1. **Background**: Attached program calculates KRD at tenors and add all Portfolio KRDs and all benchmark KRDs and does the calculation. We are modifying this program. Target program should follow below instructions:

2. Data structure:

2.1. File "**All Constant Maturity rates**" contains below columns:

1. *Below are tenor rates. For example GS1 is 1 year rate, and GS2 is 2 year tenor rate. They are in % so you would need to divide by 100 which has already been done in code.*

GS1	*GS2*	*GS3*	*GS4*	*GS5*	*GS07*	*GS10*

2. *Below are 5* ***OAS spread*** *columns*

AAA	AA	A	BBB	HY

OAS spread and tenor rates are in % so you would need to divide by 100 before doing any calculation like covariance calculation or volatility calculation

3. ***EUR/USD****-This is EUR to USD exchange rate*

2.2. File ***"Bond holdings"*** *contains below columns:*

2.2.1. Security

2.2.2. ***Portfolio/Benchmark****-Tells whether the security is in Portfolio or benchmark*

2.2.3. ***Notional****- Notional of position*

2.2.4. ***Rating****-Rating, rating will lead to OAS column in All Constant Maturity rates. For example if Rating in Bond Holdings file is A then its OAS is in A column in "All constant Maturity rates" file. These are also in % so you would need to divide by 100 before doing any calculation like covariance calculation or volatility calculation*

3. Common calculations:

3.1. Use forward fill or back ward fill for OAS and FX rate because there are many #N/A or 0 cells.

3.2. Calculate Monthly absolute changes for below columns. All columns are below:

GS1
GS2

GS3
GS4
GS5
GS07
GS10
A

Note Monthly changes are already being calculated for below columns in base code:

GS1
GS2
GS3
GS4
GS5
GS07
GS10

3.3. **Calculate Monthly return for EUR/USD.** For example if Today EUR/USD is 1.03 and next month it is 1.04 then Return is 1.04/1.03 - 1= 0.009709

3.4. ***Calculate Covariance matrix(Σ)*** *for all changes in rates i.e. GS1 to GS10, column A and EUR/USD. This has to be done for last 5 years. The base code is written that way.*

3.5. ***Calculate volatility*** *for all changes in OAS. But first convert all OAS into decimals by dividing by 100 because OAS are in % in All rates file. This has to be done for last 5 years. Since this is monthly volatility. Annualize this volatility by multiplying with sqrt(12).*

Note: *Volatility of rate changes is already being calculated in base code.*

3.6. ***Calculate volatility*** *for FX rate changes. FX rate does not need to be divided by 100. This has to be done for last 5 years. Since this is monthly FX rate, Annualize this volatility by multiplying with sqrt(12).*

4. Calculate Net Market weight for a security

4.1. **Portfolio weight for that security** = Bond Holdings-Weight when Portfolio/Benchmark = Portfolio

4.2. **Benchmark weight for that security** = Bond Holdings-Weight when Portfolio/Benchmark = Benchmark

4.3. ***Net Market weight for a security*** **= Portfolio weight for that security - Benchmark weight for that security**

5. ***KRD at security and tenor level:***

5.1. ***Calculate KRD for each portfolio security at all tenors****: So this has to be done for each security where Portfolio/Benchmark = "Portfolio". Note currently KRD is calculated for 1 bps movement at a tenor. I want you to change it from 0.0001 i.e. 1bp to 0.01 i.e. 1 decimal unit. So we will get a KRD vector for each security.*

5.2. ***Calculate EUR KRD at Security/tenor****: If the holding currency is USD then we need to convert KRD into EUR, this can be done by multiplying KRD for this security by latest EUR/USD rate from "All Constant Maturity TREas rates" sheet. If holding currency is EUR, then we don't need to follow this step.*

6. ***Government spread sensitivity for each security***

6.1. ***Calculate tenor spread duration****. We are assuming Spread duration is same as KRD. Follow steps 5.1 to 5.2.*

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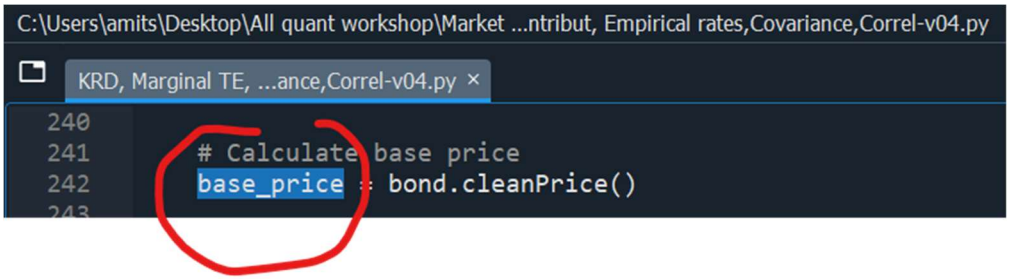
7. ***Bond price sensitivity to FX rate***

7.1. Calculate base price of security as per the current curve. Currently it gets calculated at line 242 of base code.



7.2. ***Calculate Bond Price(BP)*** *in base currency for portfolio position. Use current exchange rate.*

7.2.1. If Holding currency is EUR:

Then Bond Price = Base Price

7.2.2. If Holding currency is USD:

Then Bond Price(BP) = $\frac{(Base\ Price)}{\frac{EUR}{USD}Rate}$

Note: Above EUR/USD rate is latest rate from "All Constant Maturity rates" file.

