hopefully, be only temporary as asset prices will rise in the long run, the probability of its occurrence should be minimized.
- *Financing risk:* The long-term return on assets is insufficient to cover the scheduled liabilities payments. This is a major risk for defined-benefit plans. If the promised benefits cannot be paid, the employer must cover the deficit. This financing risk is smaller in a defined contribution plan since the minimum promised return on contribution is lower than in defined-benefit plans, and usually equal to a technical rate of 4%.

To appreciate the risk tolerance of a pension plan confronted with those risks, the money manager and the pension plan's actuaries should work together in studying assets and liabilities. They must analyse primarily:

- *the current level of reserves and surplus:* The level of reserves can be measured as a percentage of the total market value of the assets. A high level of reserves allows the pension fund to be less sensitive to price volatility on its assets and therefore allows for a greater risk tolerance.
- *The age structure of the plan:* The age structure of the pension plan depends on the age structure of active and retired workers as well as the ratio of active to retired workers. Pension plans with young, mature or old age structures will not have the same requirements in terms of asset liquidity or investment risks. A pension plan with a young age structure can afford to invest in more volatile assets with a longer-term horizon conversely, U.K. pension funds follow the recommendations of their ALM analysis and progressively reduce their very high equity exposure (over 75% invested in stocks on the average) to reflect the ageing structure of their plans[16].
- *The firm's prospects:* A firm in good financial health would have no problem in covering potential deficits in the pension fund and could wish to engage in a more aggressive investment strategy, with the prospect that higher expected returns will allow to reduce future contributions. The dynamics of the age structure of the pension plan is also a function of the future growth of the firm and its expansion plans.

A pension fund with a young age structure, a high level of reserves and expecting rapid growth of the firm's activities could engage in an asset allocation with higher volatility and, hence, higher expected returns. Conversely, a pension fund with an older age structure, low reserves and little growth potential for the firm should engage in a lower-risk, and lower-expected-return, asset allocation strategy.
The risk level of the asset allocation strategy can be adjusted with investments in liquid, short-term assets, in the form of deposits in Swiss francs. Since TOBIN (1958), we know that a rational investor should adjust his risk level by a combination of the optimal portfolio of risky assets and of the risk-free asset (the short-term interest rate) and not by a different mix of risky assets. In his "separation" theorem, Tobin insisted that the selection of the optimal portfolio of risky asset and the choice of a desired risk level are two separate decisions. One should first determine the efficient frontier as on

exhibit 8. Then one should draw the tangent to the efficient frontier that goes through the risk-free asset Rf as shown on Exhibit 9. This "tangent" portfolio is called T on the efficient frontier. The straight line connecting Rf and T defines all the optimal portfolios made up of a combination of the risky allocation T and of an investment in the risk-free interest rate. Basically, all pension funds should select the same optimal allocation of risky assets T, and reduce the risk level by placing part of their wealth in the risk-free asset. For example P corresponds to a global allocation invested partly in the optimal risky allocation T and partly in the risk-free asset.

This method offers several advantages:

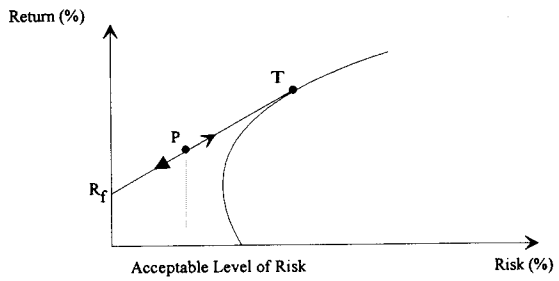
- The use of risk-free assets allows to take into account the liability structure of the pension fund through the selection of an acceptable risk level. Any change in the liability structure of the fund can be efficiently and practically reflected in the structure of the total portfolio.
- The efficient allocation of risky assets T benefits fully of the advantage of diversification
- The use of short-term risk-free assets is also an insurance against inflation as the return on such an asset is the interest rate which is closely linked to the inflation rate.

The determination of the risk level acceptable by a specific pension fund can be helped by some quantitative models discussed in the references listed in the bibliography (shortfall analysis,...). Investment guidelines set by the BVG/LPP should also be introduced in the analysis.

