Problem Set: Hand in 3

Exercise 1.

[1]

For the period 1926 to 2002, ___________ had the highest arithmetic average returns of the alternatives available.

A) common stocks of small firms
B) common stocks of large firms
C) long-term Treasury bonds
D) U. S. Treasury bills
E) none of the above

Exercise 2.

[1]

If you believe in the _________ form of the EMH, you believe that stock prices reflect all relevant information including historical stock prices and current public information about the firm, but not information that is available only to insiders.

A) semistrong
B) strong
C) weak
D) A, B, and C
E) none of the above

Exercise 3.

[1]

The weak form of the efficient market hypothesis asserts that

A) stock prices do not rapidly adjust to new information contained in past prices or past data.
B) future changes in stock prices cannot be predicted from past prices.
C) technicians cannot expect to outperform the market.
D) A and B
E) B and C

Exercise 4.

[3]

The weather report says that a devastating and unexpected freeze is expected to hit Florida tonight, during the peak of the citrus harvest. In an efficient market one would expect the price of Florida Orange's stock to

A) drop immediately.
B) remain unchanged.
C) increase immediately.
D) gradually decline for the next several weeks.
E) gradually increase for the next several weeks.

Exercise 5.

[1]

An inverted yield curve is one
A) with a hump in the middle.
B) constructed by using convertible bonds.
C) that is relatively flat.
D) that plots the inverse relationship between bond prices and bond yields.
E) that slopes downward.

Exercise 6.

[3]

Par Value	$1,000
Time to Maturity	20 years
Coupon	10% (paid annually)
Current Price	$850
Yield to Maturity	12%

Given the bond described above, if interest were paid semi-annually (rather than annually), and the bond continued to be priced at $850, the resulting effective annual yield to maturity would be:

A) Less than 12%
B) More than 12%
C) 12%
D) Cannot be determined
E) None of the above

Exercise 7.

The following is a list of prices for zero coupon bonds with different maturities and par value of $1,000.

Maturity (Years)	Price
1	$925.16
2	$862.57
3	$788.66
4	$711.00

1. What is, according to the expectations theory, the expected forward rate in the **third** year?

   A) 7.23
   B) 9.37%
   C) 9.00%
   D) 10.9%
   E) none of the above

2. What is the yield to maturity on a 3-year zero coupon bond?
   A) 6.37%
   B) 9.00%
   C) 7.33%
   D) 8.24%
   E) none of the above

3. What is the price of a 4-year maturity bond with a 10% coupon rate paid annually? (Par value = $1,000)
   A) $742.09
   B) $1,222.09
   C) $1,035.66
   D) $1,141.84
   E) none of the above

4. You have purchased a 4-year maturity bond with a 9% coupon rate paid annually. The bond has a par value of $1,000. What would the price of the bond be one year from now if the implied forward rates stay the same?
   A) $995.63
   B) $1,108.88
   C) $1,000
   D) $1,042.78
   E) none of the above

Exercise 8.

[3]

Ceteris paribus, the duration of a bond is positively correlated with the bond's
A) time to maturity.
B) coupon rate.
C) yield to maturity.
D) all of the above.
E) none of the above.

Exercise 9.

[3]

Given the time to maturity, the duration of a zero-coupon bond is higher when the discount rate is
A) higher.
B) lower.
C) equal to the risk free rate.
D) The bond's duration is independent of the discount rate.
E) none of the above.

Exercise 10.

[3]

Which of the following two bonds is more price sensitive to changes in interest rates?
1) A par value bond, X, with a 5-year-to-maturity and a 10% coupon rate.
2) A zero-coupon bond, Y, with a 5-year-to-maturity and a 10% yield-to-maturity.

A) Bond X because of the higher yield to maturity.
B) Bond X because of the longer time to maturity.
C) Bond Y because of the longer duration.
D) Both have the same sensitivity because both have the same yield to maturity.
E) None of the above

Exercise 11.

[3]

Which of the following bonds has the longest duration?

A) An 8-year maturity, 0% coupon bond.
B) An 8-year maturity, 5% coupon bond.
C) A 10-year maturity, 5% coupon bond.
D) A 10-year maturity, 0% coupon bond.
E) Cannot tell from the information given.

Exercise 12.

[3]

Immunization is not a strictly passive strategy because
A) it requires choosing an asset portfolio that matches an index.

B) there is likely to be a gap between the values of assets and liabilities in most portfolios.
C) it requires frequent rebalancing as maturities and interest rates change.
D) durations of assets and liabilities fall at the same rate.
E) none of the above.

Exercise 13.

Estimate beta for Amazon relative to the S&P index using monthly returns data for the period July 2013 to June 2018.

Use both of these two formulations

$$r_i = a + br_m + \varepsilon$$

$$(r_i - r_f) = a + b(r_m - r_f) + \varepsilon$$

i.e. with straight returns and excess returns.

Do you find a difference in the beta estimates?

