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|---|---|---|---|
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# Part 1

### Question 1

**Part a.** Investing in one country. First of all, we would like to comment on computation. We proceeded in the following way: we calculated the monthly average returns for the period of 37 years. We express returns on annual basis by multiplying monthly returns by 12. The similar procedures apply to the computation of standard deviation:

$$\bar{\mathrm{R}} = 12 * \frac{1}{T}\sum_{t=1}^{T}\left(\frac{I_t}{I_{t-1}} - 1\right) = 12 * \frac{1}{T}\sum_{t=1}^{T}\left(R_t\right)$$

$$\sigma = \sqrt{12 * \frac{1}{T-1}\sum_{t=1}^{T}\left(R_t - \bar{\mathrm{R}}\right)^2}$$

As for the risk free rate — we take current monthly rate, which equal to 0.4% per month (or 12*0.4%=4.8% on annual basis), in order to get current Sharpe Ratio.

As we can find from the table Belgium and Denmark have the highest Sharpe Ratio (SR) of 0.56 and 0.57, respectively.

| Investing in one country | | | |
|---|---|---|---|
| | Return | Volatility | SR |
| USA | 11.5% | 15.2% | 0.44 |
| UK | 14.0% | 22.5% | 0.41 |
| ITALY | 10.9% | 25.1% | 0.24 |
| AUSTRALIA | 12.8% | 23.8% | 0.34 |
| AUSTRIA | 14.0% | 21.1% | 0.44 |
| BELGIUM | 15.7% | 19.5% | 0.56 |
| FRANCE | 14.0% | 22.3% | 0.41 |
| GERMANY | 13.1% | 21.0% | 0.40 |
| CANADA | 12.2% | 18.9% | 0.39 |
| DENMARK | 15.6% | 18.9% | 0.57 |
| JAPAN | 13.5% | 22.8% | 0.38 |

**Part b.** For simplicity we estimate all pairs with the US market. As you can find from the table, creating a portfolio of two stocks improves returns and decreases volatility of (portfolio) returns. We can also see an increase in SR. Here the highest SR is 0.61 for Denmark and 0.59 for Belgium, what means that investor gets higher excess returns on one unit of risk.

| Investing in 50% in US and 50% in other country | | | | |
|---|---|---|---|---|
| Country | Return | S.D. | SR | Correlation |
| UK | 12.74% | 17% | 0.48 | 53% |
| ITALY | 11.20% | 16% | 0.39 | 29% |
| AUSTRALIA | 12.14% | 17% | 0.43 | 48% |
| AUSTRIA | 12.77% | 14% | 0.57 | 19% |
| BELGIUM | 13.60% | 15% | 0.59 | 45% |
| FRANCE | 12.77% | 16% | 0.49 | 49% |
| GERMANY | 12.28% | 15% | 0.48 | 45% |
| CANADA | 11.88% | 16% | 0.45 | 71% |
| DENMARK | 13.54% | 14% | 0.61 | 38% |
| JAPAN | 12.49% | 16% | 0.49 | 32% |

**Part c.** Investing equally in all stocks also leads to an increase of Sharpe ratio, now it is 0.59. It is still lower than for US-Denmark portfolio, but the equally weighted portfolio is far from being an optimal (tangency) portfolio anyway.

| Equal Investment in all countries | |
|---|---|
| Return | 13.4% |
| Volatility | 14.5% |
| SR | 0.59 |

**Question 2**

If Terminator like a God knows everything for sure — there is no need in theory. Investing in situation when you know for sure how that Belgium will outperform everything in 37 years means no risk for an investor. However, there might be issues associated with the fact that 37 might be too long for Terminator. We can ignore them as Terminator can always sell his portfolio and buy futures and options on Belgium stocks.

We would like to discuss this problem in another perspective — suppose Terminator is not 100% credible and we cannot believe him. In this case we face a typical

choice under uncertainty. This implies that we can use portfolio theory and diversification notion made by teacher.

One reason for making investment in all countries – small probability of huge return decline (downside risk). If each country is equally exposed to this risk and the events, which lead to plummeting stock prices (e.g., war), are not 100% correlated, than we should buy all countries. This will help to diversify downside risk.

Ex-post we can see that Belgium has a highest return over 37 years, but the volatility of return is also very high, so we cannot make our choice only based on returns. In fact, significant part of this volatility can be diversified — e.g., pair correlation between the US and other markets is on average lower than 50% (Table 2). This may a good source of diversification. Indeed, using equally weighted portfolio we have higher Sharpe Ratio compared with investment only in Belgium (Table 1 and 3).