5. Active allocation: Monitoring risks

Once a benchmark asset allocation has been selected for the long-run, the money manager will try to take advantage of the rapidly changing environment to over-perform the passive benchmark selected. This requires a constant monitoring of the risks and an assessment of changes in expected returns on various markets. We focus first on risk and then on return. Indeed, risk parameters do vary over time. No one would argue that nothing has changed over the past twenty five years. The economic and political environment is evolving over time; the economies and the financial markets are getting increasingly integrated. International capital flows are increasing. It is sometimes heard that financial markets are getting more volatile and interdependent. Rather than relying on emotive short-term impressions, we present some statistical evidence on this issue.

Exhibit 9: Optimal asset allocation, for a desired risk level



5.1 volatility and currency risk

Exhibit 10a presents the volatility of the Swiss bond market over the past two decades as well as over successive periods of five years from 1970. All calculations use monthly real Sfr. returns from end-of-year to end-of-year.; the last period only covers three years.

The volatility of the Swiss bond market has staid remarkably low and constant since 1970. This is not the case for the Swiss stock market as shown on Exhibit 10b. Markets go through tranquil and agitated periods. The first oil shock and the crash of October 1987 induced high volatility. On the average, the Swiss stock market has been somewhat more volatile in the past decade than in the previous one. This has not been the case for other national markets like the U.S. market. Exhibits 11 and 12 give the volatility of the U.S. bond and stock

markets over the same periods. We indicate the volatility in US$ and Sfr., so the difference is the contribution of currency risk. Clearly the amount of currency risk is evolving over time. The recent period has seen an increase in currency risk.

5.3 Correlation

It is often heard that financial markets are getting increasingly integrated across the world. This is certainly true for the physical integration of information system as well as the growing harmonization of trading mechanisms and transaction processing. However the question relevant to investment management is whether financial markets move increasingly in common. This would certainly be bad news because it would reduce the diversification and profit potentials. Exhibit 13 reports the time variation of the correlation of the U.S. stock market with the Swiss stock market; all calculations are in Sfr. A correlation coefficient is a statistical average of the degree of co movement of two markets. In some period the U.S. and Swiss markets are influenced by international factors and just follows the rest of the world, in other times they are solely influenced by specific domestic factors. The correlation coefficient gives an estimate of the average link between the Swiss and the U.S. markets. When

Exhibit 10a: Volatility of Swiss bonds Various periods, in real Sfr., % per year

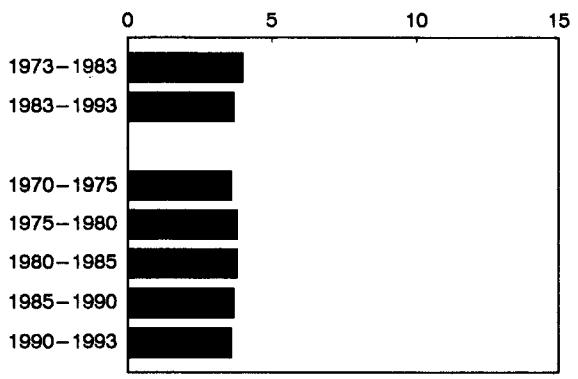


Exhibit 10b: Volatility of Swiss stocks Various periods, in real Sfr., % per year

