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The Role of Gold as a Risk Diversifier in the Performance of Five Swiss Pension Funds

1. Introduction

This study investigates the role of gold in the diversification of risk for five Swiss portfolios managed by the Swiss pension fund company Prevista. The data cover the period from 1976 to 1989, the longest period for which data was available for all five funds. The funds consist of Swiss equities, foreign equities, Swiss bonds, foreign bonds and real estate. The data consist of monthly percentage returns from January 1976 to December 1989 - a period of 168 months in all. The data are corrected for payments to, and receipts from the fund. The returns are thus unaffected by money moving into or out of the funds.

There have been a number of investigations into the role of gold in fund management. These are summarised in section 2. This study differs from almost all previous studies in that it uses actual fund results rather than simulations constructed from stock and bond indices. The first work to use real data was that of DINENIS (1990), this is the second.

The returns and risk for each fund are calculated for different investor holding periods: one month, one year and three years. Covariance between the five funds plus gold was also calculated for the same periods. The efficient frontier for the five funds was first calculated, then the effect of adding gold was determined. All computations take account of Swiss legal restrictions which prescribe maximum weightings for certain assets.

Prevista is a Swiss fund management company owned collectively by the Swiss Cantonal banks. Since its formation in 1973 Prevista has grown to become the second largest fund management company in Switzerland with assets under management totalling SFr. 2.37 billion. Prevista is consistently ranked amongst the top three fund managers in Switzerland.

The foundation manages funds which belong to Swiss pension funds. The funds are not publicly quoted and the public cannot buy shares in them. Prevista does however produce an annual report recording the activities of the funds during the year. An interesting development pioneered by Prevista at the beginning of 1989 was the creation of a Gold/Metal Fund. This is the first Swiss fund authorised for pension funds that permits investment in gold bullion.

2. Previous Studies of the Role of Gold in Portfolio Diversification

This section is not intended to be a comprehensive review but rather seeks to summarise the key stud-

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ies. The general finding of almost all studies is that gold has a negative or near zero correlation with the return to other financial assets. As a result of this countercyclical behaviour most studies have shown gold to be a valuable hedge asset. Thus adding some gold to a diversified portfolio of assets results in a higher ratio of return to risk (i.e. Sharpe Ratio). In short the studies show that adding gold increases portfolio efficiency.

SHERMAN (1982) created three simulated American portfolios from month-end equity and bond index returns over the period 1971 to 1981. The first consisted of 100% equities; the second 90% equities and 10% Treasury bills and the third 80% equities and 20% Treasury bills.

Sherman found that adding five percent of gold to the three portfolios in place of the equity portion had the effect in all cases of increasing return and reducing risk. Ten percent gold had the same effect on the purely equity portfolio. For the bond portfolios Sherman found that whilst gold improved return it also increased risk. However the improvement in return outweighed the increase in risk. The Sharpe Ratio was maximised by 15-20% gold. Sherman thus concluded that gold reduced volatility and improved returns in almost all environments.

A study of gold as a portfolio asset was performed by IRWIN and LANDA (1987) with very different results. Irwin and Landa compared gold with real estate and commodity futures as assets to be included in a diversified portfolio to minimise risk for a given expected return. Their study covered the period 1975-1985.

The efficient frontier was examined with and without the inclusion of the additional assets studied. They found that gold was not included in the optimised portfolio at any point along the efficient frontier. This absence was ascribed to the extreme volatility of gold returns relative to the volatility of returns of the other assets. It is notable in this regard that Irwin and Landa considered only quarterly holding periods.

BATCHELOR (1988) studied the investment performance of gold in 10 currencies over the period 1968-1988. The countries considered were Belgium, France, Germany, Italy, Japan, Netherlands, Spain, Switzerland, the UK and the USA. Although the nominal returns to gold were substantially different from country to country Batchelor found that the real (inflation adjusted) price of gold was similar between countries.

The returns to gold in Swiss Franc and Yen were slightly anomalous, however, in that they had appreciated against the dollar more than purchasing power parity would predict. This means that the real returns on gold to a Swiss pension fund, such as Prevista, have not been as high as in other currencies.

