MS&E 247s International Investments

MWF 3:15-4:30     Gates B01

Final Exam MS&E 247S

Fri Aug 15 2008 12:15PM-3:15PM Gates B01
Or Saturday Aug 16 2008 12:15PM-3:15PM Gates B01

Remote SCPD participants will also take the exam on Friday, 8/15

Please Submit Exam Proctor’s Name, Contact info as SCPD requires, also
c.c. to yeetienfu@yahoo.com a week before the exam.

Local SCPD students please come to Stanford to take the exam. Light
refreshments will be served.

Handout #13
International Asset Portfolios
Bond Portfolios

### Reading Assignments for this Week

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International Asset Portfolios
Bond Portfolios

MS&E 247S International Investments
Yee-Tien Fu
Return and Risk in National Bond Markets

• We assume that our investor treats the US$ as his base currency (the numeraire currency used by the investor for measuring performance).

• In general, the return on a foreign bond, as measured in US$ terms, has 3 components:
  1. Interest income earned or accrued.
  2. The capital gain or loss on the bond, resulting from the inverse relationship between interest rates and bond prices.
  3. The foreign exchange gain or loss, applied to the above two items.
Calculating Unhedged Returns in US$ Terms

\( B_t \) - the initial purchase price of the bond in foreign currency (FC) terms

\( S_t \) - the spot exchange rate, in $/FC terms, on the purchase date

After one month:

\( \tilde{B}_{t+1} \) - the value of the bond after one month, representing the initial bond price plus the price change over the month (\( \tilde{\Delta}_{t+1} \)) plus accrued interest (\( C_{t+1} \)).
Calculating Unhedged Returns in US$ Terms

Therefore:

\[ B_t S_t \] - the US$ purchase price of the foreign bond

\[ \tilde{B}_{t+1} \tilde{S}_{t+1} \] - the value of the bond after one month in US$ terms, where

\[ \tilde{B}_{t+1} \equiv B_t + \tilde{\Delta}_{t+1} + C_{t+1} \]

Note that:

If interest rates rise, bond prices fall \((\tilde{\Delta}_{t+1} < 0)\).

If interest rates fall, bond prices rise \((\tilde{\Delta}_{t+1} > 0)\).
Yield to Maturity

- Interest rate that makes the present value of the bond’s payments equal to its price

Solve the bond formula for $r$

$$P_B = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} + \frac{ParValue}{(1+r)^T}$$
Calculating Unhedged Returns in US$ Terms

The continuous rate of return on the foreign bond measured in US$ and on an unhedged basis is:

\[ \tilde{R}_{s,U} = \ln\left( \frac{\tilde{B}_{t+1} \tilde{S}_{t+1}}{B_t S_t} \right) = \ln\left( \frac{\tilde{B}_{t+1}}{B_t} \right) + \ln\left( \frac{\tilde{S}_{t+1}}{S_t} \right) = \tilde{B}_{FC} + \tilde{S}_{US$,FC} \] (14.1)

Therefore the unhedged US$ return on the foreign bond has two pieces:

1. the return on the bond in foreign currency terms (\( \tilde{B}_{FC} \)); and
2. the return on the foreign currency used to buy the bond (\( \tilde{S}_{US$,FC} \)).
Calculating Unhedged Returns in US$ Terms

Note that the return on the bond in foreign currency terms is uncertain because of the possible capital gain or loss on the bond. But the return measured in US$ has an additional source of uncertainty, the foreign exchange gain or loss.
Calculating Unhedged Returns in US$ Terms

The variance of the returns in equation (14.1) reflects the variance of each term and the covariance between the returns on the foreign bond and the returns on spot foreign exchange, or:

$$\sigma^2(R_{$,U}) = \sigma^2(B_{FC}) + \sigma^2(S_{US$\$,FC}) + 2Cov(B_{FC}; S_{US$\$,FC}) \quad (14.2)$$

Note that the covariance term can be either positive or negative, as shown in Table 14.2.
## Currency Market Returns and Bond Market Return Combinations

<table>
<thead>
<tr>
<th>Bond Market Returns</th>
<th>Currency Market Returns</th>
<th>Positive</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td>FC interest rates ↑</td>
<td></td>
<td>(A)</td>
</tr>
<tr>
<td></td>
<td>Spot FX ↓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive</td>
<td>FC interest rates ↓</td>
<td>(D)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spot FX ↓</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 14.2 Pg 496
Currency and Bond Market Returns Combinations

Cases A and B have a Fisherian foundation.