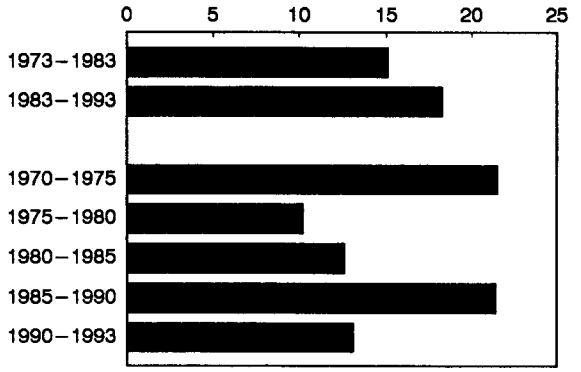


Exhibit 11: Volatility of U.S. bonds Various periods, in real Sfr., % per year

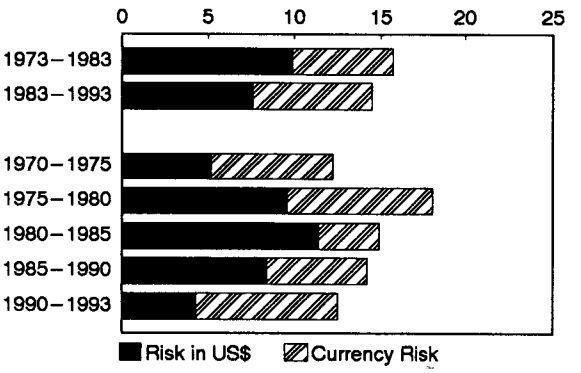
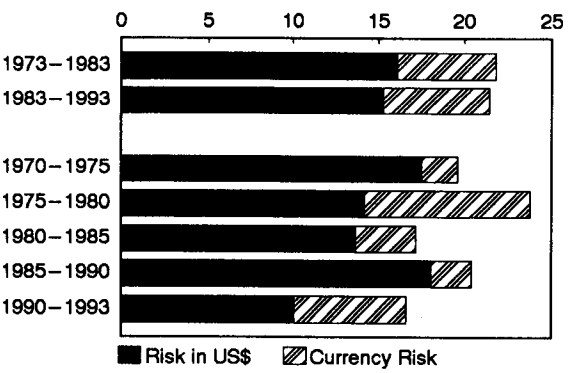


Exhibit 12: Volatility of U.S. stocks Various periods, in real Sfr., % per year



estimated over short periods of time, this correlation fluctuates significantly. The correlation in the late eighties (85-90) is similar to that in the early seventies (70-75). The correlation has increased somewhat over the past two decades (from 0.44 to 0.64). Looking at the five-year correlations we can see that the correlation tends to increase in periods of high market volatility (the first oil shock and the crash of 1987)[17].This is bad news for a portfolio manager since it is precisely in periods of large down movements that diversification (and low correlation) is most needed. However the correlation never reaches levels that would deter the case for international diversification.

Despite the media insistence that interest rates are closely correlated across the world, the degree of correlation of bond markets across the world, measured in a given reference currency, stays quite low. This can be seen on Exhibit 14 which gives the correlation between the returns on the U.S. and Swiss bond markets, measured in real Sfr. This low correlation may be partly explained by the importance of the monetary risk in bond investments as stressed above. The correlation between bond markets is much larger for currency hedged returns. Again, the correlation has increased somewhat over the past 25 years but remains quite low.

5.3 Controlling risks

Deviations of the portfolio's composition from the benchmark must be evaluated and controlled. We have talked so far about country/currency allocations, but a manager could also choose to deviate from benchmarks by emphasizing various market segments. This is often referred to as investment style. For example, one could privilege value stocks as opposed to growth stocks or long-term, low-yield bonds as opposed to short-term, high yield bonds. Active management requires a rigorous monitoring of the deviations from the benchmark and, therefore, of the "bets" taken. The risk of the portfolio must be decomposed according to the various factors influencing the risk and return of the portfolio, in deviation from the benchmark. Country factors naturally belong to those factors. Industry factors are also important. One should not neglect other factors influencing the returns of various segments of the stock market. For example, smallcap firms have been shown to be more risky than big firms but with a potential for higher returns. A portfolio must be analyzed precisely to measure its risk and its sensitivity to the various factors. The risk analysis allows a better understanding of major management decisions. Indeed, an exact measure of the risks taken, and a risk decomposition according to factors having a clear economic meaning, allow to explain

Exhibit 13: Correlation of US and Swiss stocks Various periods, in real Sfr.

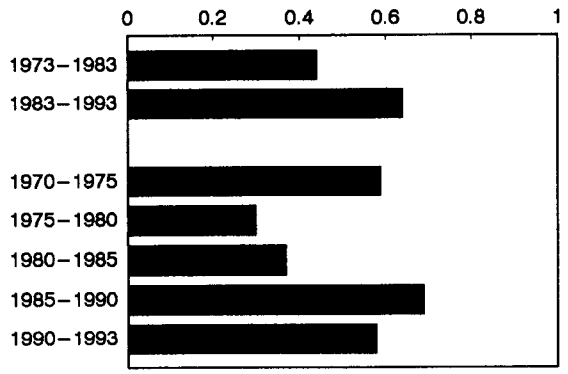
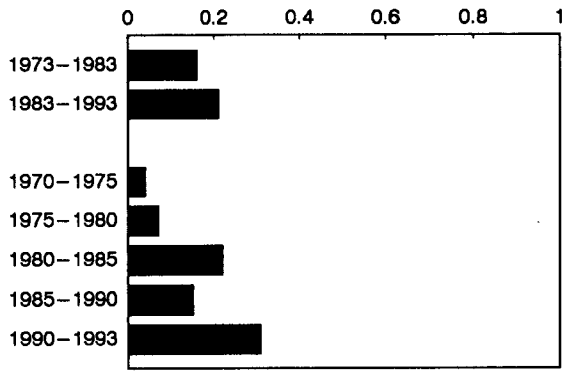


Exhibit 14: Correlation of US and Swiss bonds Various periods, in real Sfr.



and justify the investment policy selected to the pension fund trustees.