Batchelor also found that the real returns on gold were negatively correlated with the real rate of return on financial assets. Gold was thus shown to be an effective hedge against fluctuations in the returns on financial assets.

Batchelor showed that gold's negative correlation with other financial assets became larger and less variable over longer holding periods. On this basis Batchelor suggested that investors with a portfolio balanced between equities, bonds and cash should on average have switched between 5% and 20% of their investments into gold.

Over the 20-year study period gold was shown to offer higher returns and higher risks than financial assets. Gold's riskiness was found to fall as the investor's holding period increased. For periods of 5 years or more Batchelor showed that gold was no more risky than the equity markets. Furthermore the riskiness of gold was found to have been far higher in the 1970s than in the 1980s. Gold was also found to be a better hedge and notably less risky for non-dollar investors.

JAFFE (1989) studied the role of both gold and gold mining shares as investments for institutional portfolios over the period from September 1971 up to June 1987. He constructed four portfolios to mirror the likely allocations of large institutional portfolios.

Portfolio 1 with the highest proportion in equities was the most risky and portfolio 4 the least risky with over half the assets invested in bonds and real estate. Risk and return were calculated for each

portfolio and then recalculated with 5% and 10% of total assets invested in gold bullion.

The results of this study show that in all four portfolios, the mean return was increased by 5% gold and increased further by 10% gold. These results are no surprise. The return to gold exceeded that to the other asset categories.

A less obvious result was that the risk of the portfolios was reduced in all cases by the addition of 5% gold and reduced further by 10% gold. This occurs despite the higher standard deviation of gold returns because of the zero or negative correlation between the returns to gold and the other asset categories.

The same portfolio simulations were run using gold mining company shares. Jaffe found that although return was enhanced, risk was only reduced in two cases, was unchanged in one case and increased in five cases. This again could have been predicted from the correlation coefficients which show that gold mining stocks have positive correlations with other stocks.

In a very recent study DINENIS (1990), investigated the potential benefit to 30 large UK pension funds of holding gold as part of their portfolio of assets. The study period varied from fund to fund with start dates between 1976 and 1981. End dates were 1988 or 1989, and in all cases there was a minimum of eight years of data.

Dinenis's study evaluated the 30 funds in terms of the Sharpe ratio (defined above). Dinenis showed that 20 out of the 30 funds would have achieved superior performance with an investment in gold. The study calculated the percentage of gold which maximises the Sharpe ratio. Seven funds were shown to be maximised by between 1-9.9%; 10 by 10-20%; one by 20-30% and one extreme example had a maximum Sharpe ratio using 36% gold.

Dinenis shows that in order to be valuable as a means of improving the Sharpe ratio gold (or any other candidate asset) has to fulfil two conditions. The first of these is that it must provide a return in excess of the risk-free rate. The second criterion is that it should have near zero or negative correlation with the portfolio in question. Unlike the US studies, the Sterling returns on gold during the study period were less than those achieved by the 30 pension funds studied (although the returns were above the risk-free rate). This is an inevitable result of the fact that Dinenis's study period consisted almost exclusively of the 1980s. During this period the returns to gold have been much poorer than they were for periods starting in the early 1970s.

As a result, gold reduced the overall return to each portfolio. However because of the near zero or negative correlation between gold and the funds there was a reduction in portfolio risk in excess of the diminution in return such that the Sharpe ratio was enhanced.

3. The Data

The data provided by Prevista were in the form of monthly arithmetic percentage returns, corrected for flows of money to and from the funds. The returns to gold, and the risk free returns for the period 1976-89 were obtained from Datastream. The gold bullion returns are month-end Swiss Franc prices converted from dollars at the then-prevailing SFr:$ exchange rate. The three-month bank deposit rate was taken as the risk-free rate, in the absence of a Swiss equivalent to the three-month US Treasury Bills used in many studies.