For Case A, a forecast of future inflation may raise interest rates (bond market losses),

\[ i_{\text{DM}} = r_{\text{DM}} + E(\Delta P_{\text{Germany}}) \]

and depress the foreign exchange rate (currency market losses).

International Fisher Effect (Fisher Open)

\[ i_{\$} - i_{\text{DM}} = E(\Delta \text{Spot}) \]
Currency and Bond Market Returns Combinations

Cases C and D result in negative covariance between currency and bond market returns.

Case C corresponds to a tight monetary policy that raises interest rates (bond market losses) but attracts foreign capital and appreciates the exchange rate (currency market gains).

Case D suggests a low interest rate environment (bond market gains) that encourages an outflow of funds and a weaker currency market (currency market losses).
If foreign interest rates are headed down, the manager may want to buy foreign bonds.

But if lower interest rates imply a weaker currency (case D), the manager must weigh this possibility and consider a hedge to limit currency losses.
Calculating Currency-Hedged Returns in US$ Terms

After buying the foreign bond at a price $B_t$, one possible strategy is to sell all future coupon payments forward in exchange for US$ as well as sell the final return of principal forward.

This strategy is much like a currency swap that eliminates all currency risks and transforms this foreign bond into a US$ bond.
The Basic Cash Flows of a Currency Swap

- Firms A and B can each issue a 7-year bond in either the US$ or SFr market.
- Firm A has a comparative advantage in borrowing US$ while firm B has a comparative advantage in borrowing SFr.
- By borrowing in their comparative advantage currencies and then swapping, lower cost financing is possible.

<table>
<thead>
<tr>
<th></th>
<th>US$ Finance</th>
<th>SFr Finance</th>
<th>Difference (A-B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm A</td>
<td>10%</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Firm B</td>
<td>11.5%</td>
<td>6%</td>
<td>-1.5%</td>
</tr>
<tr>
<td>Difference</td>
<td></td>
<td></td>
<td>-1.0%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-0.5%</td>
</tr>
</tbody>
</table>
Together, A and B save 0.5 percent. Note that if a bank or swap dealer intermediates the transaction and charges a fee, the aggregate interest savings will be reduced.
Suppose our investor sells a one-month forward currency contract (priced at $F_t$) for an amount equal to next month’s estimated value of the bond with accrued interest, $\hat{B}_{t+1}$, where:

$$\hat{B}_{t+1} \equiv B_t + \Delta_{t+1} + C_{t+1}$$

If our investor guesses right, and $\tilde{B}_{t+1} = \hat{B}_{t+1}$, then he has made a perfect hedge. The US$ value of his foreign bond is $\hat{B}_{t+1} F_t$ and the continuous rate of return measured in US$ is:

$$\tilde{R}_{\$,H^*} = \ln\left(\frac{\hat{B}_{t+1} F_t}{B_t S_t}\right) = \ln\left(\frac{\hat{B}_{t+1}}{B_t}\right) + \ln\left(\frac{F_t}{S_t}\right) = \hat{B}_{FC} + F_{\$,FC} \quad (14.3)$$

where the $H^*$ subscript indicates a perfect hedge.
The return $R_{\$, H^*}$ also has two pieces:

The return on the bond in foreign currency terms ($\hat{B}_{FC}$) plus the one-month forward premium ($F_{US\$, FC}$). The variance of returns in equation (14.3) is:

$$\sigma^2(\tilde{R}_{\$, H^*}) = \sigma^2(\hat{B}_{FC}) + \sigma^2(F_{US\$, FC}) + 2\text{Cov}(\hat{B}_{FC}; F_{US\$, FC}) \ (14.4)$$

