Module 7.1: Static Risk Management Centered Differencing
R Commentary

See module *Ch 7.1 SRM Centered Differencing*.

SRM Centered Differencing Functions.R (Selected Excerpts and Output)

The illustration code assumes a bond price function introduced in Chapter 4 as well as the duration function (for verification) that will be explored in detail in Module 7.2. The choice of increment size is important (*h* above). If *h* is too small, then machine error is introduced. If *h* is too large, then the numerical derivative estimation may be inaccurate.

```
#
# First Derivatives of Bond Value with respect to Yield to Maturity
#
BondFD = function(B){
  if (B$Order == 1){
    OriginalYTM = B$YieldToMaturity
    High = OriginalYTM + B$ChangeInYTM
    B$YieldToMaturity = High
    UpBV = BondValue(B)
    Low = OriginalYTM - B$ChangeInYTM
    B$YieldToMaturity = Low
    DownBV = BondValue(B)
    B$YieldToMaturity = OriginalYTM
    BFD = (UpBV - DownBV) / (High - Low)
    return( BFD )
  } else if (B$Order == 2) {
    OriginalYTM = B$YieldToMaturity
    OriginalBV = BondValue(B)
    High = OriginalYTM + B$ChangeInYTM
    B$YieldToMaturity = High
    UpBV = BondValue(B)
    Low = OriginalYTM - B$ChangeInYTM
    B$YieldToMaturity = Low
    DownBV = BondValue(B)
    High2 = OriginalYTM + 2*B$ChangeInYTM
    B$YieldToMaturity = High2
    UpBV2 = BondValue(B)
    Low2 = OriginalYTM - 2*B$ChangeInYTM
    B$YieldToMaturity = Low2
    DownBV2 = BondValue(B)
    B$YieldToMaturity = OriginalYTM
    BFD = (-UpBV2 + 8.0*UpBV - 8.0*DownBV + DownBV2) / (12.0*B$ChangeInYTM)
    return( BFD )
  } else if (B$Order == 3) {
    OriginalYTM = B$YieldToMaturity
    OriginalBV = BondValue(B)
    High = OriginalYTM + B$ChangeInYTM
    B$YieldToMaturity = High
    UpBV = BondValue(B)
    Low = OriginalYTM - B$ChangeInYTM
    B$YieldToMaturity = Low
    DownBV = BondValue(B)
    High2 = OriginalYTM + 2*B$ChangeInYTM
    B$YieldToMaturity = High2
    UpBV2 = BondValue(B)
    Low2 = OriginalYTM - 2*B$ChangeInYTM
    B$YieldToMaturity = Low2
    DownBV2 = BondValue(B)
    High3 = OriginalYTM + 3*B$ChangeInYTM
    B$YieldToMaturity = High3
    UpBV3 = BondValue(B)
    Low3 = OriginalYTM - 3*B$ChangeInYTM
```


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```
    B$YieldToMaturity = Low3
    DownBV3 = BondValue(B)
    B$YieldToMaturity = OriginalYTM
    BFD=(UpBV3 - 9.0*UpBV2 + 45.0*UpBV-45.0*DownBV + 9.0*DownBV2 - DownBV3)/
      (60.0*B$ChangeInYTM)
    return( BFD )
  } else if (B$Order == 4) {
    OriginalYTM = B$YieldToMaturity
    OriginalBV = BondValue(B)
    High = OriginalYTM + B$ChangeInYTM
    B$YieldToMaturity = High
    UpBV = BondValue(B)
    Low = OriginalYTM - B$ChangeInYTM
    B$YieldToMaturity = Low
    DownBV = BondValue(B)
    High2 = OriginalYTM + 2*B$ChangeInYTM
    B$YieldToMaturity = High2
    UpBV2 = BondValue(B)
    Low2 = OriginalYTM - 2*B$ChangeInYTM
    B$YieldToMaturity = Low2
    DownBV2 = BondValue(B)
    High3 = OriginalYTM + 3*B$ChangeInYTM
    B$YieldToMaturity = High3
    UpBV3 = BondValue(B)
    Low3 = OriginalYTM - 3*B$ChangeInYTM
    B$YieldToMaturity = Low3
    DownBV3 = BondValue(B)
    High4 = OriginalYTM + 4*B$ChangeInYTM
    B$YieldToMaturity = High4
    UpBV4 = BondValue(B)
    Low4 = OriginalYTM - 4*B$ChangeInYTM
    B$YieldToMaturity = Low4
    DownBV4 = BondValue(B)
    B$YieldToMaturity = OriginalYTM
    BFD = ((DownBV4/280.0)- (4.0*DownBV3/105.0) + (DownBV2/5.0) -
      (4.0*DownBV/5.0) + (4.0*UpBV/5.0) - (UpBV2/5.0) + (4.0*UpBV3/105.0) -
      (UpBV4/280.0)) / B$ChangeInYTM
    return( BFD )
  }
}
```

SRM Centered Differencing Test.R (Selected Excerpts and Output)
This is the testing program that also provides selected output. Selected output is illustrated in following figures.

Figure 7R.1.1. Change in Yield to Maturity = 1%