For the purposes of the study, period returns were calculated using the geometric rather than the arithmetic method, since summing arithmetic returns does not produce accurate period returns. The geometric return is the product rather than the sum of the individual period returns and is given by:

$$R_N = \prod_{t=1}^{N} (1 + r_t) - 1$$

Where R_N is the N period return to the portfolio, Π is the symbol for the geometric mean, and r_t is the return to the portfolio in period t. Period returns, standard deviations of returns and correlation coefficients were calculated for holding periods of one

month, one year, and three years. The results of the calculation of return, standard deviation, and correlation coefficients are illustrated in Table 1. There are a number of observations to be made from these results.

Table 1: Prevista Funds 1976-89. Risk, Return and Correlation Coefficient Matrices.

Correlation Matrices:

One Month Holding Periods:

Real Estate	1.00					
Domestic Equities	0.11	1.00				
Foreign Equities	-0.02	0.47	1.00			
Domestic Bonds	0.12	0.34	-0.07	1.00		
Foreign Bonds	-0.08	0.23	0.54	0.21	1.00	
Gold	-0.03	0.01	0.03	-0.13	-0.01	1.00

One Year Holding Periods:

Real Estate	1.00					
Domestic Equities	0.06	1.00				
Foreign Equities	0.02	0.66	1.00			
Domestic Bonds	0.27	0.13	-0.23	1.00		
Foreign Bonds	0.22	0.21	0.59	0.21	1.00	
Gold	-0.40	-0.19	0.11	-0.47	-0.09	1.00

Three Year Holding Periods:

Real Estate	1.00					
Domestic Equities	0.16	1.00				
Foreign Equities	0.07	0.69	1.00			
Domestic Bonds	0.49	0.38	0.16	1.00		
Foreign Bonds	0.23	0.45	0.86	0.41	1.00	
Gold	-0.50	-0.51	-0.43	-0.62	-0.58	1.00

Risk and Returns:

	One Month		One Year		Three Years	
	R	SD	R	SD	R	SD
3-Month Deposit	0.38	0.13	4.45	1.59	13.74	5.54
Real Estate	0.52	0.39	6.33	1.48	19.31	2.76
Domestic Equities	0.89	3.16	11.89	15.53	39.62	34.74
Foreign Equities	0.62	3.96	8.18	17.95	28.92	33.73
Domestic Bonds	0.40	0.74	4.74	4.30	14.14	6.96
Foreign Bonds	0.51	1.55	6.41	8.01	20.93	17.83
Gold	0.56	6.71	10.16	37.32	35.56	75.98

Note:
Returns and standard deviations are calculated per holding period and are not annualised.

a) All funds show a marked reduction in riskiness (measured by standard deviation) as holding period increases. This means that for longer term investors the risks associated with short term volatility are largely smoothed out. This fall in riskiness is called mean reversion. Part of this mean reversion may be explained by the overlapping nature of the longer periods.
b) Gold is strongly mean reverting. It falls from a standard deviation of 6.7% for monthly holding periods to 2.1% per month for holding periods of three years. The strong degree of mean reversion displayed by gold accords with the findings of other studies, notably Batchelor (op. cit.) who showed that over longer periods gold was only a little more risky than equity investment.
c) There is a close relationship between risk and return. Domestic equities have the highest return and a high level of risk, whilst domestic bonds have the lowest return and lowest risk. The relationship between risk and return appears to become closer as the holding period lengthens.
d) With the exception of gold the correlation coefficients between most assets are positive. This is not obvious for monthly holding periods but becomes clearer as the holding period lengthens. These correlations suggest that gold would be the best asset to combine with any of the others to diversify risk.
e) The return to gold increases substantially as the holding period gets longer. This can be attributed to the fact that the gold price was broadly unchanged for the years 1976-1978 before rising strongly in 1979. As a result very high returns were made on gold investment in the years 1979-1981 (since it had been bought at much lower prices in 1976-1978). The overall period average is consequently higher.