As an empirical matter, $\sigma^2(\tilde{R}_{\$, H^*})$ should be less than $\sigma^2(\tilde{R}_{\$, U})$ because the volatility of the forward premium is far smaller than the volatility of exchange rate changes.
Forward Premium and Spot Rate Change
$/DM One-Month Forward Rates: Jan 1979 - Jul 1990

Levich Figure 5.8A
Forward Premium and Spot Rate Change
$/DM Three-Month Forward Rates: Jan 1979 - Jul 1990

Levich Figure 5.8B
Most likely, our investor cannot perfectly predict the future price of the foreign bond.

We define the prediction error as the actual minus the expected bond price, or:

$$\tilde{\varepsilon}_{t+1} \equiv \tilde{B}_{t+1} - \hat{B}_{t+1} = \tilde{\Delta}_{t+1} - \hat{\Delta}_{t+1}$$

The term $\tilde{\varepsilon}_{t+1}$ and its volatility represent the interest rate risk in the foreign bond market. If $\tilde{\varepsilon}_{t+1} > 0$, our hedge amount was too small and the unexpected (positive) excess value of the bond is valued at $S_{t+1}$ and we need to sell the unexpected additional funds in the market at $S_{t+1}$. 
Conversely, if $\tilde{\varepsilon}_{t+1} < 0$, our hedged amount was too large (we oversold foreign currency forward) and we need to buy unexpected additional funds in the market at $S_{t+1}$.

In general, once the value of the future exchange rate is known, we measure the continuous rate of return on the foreign bond measured in US$ and on a currency-hedged basis as:

$$\tilde{R}_{S,H} = \ln\left(\frac{\hat{B}_{t+1}F_t}{B_tS_t}\right) + \ln\left(\frac{\tilde{\varepsilon}_{t+1}S_{t+1}}{B_tS_t}\right)$$

$$= \ln\left(\frac{\hat{B}_{t+1}}{B_t}\right) + \ln\left(\frac{F_t}{S_t}\right) + \ln\left(\frac{\tilde{\varepsilon}_{t+1}S_{t+1}}{B_tS_t}\right)$$  

(14.5)

$$= \tilde{B}_{FC} + F_{\text{US$},FC} + \ln\left(\frac{\tilde{\varepsilon}_{t+1}S_{t+1}}{B_tS_t}\right)$$
\[ \tilde{R}_{\$,H} = \ln\left( \frac{\hat{B}_{t+1}F_t}{B_tS_t} \right) + \ln\left( \frac{\tilde{\varepsilon}_{t+1}S_{t+1}}{B_tS_t} \right) \]

\[ = \ln\left( \frac{\hat{B}_{t+1}}{B_t} \right) + \ln\left( \frac{F_t}{S_t} \right) + \ln\left( \frac{\tilde{\varepsilon}_{t+1}S_{t+1}}{B_tS_t} \right) \quad (14.5) \]

\[ = B_{\text{FC}} + F_{\text{US\$,FC}} + \ln\left( \frac{\tilde{\varepsilon}_{t+1}S_{t+1}}{B_tS_t} \right) \]

In order to allow for the possibility that \( \tilde{\varepsilon}_{t+1} \) may be negative, we need to modify the definition of the hedged US$ return in equation (14.5) on page 497.
\[ \tilde{R}_{s,H} = \ln \left( \frac{\hat{B}_{t+1} F_t}{B_t S_t} + \frac{\tilde{\varepsilon}_{t+1} \tilde{S}_{t+1}}{B_t S_t} \right) \] (14.5a)

\[ = \ln \left[ \frac{\hat{B}_{t+1} F_t}{B_t S_t} \left( 1 + \frac{\tilde{\varepsilon}_{t+1} \tilde{S}_{t+1}}{\hat{B}_{t+1} F_t} \right) \right] \] (14.5b)

\[ = \ln \left[ \frac{\hat{B}_{t+1} F_t}{B_t S_t} \right] + \ln \left[ \left( 1 + \frac{\tilde{\varepsilon}_{t+1} \tilde{S}_{t+1}}{\hat{B}_{t+1} F_t} \right) \right] \] (14.5c)
Using equation (14.5c), we can allow for cases where $\varepsilon_{t+1} < 0$. The formula produces sensible answers, and it is still valid to think of the hedged return as the sum of three pieces: the predicted price change of the bond, the forward premium, and the residual unpredicted price change of the bond.