```
> BONDInputData$ChangeInYTM = 1.0
> FD1 <- BondFD(BONDInputData)
> BONDInputData$Order <- 2
> FD2 <- BondFD(BONDInputData)
> BONDInputData$Order <- 3
> FD3 <- BondFD(BONDInputData)
> BONDInputData$Order <- 4
> FD4 <- BondFD(BONDInputData)
> MDDur <- Duration(BONDInputData)
> FD <- -MDDur*BondValue(BONDInputData)/100
> MDDur
[1] 8.710204
> Error1 <- FD1 - FD; Error2 <- FD2 - FD; Error3 <- FD3 - FD; Error4 <- FD4 - FD
> Error1; Error2; Error3; Error4
[1] -146.9193
[1] 0.3773835
[1] -0.001237588
[1] 4.925503e-06
```


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Figure 7R.1.2. Change in Yield to Maturity = 0.1%

```
> #
> # Change YTM by 10 basis points
> #
> BONDInputData$ChangeInYTM = 0.1
> FD1 <- BondFD(BONDInputData)
> BONDInputData$Order <- 2
> FD2 <- BondFD(BONDInputData)
> BONDInputData$Order <- 3
> FD3 <- BondFD(BONDInputData)
> BONDInputData$Order <- 4
> FD4 <- BondFD(BONDInputData)
> MDDur <- Duration(BONDInputData)
> FD <- -MDDur*BondValue(BONDInputData)/100
> Error1 <- FD1 - FD; Error2 <- FD2 - FD; Error3 <- FD3 - FD; Error4 <- FD4 - FD
> Error1; Error2; Error3; Error4
[1] 1.449371e-08
[1] 3.768281e-05
[1] 1.263106e-08
[1] 1.449371e-08
```

Figure 7R.1.3. Change in Yield to Maturity = 0.01%

```
> #
> # Change YTM by 1 basis points
> #
> BONDInputData$ChangeInYTM = 0.01
> FD1 <- BondFD(BONDInputData)
> BONDInputData$Order <- 2
> FD2 <- BondFD(BONDInputData)
> BONDInputData$Order <- 3
> FD3 <- BondFD(BONDInputData)
> BONDInputData$Order <- 4
> FD4 <- BondFD(BONDInputData)
> MDDur <- Duration(BONDInputData)
> FD <- -MDDur*BondValue(BONDInputData)/100
> Error1 <- FD1 - FD; Error2 <- FD2 - FD; Error3 <- FD3 - FD; Error4 <- FD4 - FD
> Error1; Error2; Error3; Error4
[1] 1.212175e-08
[1] 5.558832e-09
[1] 1.67347e-09
[1] 1.212175e-08
```

(Note the machine error beginning to increase in Order 3 and 4.)

Figure 7R.1.4. Change in Yield to Maturity = 0.00001%

```
> #
> # Change YTM by 0.0000001 basis points
> #
> BONDInputData$ChangeInYTM = 0.00000001
> FD1 <- BondFD(BONDInputData)
> BONDInputData$Order <- 2
> FD2 <- BondFD(BONDInputData)
> BONDInputData$Order <- 3
> FD3 <- BondFD(BONDInputData)
> BONDInputData$Order <- 4
> FD4 <- BondFD(BONDInputData)
> MDDur <- Duration(BONDInputData)
> FD <- -MDDur*BondValue(BONDInputData)/100
> Error1 <- FD1 - FD; Error2 <- FD2 - FD; Error3 <- FD3 - FD; Error4 <- FD4 - FD
> Error1; Error2; Error3; Error4
[1] -0.01492698
[1] -0.0141236
[1] -0.02304877
[1] -0.01492698
```

(Note the machine error is dominating for all orders.)

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