From Table 1 it is clear that gold fulfils the two criteria outlined by DINENIS (1990) for a candidate asset to be included in a portfolio. That is gold is uncorrelated with other assets (indeed it is strongly negatively correlated for longer holding periods) and it has a positive rate of return.

There is one major caveat in calculating the optimal combination of assets to hold. Swiss law prescribes a series of constraints restricting asset allocation to particular maximum levels. Four of these constraints are relevant to Prevista, these are:

Asset	*Maximum Weighting*
Real Estate	30%
All Equities	50%
Foreign equities	25%
Foreign Bonds	30%

These restrictions may have a significant impact upon the calculation of the efficient frontier, since constraining asset allocations to certain levels may produce sub-optimal portfolios. The resultant sub-efficient frontier may even have a distorted shape. In addition to their distorting effect, these legal constraints make the calculation of the efficient frontier far more difficult.

4. Results

Optimal asset allocations were calculated on two bases. Firstly the efficient frontier was determined for the combination of all five funds, and then calculated again along with gold. This was done by using quadratic programming techniques to minimise the standard deviation of the portfolio at a given level of return, subject to the constraints discussed above. (A formal discussion of the optimisation process is provided in the appendix attached.) The visible portfolio shares of each asset at each level of return along the efficient frontier was recorded. The results of portfolio optimisation are illustrated in figures 1, 2 and 3.

Secondly, the effect of adding gold to the Swiss bond fund alone was evaluated. This is a much simpler calculation and is readily performed using a spreadsheet. Other single fund holdings were not evaluated because of the legal constraints discussed above. Figure 4 shows the effect of combining gold with Swiss bonds. Figures 1 to 3 show that gold is a valuable asset in risk diversification for holders of the Prevista funds. Whatever the investor's level of risk-aversion he should hold a proportion of his assets in gold to minimise the risk to which he is exposed. However the actual level of risk and return that an investor assumes along the efficient frontier

Figure 1: The Minimum Risk Set With and Without Gold, One Month Holding Periods, Prevista Funds, 1976-1989.

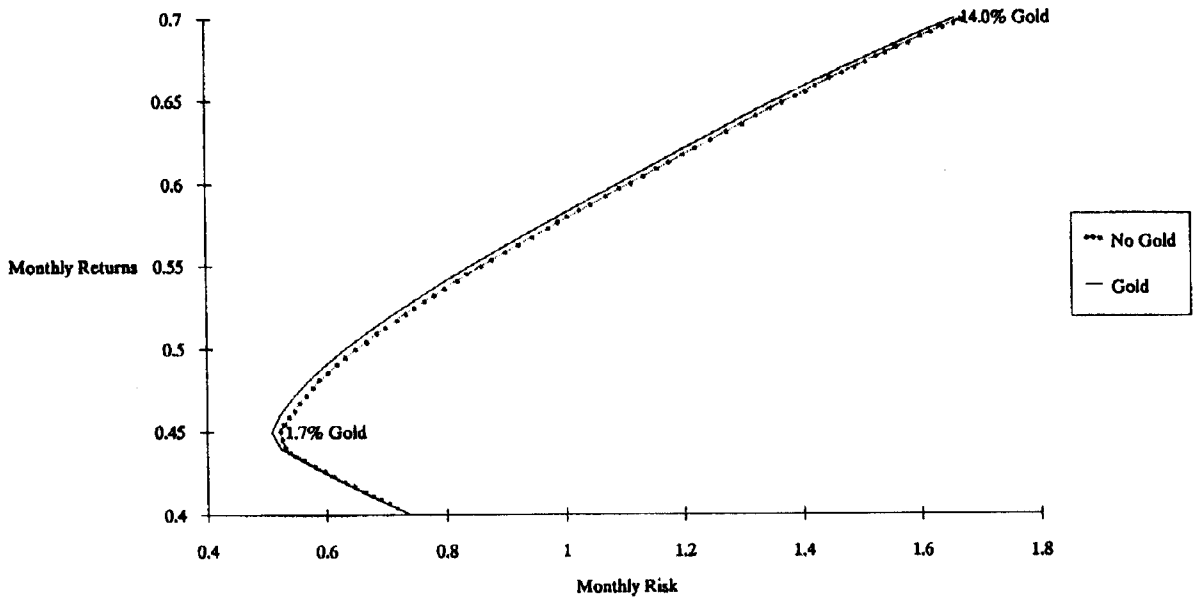


Figure 2: The Minimum Risk Set With and Without the Inclusion of Gold, One Year Holding Periods, Prevista Funds, 1976-1989.