6. Active allocation: enhancing return

An active investment strategy requires some expertise in forecasting markets, currencies or interest rates. These forecasts leads to tactical deviations from the benchmark asset allocation. In this section, we present an illustration of two approaches to active deviations from a benchmark:

- Some markets can over(under)-perform others over a period of one or a few years, but this cannot be expected to last for ever. A global investment strategy allows to select markets that are likely to over-perform in the near-term while keeping risk within reasonable levels thanks to the benefits of international risk diversification. For example, the fact that the Swiss stock market had an excellent performance in 1992 and 1993 compared to other market is no guarantee that the Swiss market will also be the best performer in the late nineties. As an illustration of the importance of keeping abreast with changes in the world environment, we discuss next the advantages of including emerging stock markets in the investment strategy.
- Another component of active tactical asset allocation is the selection of securities within an asset class. For example, some manager tend to focus on specific industries, others tend to prefer value stocks as opposed to growth stocks. These choices are guided by the investment style of the manager. A brief discussion of the implementation of a specific investment style is provided below.

6.1 The case for emerging markets

The performance of the national stock market is linked to the rate of growth of the economy. Twenty years ago, a motivation for international investment was to invest in rapidly growing economies like Japan. Japan did provide superb market performance but it has become a mature economy and market. Over the years many countries have provided this rapid development potential and reached a more mature stage. One could think of many Asian and European countries. This could justify an increase in correlation across developed markets. While the stock markets of these countries do not offer anymore the same attractive high-growth/high-risk profile, new markets have emerged to replace them. These markets are often referred to as Emerging markets. These markets have three main characteristics:

- high volatility
- high growth potential
- low correlation with the developed markets

The International Finance Corporation (IFC) of the World Bank maintains an extensive data base for these markets since the end of 1984. Exhibit 15 gives some statistics on these markets based on monthly total returns for the past nine years. The presentation is similar to that of Exhibit 2, except for the last column which indicates the correlation of the emerging stock market with the Swiss stock market. Many countries had a weak currency with a huge annual deprecation rate relative to the Swiss franc. This is certainly the case for Argentina and Brazil. However the stock market appreciation made up for the monetary depreciation and the net result in Sfr. is often very good. Many of these markets achieved an annualized performance larger than 30% per year in real Sfr. The volatility of these markets is indeed very large, but their correlation with the Swiss market tends to be much smaller than that of developed markets. The high volatility of emerging markets was illustrated at the end of 1994, with the Mexican crisis. At the start of 1994, emerging markets had a joint market capitalization close to US$ 1 trillion or about 8% of that of the developed markets.

The practical question is whether the addition of emerging markets in our investment universe would improve the risk adjusted performance of global

Exhibit 15: Annualized Performance, Risk and Correlation with Swiss Stocks Dec 1984- Dec 1993, Real returns adjusted for Swiss wage inflation