## CFA questions

Question 12 (Ch.6)

$$\sigma = 14\%, w = 60\%$$
$$E\{R\} = 10\% + 6\% = 16\%$$
$$E\{R_p\} = wE\{R\} + (1-w)R_f = 12\%$$
$$\sigma_p^2 = V\{R_p\} = w^2\sigma^2 \rightarrow \sigma_p = w\ \sigma = 8.4\%$$

Question 13 (Ch.6)

$$\frac{R - R_f}{\sigma} = \frac{10\%}{14\%} = 0.71$$

Question 23 (Ch.7)

a. Risk of investing in a security can divided into two parts — systematic risk and firm-specific risk. The former relates to a risk which is common to all equity in the market and therefore cannot be diversified. On contrast, firm-specific risk is diversifiable, because events that lead to a change in returns are independent. That in turn implies that adding securities in portfolio in a right way can reduce firm-specific risk. Example of systematic risk — slowdown in the economy, increase in fed funds rates. This events have are common to all securities and financial market. Example of firm-specific risk — police found that CEO of a company was using illegal drugs.

b. As the number of securities increase, firm-specific risk is declining and in the limit it can be eliminated. On the other hand, systematic risk does not depend on number of companies, because it is a common risk to all securities. So the larger number of companies in portfolio reduces firm-specific risk, without changing systematic (market) risk, thus reducing the total risk.

Question 24 (Ch. 7)

In respect to two criteria: enhancing return and probably reducing the volatility the best fund to add is Fund D. The expected return is just the weighted average, so then we can not add Fund B – the return will go down. Index funds A and C both have very strong correlation with the current portfolio and relatively high standard deviations at the same time. If we look at fund D we can see that it may help to improve returns and at the same time lower the volatility, mainly because of its low volatility.

**Question 26 (Ch.7)**

| | Expected Monthly Returns | Standard Deviation of Monthly Returns |
|---|---|---|
| **Original Portfolio** | 0.67% | 2.37% |
| **Euro Co.** | 1.25% | 2.95% |
| **Correlation (Orig. Portf., Euro Co.)** | 0.4 | |

***a. Grace keeps the Euro Co.:***

| | Investment | Weight |
|---|---|---|
| **Original Portfolio** | 900,000.00 | 0.90 |
| **Euro Co.** | 100,000.00 | 0.10 |
| **New Portfolio** | 1,000,000.00 | |

i.

Expected Return = 0.90 * 0.67% + 0.10 * 1.25%=0.73%

ii. Covariance = $Cov(x,y) = \sigma_y \sigma_x Corr(x,y)$

Covariance = 2.37% * 2.95% * 0.40=0.028%

Standard Deviation = $\left(w_x^2\sigma_x^2 + w_y^2\sigma_y^2 + 2w_x w_y \sigma_y \sigma_x Corr(x,y)\right)^{1/2}$

Standard Deviation = [$0.90^2$ * $2.37^2$ + $0.10^2$ * $2.95^2$ + 2 * 0.90 * 0.10 * 2.37 * 2.95 * 0.40] $^{½}$=2.27%

***b. Sell Euro Co stock, and invest in government security yielding 0.42% per month. Calculate***

| | Investment | Weight | Expected Return | S.D. |
|---|---|---|---|---|
| Original Portfolio | 900,000 | 0.90 | 0.67% | 2.37% |
| Government Security | 100,000 | 0.10 | 0.48% | 0.0% |
| Total Portfolio | 1,000,000 | 1.00 | 0.65% | 2.13% |

i.

Expected Return = 0.90 * 0.67% + 0.10 * 0.48%=0.65%

ii. Covariance $Cov(x, y) = \sigma_y \sigma_x Corr(x, y)$

Since it is a government security, which by is risk free, the standard deviation of this bond should be zero. So, the covariance should be also zero.

iii.

Standard Deviation = $[0.90^2 * 2.37^2 + 0.10^2 * 0^2 + 2 * 0.90 * 0.10 * 2.37 * 0 * 0]^{½}$=0.9*2.37%=2.13

***c. Determine systematic risk of her new portfolio, which includes the government securities, will be higher or lower than that of her original portfolio***

The systematic risk of the new portfolio will be lower. The risk of the portfolio will decrease due to adding a risk-free government security (which has no volatility as it is risk free).

d. Her husband's comment is incorrect. We should take into account XYZ stock's correlation with the original portfolio. If the XYZ stock's correlation with the original portfolio is greater than 0.40 (correlation of Euro Co stock), the benefits of diversification are not large enough. Since Euro Co stock has the same correlation, and XYZ gives the same expected returns as Euro Co stock but with higher volatility (standard deviation). The benefit of replacing the Euro Co stock with XYZ stock will be achieved only when the correlation is less than 0.40 (correlation of Euro Co stock) which will give same expected return for reduced risk as compared to Euro Co stock.