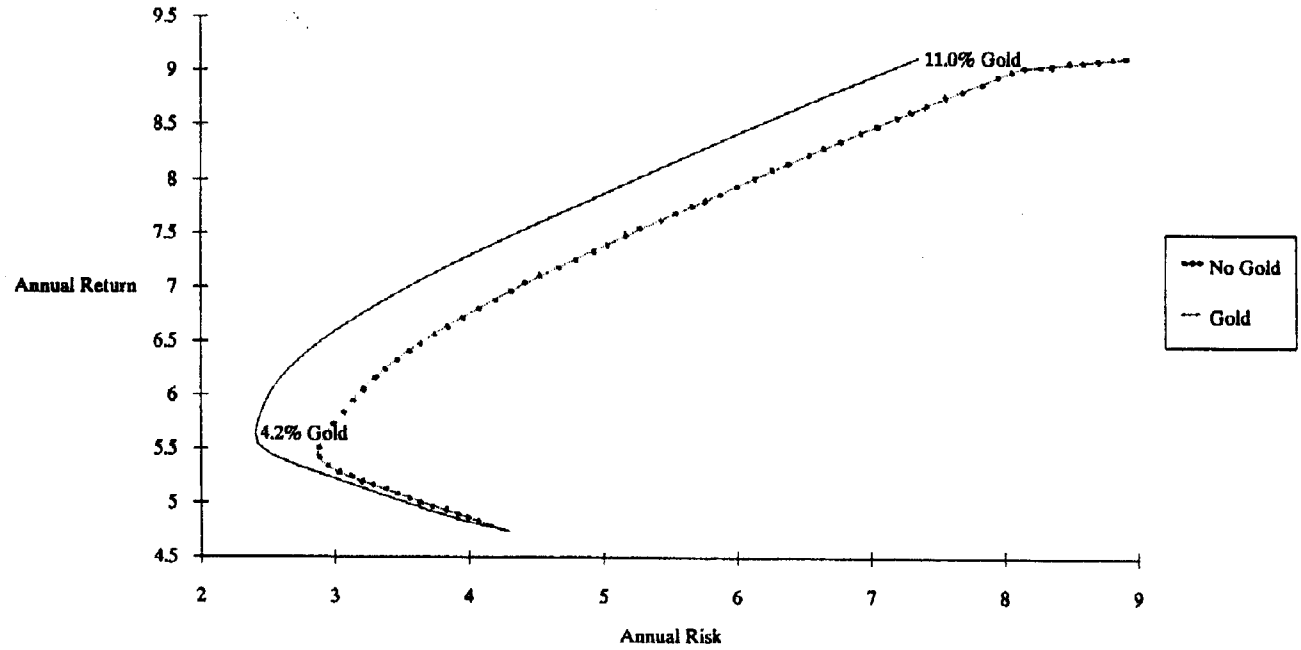


Figure 3: The Minimum Risk Set With and Without Gold, Three Year Holding Periods, Prevista Funds, 1976-1989.