	ANNUAL RETURN %	CAPITAL GAIN %	DIV. YIELD %	CURR. GAIN %	TOTAL RISK %	RISK IN LC %	Correlation with Swiss Stock
SWISS bonds	1.3	-0.2	5.5	-4.0	3.7	3.5	0.39
SWISS Stocks	11.3	12.7	2.6	-4.0	19.2	19.1	1.00
ARGENTINA	35.7	365.7	15.8	-349.8	106.6	174.1	0.13
BRAZIL	8.8	757.1	48.6	-800.9	72.2	94.7	0.25
CHILE	42.0	61.3	12.2	-35.5	33.1	26.5	0.25
COLOMBIA	32.6	63.4	12.6	-47.4	38.8	30.9	0.10
GREECE	15.6	23.5	9.5	-21.3	45.0	44.4	0.14
INDIA	11.5	28.9	2.9	-24.2	36.4	37.1	0.11
JORDAN	3.2	12.0	4.7	-17.6	21.2	17.3	0.33
KOREA	14.7	20.2	1.9	-11.4	35.2	29.6	0.28
MALAYSIA	10.6	16.5	2.7	-12.6	31.8	26.8	0.46
MEXICO	44.7	98.9	8.2	-66.4	52.1	46.5	0.36
NIGERIA	-11.9	33.8	11.5	-61.2	42.5	12.0	0.04
PAKISTAN	16.6	26.5	7.6	-21.5	27.2	24.5	0.21
PHILIPPINES	42.5	54.5	4.4	-20.4	40.5	39.9	0.31
PORTUGAL*	17.6	23.2	2.7	-12.3	45.0	44.1	0.27
TAIWAN	21.1	22.1	1.7	-6.6	58.1	52.6	0.25
THAILAND	30.2	31.5	6.4	-11.7	36.6	31.2	0.47
TURKEY*	17.5	66.0	8.9	-61.3	64.6	66.5	0.02
VENEZUELA	11.6	57.0	3.2	-52.5	46.6	39.9	-0.06
ZIMBABWE	17.5	36.3	12.2	-35.0	32.5	30.0	0.02

* from December 1985

asset allocations. We can perform an asset-allocation optimization similar to that reported in Exhibit 8, but with the addition of emerging markets to the investment universe. The result is reproduced on Exhibit 16. The bottom curve is the same as in Exhibit 8, the top curve allows for investments in emerging markets. Allocations including emerging markets clearly dominate except for very low risk level. The gain in terms of risk adjusted performance is considerable. Emerging markets are very risky and are somewhat linked to the developed markets. However, adding a small allocation to these markets greatly improves the return potential of the portfolio without significant risk increase.

6.2 Investment style

Different investment styles will lead to deviations from the benchmark and therefore to differences in performance. One typical decision already discussed is whether one would prefer value stocks or growth stocks. Value stocks are often defined as firms whose stock price is low compared to its book value. These firms are characterized by a poor historical stock price performance and high values for ratios like Book-to-Market price ratio, Dividend yield, Earnings to Price ratio. Conversely growth or glamour stocks tend to have had rapid market price growth, often linked to past growth to earnings and high Price-Earning ratio.

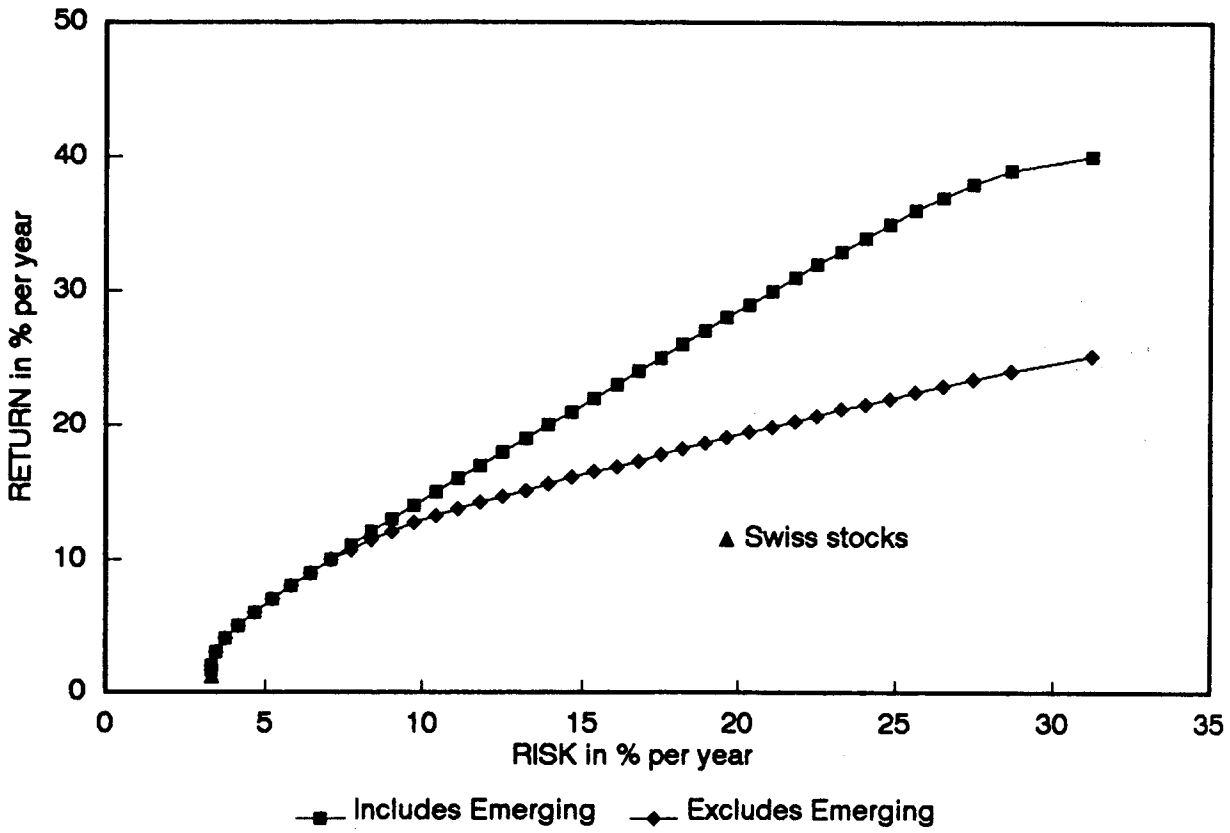
Studies[18] in the U.S. and abroad have shown the returns on value and growth stocks can differ si-