With $\varepsilon_{t+1} = 0$, we still have the result that the perfectly hedged portfolio earns a constant (known return) and no error variance.
Equation (14.5) shows the return on a currency-hedged foreign bond.

This return has three pieces:

(1) the return from the predicted price change on the bond in foreign currency terms,

(2) the forward premium (or discount) on the foreign currency used to buy the bonds, and

(3) a residual term representing the unpredicted price change in the foreign bond that is valued at the future uncertain spot exchange rate.
Notice that the US$ returns on the first two pieces are certain, because the predicted end-of-month value of the bond has been sold forward at a price $F_t$. The primary source of uncertainty ($\tilde{\varepsilon}_{t+1}$) stems from our inability to predict $\tilde{B}_{t+1}$ and $\tilde{\Delta}_{t+1}$ with certainty because of interest rate risk in the foreign bond market.

The variance of returns for the currency-hedged bond in equation (14.5) is now:

$$\sigma^2(\tilde{R}_{\$,H}) = \left[ \frac{S_{t+1}}{B_t S_t} \right]^2 \sigma^2(\tilde{\varepsilon}_{t+1})$$ (14.6)
Equation (14.6) is a conditional variance, conditional on $\tilde{S}_{t+1} = S_{t+1}$. In general, $\sigma^2(R_{S,H})$ depends on the combined effects of $\sigma^2(\tilde{\varepsilon}_{t+1})$ and $\sigma^2(\tilde{S}_{t+1})$.

$$\sigma^2(\tilde{R}_{S,H}) = \left[ \frac{S_{t+1}}{(B_t S_t)} \right]^2 \sigma^2(\tilde{\varepsilon}_{t+1}) \quad (14.6)$$

If there were no interest rate risk, then the prediction of $\tilde{B}_{t+1}$ is perfect, and $\tilde{\varepsilon}_{t+1} = 0$. In this special case, there is no residual element associated with interest rate risk. Thus, the US$ returns on the currency-hedged bond are given with certainty. Variance of returns in this case is zero.
Calculation of Prices and Returns for a Five-Year German Bund on an Unhedged Investment

The 5-year German Bund is priced at par with a 4.00% coupon paid annually.

The initial spot exchange rate $S_0 = $0.65/DM, so the purchase of a DM1 million bond requires an outlay of $1,000,000 \times 0.65 = $650,000.

At the end of year 1:

Suppose $i_{DM}$ falls to 3.75%, spot DM weakens to $0.625.

Each coupon payment is $1,000,000 \times 0.04 = DM40,000.

DM bond price

\[
= \frac{40,000}{(1 + 0.0375)} + \frac{40,000}{(1 + 0.0375)^2} + \frac{40,000}{(1 + 0.0375)^3} + \frac{40,000 + 1,000,000}{(1 + 0.0375)^4}
\]

\[
= 1,009,128.46
\]

Box 14.1
Calculation of Prices and Returns for a Five-Year German Bund on an Unhedged Investment

So, in DM terms, the return for the first year

\[
= \ln \left[ \frac{1,009,128.46 + 40,000}{1,000,000} \right] \times 100 = 4.80\%
\]

Since the spot DM has weakened to $0.625, the bond’s US$ value is 1,009,128.46 x 0.625 = $630,705.29, and the coupon value is 40,000 x 0.625 = $25,000.

So, in US$ terms, the first year return that reflects the coupon and exchange rate loss

\[
= \ln \left[ \frac{630,705.29 + 25,000}{650,000} \right] \times 100 = 0.87\%
\]
Calculation of Prices and Returns for a Five-Year German Bund on a Currency-Hedged Investment

The 5-year German Bund is priced at par with a 4.00% coupon paid annually.