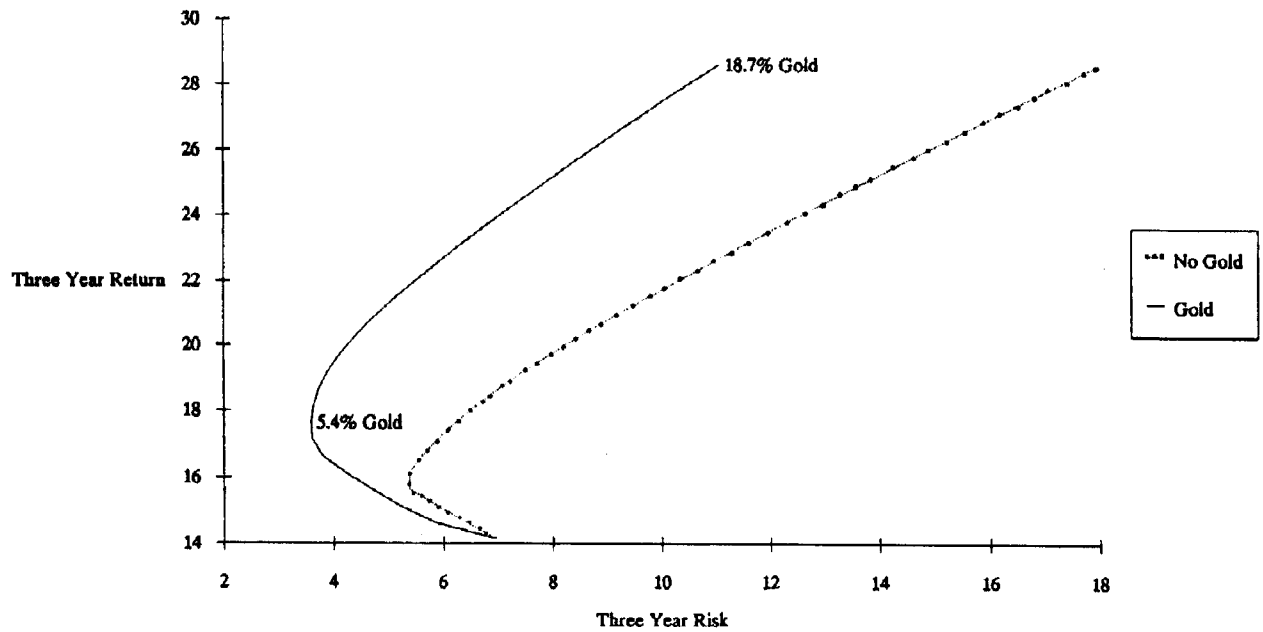
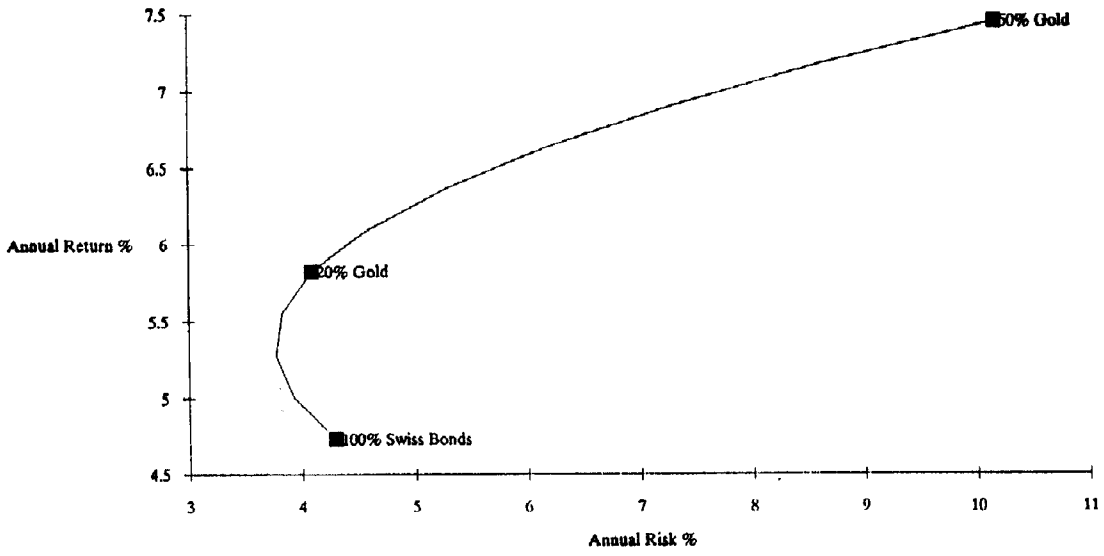


Figure 4: Prevista Bond Fund With Varying Gold Weightings, One Year Holding Periods. 1976-1989.



may be a subjective decision [1].