gnificantly, in either direction, from month to month or year to year. A common explanation for the fashion of growth strategies is that market participants irrationally extrapolate past trends. They value growth stocks as if earnings growth were to continue in the future at the same rate as in the past. They "fall in love" with the top market performers and project a similar good performance in the future without due analysis of the fundamentals. A value strategy means to take the Contrarian view and privilege stocks which are cheap and provide good value. The conclusions of the previous studies is that value strategies tend to over-perform growth strategies, without incurring higher risks.

Once a style, such as a value strategy, has been chosen, the selection of individual firms can be based on a combination of technical analysis and fundamental analysis. Another investment style is to privilege small-capitalization stocks, i.e. stock of small firms. These securities are usually not included in the major national stock indexes used to measure the performance of those markets. The introduction of small firms presents an advantage in terms of risk diversification. These stocks are quite volatile but they tend to have a fairly low correlation with the rest of the market. In order to achieve this risk-reduction benefit, the portfolio of small firms must be sufficiently diversified. They must also be selected after a careful screening of their risk characteristics: Fundamental analysis, solid financial ratios, good management team, etc...

Small firms can also enhance the performance of the portfolio. Small firms tend to be more sensitive to the business cycle. hence their stock price tends to

Exhibit 16: Efficient frontier with emerging markets 1984-1993, in real Sfr.



be strongly affected by a recession. However all studies[19] have shown that small firms tend to over-perform large firms over long periods, even after adjusting for their larger risk.
To summarize, investment style management can be characterized by bets on major market factors and they require quantitative tools to manage the risks taken.

7. Conclusions

Several conclusions emerge from this study based on past long term and recent experience:

1) The investment objectives of a pension fund should be linked to its liability structure. A Swiss pension fund should try to conduct a risk/return optimization in real terms. In other words, the fund should try to maximize the real return on the portfolio, adjusted for wage inflation, consistent with a level of risk judged to be acceptable in the short run. The acceptable risk level should be set in line with liability structure of the pension fund.
2) It is not easy to achieve a return on assets greater than the growth rate in wages and stocks ought to be a significant component of the investment strategy of a Swiss pension fund.
3) International diversification would be beneficial to a Swiss pension fund in terms of risk and return. This is already true for passive international diversification but a strong case can be built for large potential reward for active international asset allocation.
4) The volatility and correlation of markets evolve over time. The fund manager must be sure to monitor this changing environment to control the risks and be in a position to take advantage of opportunities.
5) Monetary considerations are an important determinant of the performance and risk of bond investments. This is less so for stock investments. Monetary risk tends to be increasing. This means that more effort should be devoted to this dimension and that careful consideration should be given to currency hedging and using new financial instruments to adapt the risk profile of the asset allocation.
6) Many stock markets which provided, ten or twenty years, ago great prospects for performance and diversification, despite their high volatility, have now become more mature and more closely linked to the other developed markets. In turn, new markets have emerged which seem to provide those attractive benefits for the coming years.
7) An active investment strategy requires a close monitoring of the factors that affect the prospects and risks of all investments.
8) An appropriate investment style allows to improve on the performance of the asset allocation.