The DM is at roughly a 1% forward premium, and slightly larger when DM interest rates fall.

Estimate of the expected future bond price = previous value of the bond plus the coupon payment.
For the first year:
The initial bond value = DM1,000,000.

With DM40,000 of interest expected, the investor hedges by selling DM1,040,000 forward at $0.6560/DM, resulting in
$1,040,000 \times 0.6560 = $682,240.
Calculation of Prices and Returns for a Five-Year German Bund on a Currency-Hedged Investment

Because DM interest rates dropped, the bond price rose to DM1,009,128 (underhedged by the amount of DM9,128). The additional DM9,128 must be marked to market at the current spot rate, which gives a US$ value of 9,128x0.625 = $5,705.

The total rate of return over the first period is thus

\[
= \ln \left[ \frac{682,240 + 5705}{650,000} \right] \times 100 = 5.67\%
\]
Central Bank Risk vs Interest Rate Risk

Interest rate risk refers to uncertainty about future interest rates that introduces the possibility for capital gains and losses on long-term bonds.

Central bank risk refers to uncertainty about the national monetary authority to deliver monetary policy that results in a particular level of interest rate risk.
Active Hedging vs Passive Hedging Strategies

What are their advantages?

In a passive hedging strategy, the investor follows the same hedging plan over time independent of market conditions. For example, rules whereby the investor always hedges 100%, or always hedges 10%.

With active hedging, the amount hedged fluctuates.

A passive strategy is a low-cost means of reducing exposure to risks. The investor is sure to be protected against large negative shocks, but he also forgoes the opportunities of large gains from positive shocks.

In an active strategy, the investor retains risks during certain periods. This offers the possibility of higher returns if the investor has expertise in judging when to hedge and when not to hedge.
Three Types of Active Strategies

“Currency-driven” investment strategy places the focus on finding good performing currencies and buy safe assets (e.g., government bonds) denominated in that currency.

The obvious way to speculate on a currency view is to take a position in foreign exchange spot, forward, or futures contracts.

If the currency forecast is correct, the speculation will be profitable.
Three Types of Active Strategies

A second strategy is to “ignore currency” when making international investments, based on the premise that the currency effects cancel out over the long run. If the investor has expertise in picking good stocks or bonds, this expertise will be awarded.

What if the stocks or bonds are denominated in a foreign currency? If the forward rate and future spot rate are equal, on average, the investor can hedge this currency risk without sacrificing long-term returns.
Three Types of Active Strategies

A final strategy is the “ultraselective” approach, in which the investor picks only those situations where both positive foreign bond and currency returns are expected.

This calls for either short positions in unhedged bonds (Case A in Table 14.2), when both bonds and currency are expected to weak, or long positions in unhedged bonds (Case B), when both bonds and currency are expected to strengthen.
## Currency Market Returns and Bond Market Return Combinations

<table>
<thead>
<tr>
<th>Bond Market Returns</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Negative</strong></td>
<td>FC interest rates ↑</td>
</tr>
<tr>
<td></td>
<td>Spot FX ↓</td>
</tr>
<tr>
<td><strong>Positive</strong></td>
<td>FC interest rates ↓</td>
</tr>
<tr>
<td></td>
<td>Spot FX ↓</td>
</tr>
</tbody>
</table>

- (A) FC interest rates ↑, Spot FX ↓
- (B) FC interest rates ↓, Spot FX ↑
- (C) FC interest rates ↑, Spot FX ↑
- (D) FC interest rates ↓, Spot FX ↓

Table 14.2 Pg 496
While this approach may be successful, it is far too limiting. The investor passes up favorable bond markets when the currency is expected to weaken (Case D), and passes up favorable currency plays when profitable foreign stocks or bonds cannot be identified (Case C).

Our analysis demonstrates that the currency and interest rate risk dimensions of an international bond portfolio are separable investments. We show this in Table 14.5 for a world with three countries and three currencies.