***e.***

i. Standard deviation is based on the assumption of symmetric return — that implies that negative and positive changes of returns are all treated as risk. One may argue that he do not care as much about upside risk as about downside risk. So, standard deviation is something average between upside risk (volatility) and downside risk. More over, if the returns has negative skewness (low probability of a large downside risk), it cannot be directly captured by standard deviation, as it's the second central moment, while skewness is captured by the third moment.

Ii. We can use a standard deviation which takes into account only negative returns, ignoring positive. We can also think of estimating skewness as a measure of "fat left tail". There are a lot of other measures we can use — Value-at-Risk, time series models (like GARCH(1,1)) for conditional volatility.

Question 4 (Ch.9)

I will offer 1000/(6%+0.5*10%)-1000/(6%+10%) = 2840.9 more.

Question 22 (Ch.9)

a. Erx=5%+0.8*9% = 12.2%

   Ery=5%+1.5*9% = 18.5%

   alpha x = 14-12.2 = 1.8%

   alpha y = 17-18.5 = -1.5%

b. i. When adding to the well-diversified portfolio we will choose a stock with positive alpha, that is X.

   ii. When holding as a single portfolio we want something with higher Sharpe Ratio:

   SRx = 7.2/36 = 0.2

   SRy = 13.5/25 = 0.54

   So we will choose stock Y.

# Harvard Management Company Case

## Current company strategy

The objective was to partially finance the activities of the University by earning money on financial markets. The management chose the strategy of preserving the value of the endowment in perpetuity, that is not allowing expenses to decrease its real value. This issue actually lies beyond the investment theory in the field of the choice in time theory, and this particular choice (equal real distribution between "generations") is a matter of preferences.

## Key elements of the strategy

To make investments which will bring additional value HMC used several techniques:

- performed deep analysis to exploit arbitrage opportunities. They successfully implemented "buy underpriced – sell overpriced" strategy using hedging where possible, which shows the professionalism of a team.
- adjusted the weights in portfolio to play on current market moves, at this they were not very successful, so probably it's worth abandoning such an activity
- implemented compensation policy, which provides huge incentives for the traders and analysts to perform well in the long run. We think that allowing for negative incentive bonus and clawback clause is a smart move designed not to allow traders to take additional unnecessary risk.
- established risk control, which monitored the positions and run stress test on portfolio. Although we can see the results of risk control: probably it was under the pressure from risk department, that the leverage ratio was decreased from 4.2 in 1998 and 4.9 in 1999 to 2.8 in November 2000, we don't see a clear periodic measure that allows to quantify the exposure to the risk such as VaR.

## Optimal Portfolio Allocation Problem

In theory one should keep a portion of tangent portfolio and risk free asset. A Policy portfolio of HMC is really different from all the portfolios on the efficient frontier, calculated by the analyst. Now we will address this issue in more detail.

First, we would like to notice that in comparison to other Universities' portfolios one of HMC seems to be more diversified. Almost only in Harvard they have investments in high-yield bonds and inflation indexed bonds. Although the latter is likely to be because of the real value preserving policy, we think that it lowers the exposure of portfolio to the non-systematic risk.

After building the efficient frontier analysts found striking results about the candidates to tangency portfolio (there is no one, because SRs are all almost the same):

- non of domestic equity was included
- non of foreign equity was included
- with conservative position (low return and volatility) one should keep a lot of inflation-indexed bond
- to make a more aggressive position one should heavily invest in commodities and real estate, heavily borrowing at the same time

The explanation for potentially high weight in commodities is its negative correlation with almost all instruments, so investments in commodities are required in large amount to provide the insurance of negative financial markets moves.

Nevertheless, we agree that establishing additional constraints on the weights based on the previous Policy portfolio was justified. There is not enough illustrative history for some of the investment types and in addition it was a bull market for the last 20 years. That's why sensitivity of the optimal weights to the assumptions and difficulties in empirical estimation of the parameters could lead to misleading results.

We suggest that HMC should use the results of efficient frontier calculations to gradually enhance its portfolio. We believe that if the assumptions were not precise but very reasonable, then the calculations provide real inside about the tangency portfolio, which will allow to get more return on one unit of risk.

## Other issues

**Risk tolerance.**

As now more than 25% of the University is financed through the income from the investments, the theory shows that it should become more risk averse (as now the higher part of its income is at risk), that is to adopt more conservative investment strategies with lower but more stable returns.

**Reliance on new asset classes.**

One shouldn't judge on the basis of volatility and return of an individual asset class taken alone. What matters is its contribution to the whole portfolio.

**Active management.**

We believe that HMC shouldn't follow the temptation to increase its exposure to active management risk. Although the history shows successful results, the future results are not guaranteed. More over the higher costs involved in finding further arbitrage opportunities may not be justified. So it will be sacrificing the expected return for the sake of a hope.