Footnotes

[1] The BVG/LPP are the Swiss Federal guidelines for retirement provisions.
[2] Several references on this topic are given in the bibliography.
[3] There is some freedom in selecting the accounting valuation method. Some assets can be valued at their historical cost or at their nominal value, rather than at their current market value.
[4] Several variants of these two basic models can be implemented.
[5] Source J.P. STEINER, Nestlé pension fund. The balance has been financed at the expense of departing employees. This will be more difficult in the future as the legislation now offers better protection to departing employees ("convention de libre passage").
[6] This is the case for the "IInd Pilar" and many Swiss private pension funds.
[7] Potential problems due to a change in system are discussed by BRANDENBERGER and WOLTER (1994).
[8] For example, the Federal Constitution sets the objective that the pension be at least equal to 20% of the last AHV/AVS salary. Corporation sometimes negociate higher minimum objectives with their employees.

[9] According to MERCER, foreign assets make up over 20% of Dutch pension assets and 30% of British pension assets.

[10] An extensive discussion on the benefits of international investments is provided in SOLNIK B., International Invesments, Addison Wesley, Reading Ma, USA, 3rd edition 1995. A recent analysis for a German, Japanese, UK and US investor is provided in ODIER and SOLNIK (1993).

[11] The yearly wage index and the monthly Consumer price Index (CPI) comes from the OFIAMT. A monthly wage index is constructed by applying the monthly pattern of the CPI to the wage index. Stock returns are calculated using the Morgan Stanley Capital International indices. Bond returns are calculated using the Lombard Odier bond indices.

[12] Remember that a correlation coefficient lies between +1 , perfect correlation, and -1 , perfect acyclical variations. The square of the correlation or R-square is a good measure of the percentage of common variation of the two markets. 14. For a theoretical discussion on optimal hedging see ADLER and DUMAS (1983), BLACK (1989), ADLER and SOLNIK (1990), SOLNIK (1993) and ODIER and SOLNIK (1993).

[13] For a theoretical discussion on optimal hedging see ADLER and DUMAS (1983), BLACK (1989), ADLER and SOLNIK (1993).

[14] The calculation of the efficient frontier is based on the data presented in Exhibit 2. No short-selling is allowed. In Exhibit 7 we restrict the investment universe to bonds, no stock investments are allowed but no maximum constraint is set on foreign investments.

[15] In theory, one should also consider the cross-product of inflation with the nominal asset return. Given the low variance in inflation, this term is negligible, for all practical purposes.

[16] Source: WYATT/Wall Street Journal, "European Pension Fund Survey", Wall Street Journal, August 2, 1994.

[17] See LONGIN and SOLNIK (1995)

[18] See for example FAMA and FRENCH (1992) and CAPAUL, ROWLEY and SHARPE (1993).

[19] See for example FAMA and FRENCH (1992) and DIMSON (1988).

References

ADLER, M. and B. SOLNIK (1990): "The Individuality of Universal Hedging", Financial Analysts Journal 46, May/June, pp. 7-8.

ADLER, M. and B. DUMAS (1983): "International Portfolio Choice and Corporation Finance: A Synthesis, Journal of Finance 38, June, pp. 925-984.

AMMANN, D. (1990): "Anlagestrategien fnr Pensionskassen", Schriftenreihe des Instituts für Betriebswirtschaft, Wirtschaftswissenschaftliches Zentrum der Universität Basel, Verlag Paul Haupt, Bern und Stuttgart.

AMMANN, D. (1991): "Ganzheitliches Risikomanagement für Pensionskassen", Schweizerische Zeitschrift für Sozialversicherung und Berufliche Vorsorge Nr. 4, pp. 196-198.

AMMANN, D. (1992): "Asset and Liability Management für Pensionskassens", Finanzmarkt und Portfolio Management 6, pp. 193 -203.

BENELLI, G. (1993): "Aus der Praxis : Risikokontrolle bei Pensionskassenanlagen", Finanzmarkt und Portfolio Management 7, pp. 226-235.

BLACK, F. (1989): "Universal hedging: Optimizing Currency Risk and Reward in International Equity Portfolio", Financial Ananlysts Journal 45,July/August, pp. 16-22.