7.3. ***Calculate Bond Price(*** BP^+***)*** *in base currency for portfolio position for increased exchange rate.*

7.3.1. Increase current/latest exchange rate by 0.01.

7.3.2. Follow steps 7.2.1 and 7.2.2 to calculate BP^+ *but use decreased exchange rate. Obviously if position is already in EUR then Bond Price won't change.*

7.4. ***Calculate Bond Price(*** BP^{-} ***)*** *in base currency for portfolio position for decreased exchange rate.*

7.4.1. Decrease current/latest exchange rate by 0.01.

7.4.2. Follow steps 6.3.1 and 6.3.2 to calculate BP^{-} *but use decreased exchange rate. Obviously if position is already in EUR then Bond Price won't change.*

7.5. **Calculate Bond Price sensitivity to exchange rate**

Bond Exchange rate sensitivity = $\frac{(BP^{-}-BP^{+})}{2\times BP\times 0.01}$

8. **Collect covariances, KRD factor vector, Government spread factor, FX sensitivity factor**

8.1. ***Get covariance matrix(Σ) of rates changes.***

This was done in step 3.4

8.2. ***Get net weight of security***

This was done in step 4.3

8.3. **Get KRD vector of security from step 5**

8.4. **Get Government spread of security from step 6**

8.5. **Get FX sensitivity of security from step 7**

8.6. ***Calculate net KRD for security***

Net KRD = Net security weight of security × KRD Vector of security. So we will get a Net KRD Vector

8.7. ***Calculate net government spread for security***

Net ***government spread*** = Net security weight of security × Government spread

8.8. **Calculate net FX sensitivity for security**

Net ***FX sensitivity*** = Net security weight of security × FX sensitivity

9. Calculate TEV for security

9.1. In this section we will use net factor sensitivities collected in step 8.

9.2. Create a combined factor vector of 7 KRDs, Government spread and FX sensitivity, so the vector would have 9 rows and 1 column.

9.3. Calculate TEV for security

$$\boldsymbol{TE^2 = Combined\ factor\ vector^T \times \Sigma \times Combined\ factor\ vector}$$

$$\boldsymbol{TE = \sqrt{Combined\ factor\ vector^T \times \Sigma \times Combined\ factor\ vector}}$$

10. Calculate marginal TEV for each factor for each security.

This is simply sensitivity for security TEV to each exposure i.e. what happens to security TEV if we increase that factor exposure by 1 unit. So this step will calculate 9 Marginal TEVs for each security

Marginal TE = (Σ × Net exposure vector) / Total_TEV

a) Σ = Covariance matrix of 9 factors
b) Net exposure vector = Net weight of security × Sensitivity vector of 9 factors i.e. 7 KRDs, 1 OAS sensitivity, and 1 FX sensitivity
c) Total TEV comes from step 9

11. Calculate contribution to TEV for each factor for each security.

This is contribution to TEV for security TEV to each exposure. So this step will calculate 9 contributions to TEVs for each security.

Contribution to TEV = net_exposure_vector * marginal_te_vector

a) Net exposure vector = Net weight of security × Sensitivity vector of 9 factors i.e. 7 KRDs, 1 OAS sensitivity, and 1 FX sensitivity
b) Marginal TEV comes from step 10

12. Create final excel report with below columns for all Portfolio securities:

Each portfolio security creates a new row.

a) Security-It comes from Bond holdings sheet. If there are 20 Portfolio holdings then there are 20 securities and hence 20 security rows in xls report
b) Net market weight(%)-This is Portfolio weight – Benchmark weight for this security.
c) Curve contribution TEV-This is sum of 7 rate Contributions to TEVs.
d) Government Spread contribution TEV-This is government contribution to TEV
e) FX contribution TEV- This is FX contribution to TEV
f) Marginal TEV 1yr
g) Marginal TEV 2yr
h) Marginal TEV 3yr
i) Marginal TEV 4yr
j) Marginal TEV 5yr
k) Marginal TEV 7yr
l) Marginal TEV 10yr
m) Marginal TEV Government spread
n) Marginal TEV FX
o) Contribution to TEV 1yr
p) Contribution to TEV 2yr
q) Contribution to TEV 3yr

r) Contribution to TEV 4yr
s) Contribution to TEV 5yr
t) Contribution to TEV 7yr
u) Contribution to TEV 10yr
v) Contribution to TEV Government spread
w) Contribution to TEV FX

A total row at top of xls report is required. This Total row will will have below cell values:

a) Security placeholder: Write Total
b) Net market weight(%)-Sum of all net market weights for all securities.
c) Curve contribution TEV-This is sum of all Curve contribution TEV for all securities.
d) Government Spread contribution TEV- This is sum of all Government Spread contribution TEV for all securities.
e) FX contribution TEV- This is sum of all FX contribution to TEV for all securities.
f) Marginal TEV 1yr -Keep blank
g) Marginal TEV 2yr -Keep blank
h) Marginal TEV 3yr -Keep blank
i) Marginal TEV 4yr -Keep blank
j) Marginal TEV 5yr -Keep blank
k) Marginal TEV 7yr -Keep blank
l) Marginal TEV 10yr -Keep blank
m) Marginal TEV Government spread -Keep blank
n) Marginal TEV FX -Keep blank
o) Contribution to TEV 1yr- This is sum of all Contribution to TEV 1yr for all securities.
p) Contribution to TEV 2yr- This is sum of all Contribution to TEV 2yr for all securities.
q) Contribution to TEV 3yr- This is sum of all Contribution to TEV 3yr for all securities.
r) Contribution to TEV 4yr- This is sum of all Contribution to TEV 4yr for all securities.
s) Contribution to TEV 5yr- This is sum of all Contribution to TEV 5yr for all securities.
t) Contribution to TEV 7yr- This is sum of all Contribution to TEV 7yr for all securities.
u) Contribution to TEV 10yr- This is sum of all Contribution to TEV 10yr for all securities.

v) Contribution to TEV Government spread - This is sum of all Contribution to TEV Government spread for all securities.
w) Contribution to TEV FX- This is sum of all Contribution to TEV FX for all securities.