An investor who wanted to invest in U.S. bonds but hold an exposure to ¥ currency risk would buy U.S. Treasuries and currency hedge them into ¥ (cell A) by selling US$ forward for ¥.
### The Expanded Opportunity Set of National Bond Markets Currency Risk and Interest Rate Risk Dimensions

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<thead>
<tr>
<th>Interest Rate Risk</th>
<th>Currency Risk</th>
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<td><strong>United States</strong></td>
<td><strong>US$</strong></td>
</tr>
<tr>
<td>U.S. T-Bond: Currency hedged to DM</td>
<td>U.S. T-Bond: Currency hedged to ¥</td>
</tr>
<tr>
<td><strong>Germany</strong></td>
<td><strong>DM</strong></td>
</tr>
<tr>
<td>German Bund: Currency hedged to $</td>
<td>German Government Bond (Bund)</td>
</tr>
<tr>
<td><strong>Japan</strong></td>
<td><strong>¥</strong></td>
</tr>
<tr>
<td>JGB: Currency hedged to $</td>
<td>JGB: Currency hedged to DM</td>
</tr>
</tbody>
</table>

Table 14.5 Pg 508
What are the key elements to take into consideration when investing in an international bond portfolio?

The first criterion is selecting a market with no controls on capital outflows. Other institutional considerations - market size, liquidity, taxation - play a role. Active portfolio decisions are made on the basis of estimated risk and return. The investor can hedge a large portion of the currency risk in foreign bonds if liquid short-term currency forward markets are available.

Average Return (% per annum)

Risk: Standard Deviation of Returns

Global Portfolio

Unhedged Portfolios

Dollar Portfolio

Hedged Portfolios
About Figure 14.4 --

• The sample period is January 1977 - December 1990, monthly data.

• Securities are 10-year government bonds issued by the United States, Canada, Germany, Japan, and the United Kingdom.

• The unhedged global portfolio is an equally-weighted portfolio of non-U.S. securities.

• The hedged global portfolio is based on one-month forward currency contract, rolled over monthly.

• The end points of the frontier represent 100 percent in U.S. bonds or 100% in global bonds.

• Interior points on the frontier represent 90/10, 80/20, 70/30, etc. combinations.
Efficient Portfolio Frontiers with Active and Passive Hedges
1977-1990

Average Return (% per annum)

Risk: Standard Deviation of Returns

- Global Portfolio
- Unhedged Portfolios
- Dollar Portfolio
- Hedged Portfolios

+ Currency Overlay Strategy

x Tactical Hedge Strategy
About Figure 14.5 --

- Securities are 10-year government bonds issued by U.S., Canada, Germany, Japan, and U.K..
- The *unhedged* global portfolio is an equally-weighted portfolio of non-U.S. securities.
- The *hedged* global portfolio is based on one-month forward currency contract, rolled over monthly.
- The *tactical hedge* portfolio actively hedges a percentage of the global portfolio based on the signals from 10 technical trading rules.
- The *overlay* portfolio reflects the performance of the hedged global portfolio combined with a currency fund actively managed based on the signals from 10 technical trading rules.
A tactical hedging strategy is one where the percentage of currency futures to sell for currency I \((P_{T,I})\) based on the 10 technical rules is determined by the formula:

\[
P_{T,I} = \begin{cases} 
100\% & \text{for } N_{L,I} \leq 4 \\
[10 - (N_{L,I} - N_{S,I})] \times 10\% & \text{for } N_{L,I} \geq 5 
\end{cases}
\]

where \(N_{L,I}\) and \(N_{S,I}\) are the number of technical rules advocating long and short currency positions respectively.

The currency overlay strategy is actually a combination of two separate investments: (1) a foreign currency bond position that is always hedged against currency risk, and (2) a currency position governed by the trading rule \(P_{I} = [(N_{L,I} - N_{S,I})] \times 10\%\). If all trading rules recommend a long (short) position the currency overlay strategy will be 100% unhedged (overhedged to become net 100% short in the foreign currency).
Assignment from Chapter 14

Exercises 1, 2.