The actual combination of assets that the investor should hold varies with the level of risk assumed, as well as the holding period. Table 2 shows the optimal combination of assets at two particular points along the efficient frontier. The first combination is the minimum risk portfolio. The second combination is the return that an investor could achieve if the maximum permissible weighting of 50% was held in equities.

Figures 1 to 3 show that for longer holding periods more risk is offset by the addition of gold and that the amounts of gold required to minimise this risk are higher than for shorter holding periods. Gold's strongly negative correlation and its higher returns over long time periods are the reasons for his. As a result the amount of gold needed for the minimum risk portfolio rises from 1.7% for one month holding periods to 5.4% for three year holding periods. The other factor which influences the amount of gold required to optimise the efficient set is the level of risk assumed within a holding period. For one year holding periods an optimal gold allocation of 4.19% is required to optimise the minimum risk portfolio, but this rises to an 11.04% gold allocation for the maximum permissible return portfolio.

Table 2: Prevista Funds - Optimal Asset Allocation with Constraints.

Minimum Risk Portfolio

	1 Month	1 Year	3 Years
Real Estate	30.00%	30.00%	30.00%
Domestic Equities	0.00%	0.15%	0.59%
Foreign Equities	1.51%	4.58%	2.17%
Domestic Bonds	59.56%	59.44%	57.03%
Foreign Bonds	7.21%	1.64%	4.84%
Gold	1.72%	4.19%	5.37%

Maximum Return Portfolio

	1 Month	1 Year	3 Years
Real Estate	30.00%	30.00%	22.28%
Domestic Equities	50.00%	50.00%	50.00%
Foreign Equities	0.00%	0.00%	0.00%
Domestic Bonds	0.00%	0.00%	0.00%
Foreign Bonds	6.00%	8.96%	9.07%
Gold	14.00%	11.04%	18.65%

Note: The maximum return portfolio is the one where legal constraints prevent a higher allocation in domestic equities.

Throughout these results, the only constraint that is binding for most portfolios is that which restricts real estate holdings to 30%. However for the very highest levels of return the constraint that holds equity investments to 50% becomes visible and is binding. The other constraints do not become visible at any point i.e. asset allocation does not transgress them.

Although portfolio optimisation was only attempted subject to the Swiss legal constraints, we can speculate over the asset allocations that would result from an unconstrained portfolio. Since real estate is restricted to 30% for most positions along the efficient frontier, much higher allocations would result in an unconstrained world. As a result Swiss bond weightings would probably fall. Since gold has a pronounced negative correlation with real estate it would probably have a positive weighting in the absence of constraints.

At the highest levels of return the allocation to equities is entirely directed to Swiss equities. Equity weighting in the minimum risk portfolios, however, includes a foreign equity component. This can be attributed to the negative correlation that exists between Swiss bonds, which dominate asset allocation, and foreign equities over shorter holding periods.

Figure 4 shows the efficient frontier for a simple combination of gold and Swiss bonds for one year holding periods. This graph shows that gold combined with bonds both reduces risk and increases return. A weighting of 10% gold would produce a portfolio with lower risk and higher return than a portfolio entirely confined to Swiss bonds. It is only for gold weightings above around 20% that the augmented fund's riskiness exceeds that of Swiss bonds alone.

5. Summary and Conclusions

This study investigated the value of gold as a means of diversifying the risk associated with the efficient set of portfolios assembled from Prevista's five Swiss pension funds over the period 1976-1989. To that end the statistical properties of the five funds and of gold were investigated. The Swiss equity fund had the highest return and the returns to the other four funds were related to their riskiness, with Swiss bonds giving the lowest return.

Gold was shown to be a valuable asset by reducing risk at each level of return. The efficient frontier was consequently shifted upwards and to the left i.e. it was rendered more efficient. For longer holding periods and for the more risky portfolios more gold was required, and the degree of risk offset was larger.