BRANDENBERGER, B. and H.-J. WOLTER (1994): "Auswirkungen eines Wechsels vom Leistungs- zum Beitragsprimat auf die Finanzielle Führung einer Pensionkasse", unpublished manuscript, Complementa AG, St Gallen.

CAPAUL, C., I. ROWLEY and W. SHARPE (1993): "International Value and Growth Stock Returns", Financial Ananlysts Journal 49, January/February, pp. 27-36.

DIMSON, E. (ed.) (1988): "Stock Market Anomalies", Cambridge: Cambridge University Press, Cambridge.

FAMA, E. and K. FRENCH (1992): "The Cross-section of Expected Stock Returns", Journal of Finance 47, pp. 427-466.

JÄGER, S. and H. ZIMMERMANN (1992): "On Surplus Shortfall Constraints", Working Paper, Schweizerisches Institut für Banken und Finanzen der Hochschule St. Gallen.

LONGIN, F. and B. SOLNIK (1995): "Is the Correlation in International Equity Returns Constant: 1960-1990?", Journal of International Money and Finance 14, pp. 3-26.

MEIER, P. (1993): "Aus der Praxis : Anlagestrategien für Pensionskassen - Auswirkungen der neuen Anlagerichtlinien", Finanzmarkt und Portfolio Management 7, pp. 365-372.

ODIER, P. and B. SOLNIK (1993): "Lessons for International Asset Allocation", Financial Analysts Journal, March/April.

ODIER, P., B. SOLNIK and J.-M. MIVELAZ (1991): "International Diversification for Swiss Pension Funds" Finanzmarkt und Portfolio Management 5, pp. 20-38.

RUDOLF, M. (1994): "Efficient Frontier und Shortfall Risk", Working Paper, Schweizerisches Institut für Banken und Finanzen der Hochschule St. Gallen.

SOLNIK, B. (1993): "Currency Hedging and Siegel's Paradox: On Black's Universal Hedging Rule", Review of International Economics 49, June, pp. 63-74.
SOLNIK, B. (1991): "International Invesments", 2nd edition, Addison Wesley, Reading Ma, USA.
TOBIN, J. (1958): "Liquidity Preference as Behavior Toward Risk", Review of Economic Studies 25, February, pp. 65-86.
WOLTER (1992): "Pensionskassen Schweiz : Neue Strategien für wachsende Leistungsansprüche", Manuskript, Schweizerisches Institut für Banken und Finanzen der Hochschule St. Gallen.
WUFFLI, P. and T. WILSON (1992): "Aus der Praxis : Ein integriertes Vorgehen zur Verbesserung des Asset-Liability Managements", Finanzmarkt und Portfolio Management 6, pp. 433-441.
WYATT/Wall Street Journal (1994): "European Pension Fund Survey", Wall Street Journal, August 2, p. 1.
WYDLER, D. (1992): "Einige grundsätzliche Gedanken zu Schweizer Pensionskassen" Finanzmarkt und Portfolio Management 6, pp. 169-178.
ZENGER, C. (1992): "Zeithorizont, Ausfallwahrscheinlichkeit und Risiko: Einige Bemerkuingen aus der Sicht des Praktikers"? Finanzmarkt und Portfolio Management 6. pp. 104-113
ZIMMERMANN, H. (1992): "Zeithorizont, Risiko und Performance : Eine Ubersicht", Finanzmarkt und Portfolio Management 5, pp. 164-181.
ZIMMERMANN, H. (1992): "Replik zum Thema: Ausfallrisiko und Zeithorizont", Finanzmarkt und Portfolio Management 6, pp. 114-117.
ZIMMERMANN, H. (1993): "Downside Risk, Options, and Investment Time Horizon" Working Paper, Schweizerisches Institut für Banken und Finanzen der Hochschule St. Gallen.
ZIMMERMANN, H. (1993): "Pensionskassen: Massive Ertragsausfälle durch Unzweckmässige Performance-Kontrolle", Schweizer Bank, Nr. 9, pp. 48-50.
ZIMMERMANN, H., C. ARCE, S. JAEGER and H.-J. WOLTER, H.-J. (1993): "Shortfall-Risiko und Zeithorizonteffekte", Finanzmarkt und Portfolio Management 7, pp. 330-338.