The efficient frontier was calculated subject to the Swiss legal constraints on asset allocation. Only two of these constraints were found to be binding. The restriction of real estate to a 30% weighting was binding for a substantial proportion of the lower risk portfolios both with and without the addition of gold. The second restriction visible was that limiting equities to a maximum of 50% of a portfolio. This became binding for the highest risk and return portfolios. Since gold is negatively correlated with all assets, positive gold weighting would probably occur in an unconstrained world too.

This study confirms the findings of a number of earlier investigations. It extends earlier results involving gold to the Swiss Franc, and a set of real well-managed, above-average performing funds. The findings are that gold is negatively correlated with the returns to equities, bonds and real estate, and that it is progressively less risky over longer holding periods.

Appendix

Consider a portfolio of six risky assets (real estate, domestic equity, foreign equity, domestic bonds, foreign bonds and gold) with return vector $\boldsymbol{r}$ (6 x 1), mean return vector μ (6 x 1) and covariance matrix Σ (6 x 6). A portfolio consisting of the six risky assets is an efficient portfolio if and only if $\boldsymbol{w}$, the 6-vector portfolio weights, is the solution of the following problem

$$\min_{\{w\}} \frac{1}{2} w^T \Sigma w$$

s.t. $w^T \mu = m$ (1)

$w^T \mathbf{1} = 1$ (2)

$Bw \leq b$ (3)

$0 \leq Bw$ (4)

where m denotes the expected rate of return on the portfolio and $\mathbf{1}$ (6 x 1) is a vector of ones. The matrix B and the vector b are defined as

$$B = \begin{vmatrix} 100000 \\ 010000 \\ 001000 \\ 000100 \\ 000010 \\ 000001 \\ 011000 \end{vmatrix} \qquad b = \begin{vmatrix} 0.30 \\ 0.50 \\ 0.25 \\ 1.00 \\ 1.00 \\ 1.00 \\ 0.50 \end{vmatrix}$$

The vector of optimal weights is given by

$$w = \Sigma^{-1}B(\lambda_2 - \lambda_1) + \{[c(m - \Delta_2) - (1 - \Delta_1)\, b]/d\}\Sigma^{-1}\mu + \{(a(1 - \Delta_1) - b(m - \Delta_2)]/d\}\Sigma^{-1}\mathbf{1} \quad (5)$$

where a, b, c and d are the efficient set constants given by

$$a = \mu^T\Sigma^{-1}\mu \qquad b = \mu^T\Sigma^{-1}\mathbf{1} \qquad c = \mathbf{1}^T\Sigma^{-1}\mathbf{1}$$
$$d = (ac - b^2)$$

Δ_1 and Δ_2 are constants defined as

$$\Delta_1 = \mathbf{1}'\Sigma^{-1}B(\lambda_2 - \lambda_1) \qquad \Delta_1 = \mu'\Sigma^{-1}B(\lambda_2 - \lambda_1)$$

and λ_1 and λ_2 are the vector of the Lagrange multipliers associated with constraints (3) and (4). If none of the constraints is binding: $\lambda_1 = \lambda_2 = 0$, unrestricted case.
The variance of the rate of return on the portfolio is given by

$$\sigma^2 = b'\lambda_1 + [a\,(1 - \Delta_1) + b\,\Delta_2]/d + (c/d)m^2 - \{[\,(2 - \Delta_1)b - c\Delta_2]/d\}m \quad (6)$$

Equation (6) traces the locus of feasible mean-variance-efficient portfolios. In the (σ^2, m) space, the locus is a parabola, while in the (σ, m) space it is a hyperbola. The same constrained quadratic programming problem was also solved and the feasible efficient frontier obtained for a case when gold was not included in the portfolio.

Footnote

[1] If there is a risk-free asset then the choice of the optimal portfolio is no longer subjective. In this case there is a portfolio (termed to market portfolio) which when combined with the risk-free asset gives higher returns for the same level of risk.

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