Exercise 14.

Folketrygdfondet - performance [8]

In this exercise we will do a performance analysis of the returns of Folketrygdfondet.

At the course homepage there is a link to various data from Folketrygdfondet. The relevant file is a csv file with monthly equity returns for the portfolio, and various other information

- Rp – monthly returns for Folketrygdfondet's equity portfolio
- Rf – risk free rate
- Rmew – monthly returns for a value weighted market portfolio
- Rmvw – monthly returns for an equally weighted market portfolio
- Rm_OSEAX – monthly return for the norwegian index OSEAX
- SMB, HML, UMD – factor portfolios for Norway corresponding to the portfolios created by Ken French.

With this data, do the following analysis:

1. Calculate Sharpe ratios for the Folketrygdfondet portfolio, as well as Sharpe ratios for the various market portfolios. Do it for the following subperiods: 1998–2022, 2013–2022 and 2018–2022.
2. For the same subperiods calculate the alpha relative to the equally and value weighted portfolios. The alpha should be calculated both against the market portfolio, and the Fama-French 3-factor model.

Exercise 15.

Saving [6]

A bank is offering a 3-year savings product (or "spareprodukt") with interest rates of 2.75% for the first year, 3.00% for the second year, and 3.50% for the third year. To receive these interest rates, you have to hold on to this product for the whole 3 year period.

(a) Calculate the yield curve (i.e. spot rates) implied by this savings product.

Consider two bonds that are traded in the market, bond A and bond B. Both have a maturity of 3 years and both have face values of 100. Bond A is a zero coupon bond and bond B is a 7% coupon bond.

(b) Suppose that the implied yield curve from (a) happens to be the actual yield curve in the market. Calculate the no-arbitrage prices for bonds A and B.

(c) Suppose you calculate the yields (to maturity) on bonds A and B. You find that the yield on one is higher than the yield on the other, and having just been hired by the bank (at a very respectable salary) you rush eagerly to your manager to tell her that the bank should go long in the one with the higher yield and short in the other. She will be impressed by your eagerness, but will she be impressed by your recommendation? Why or why not?

(d) Bond m has higher *duration* compared to bond n. Which of the two bonds' market prices are more sensitive to a change in interest rates?

(e) Bond x has higher *convexity* compared to bond y. If the two bonds have equal duration, which of the two bonds' market prices are more sensitive to a change in interest rates?

Exercise 16.

[2]

A bond is currently priced at $B_0 = 97.5563$. The bond has an annual coupon of 10% (with discrete, annual compounding), a face value of 100, and a time to maturity of 3 years.

1. If the current (annual, discretely compounded) interest rate decreases by one percentage point, what is the new bond price?

Solutions

Problem Set: Hand in 3

Solution to Exercise 1.

[1]

A

In general, common stock of small firms would expected to earn the highest rate of return of the investment alternatives, as these alternatives are riskier than the other choices.

Solution to Exercise 2.

[1]

A

The semistrong form of EMH maintains that stock prices immediately reflect all historical and current public information, but not inside information.

Solution to Exercise 3.

[1]

E

Stock prices do adjust rapidly to new information.

Solution to Exercise 4.

[3]

A

In an efficient market the price of the stock should drop immediately when the bad news is announced. If later news changes the perceived impact to Florida Orange, the price may once again adjust quickly to the new information. A gradual change is a violation of the EMH.

Solution to Exercise 5.

[1]

E. An inverted yield curve occurs when short-term rates are higher than long-term rates.

Solution to Exercise 6.

[3]

B FV = 1000, PV = -850, PMT = 50, n = 40, i = 5.9964 (semi-annual); $(1.059964)^2$ - 1 = 12.35%.

Solution to Exercise 7.

Solve things in more generality.

Find discount factors `d` implied in the zero price

```
>  P = [ 925.16 862.57 788.66 711.00]
>  d = P./1000
>  d =
     0.9252   0.8626   0.7887   0.7110
```

Alternatively, can find the various spot rates, from the relationship

$$d_t = \frac{1}{(1+r_t)^t}$$

Solving for r_t, find that

$$r_t = \left(\frac{1}{d_t}\right)^{\frac{1}{t}} - 1 = \sqrt[t]{\frac{1}{d_t}} - 1$$

So for example $r_1 = 1/d_1 = 0.080894$ and $r_2 = \sqrt{\frac{1}{d_2}} = 0.076720$

```
> r = (1./d).^(1./t)-1
r =
   0.080894   0.076720   0.082356   0.089012
```

or in percent

```
> r=100*r
r =
   8.0894   7.6720   8.2356   8.9012
```

Similarly calculate the forward rates using

$$f_t = \frac{(1+r_t)^t}{(1+r_{t-1})^{t-1}} - 1$$

```
>> f1=r(1)
f1 = 0.080894
>> f2 = (1+r(2))^2/(1+r(1))-1
f2 = 0.072562
>> f3 = (1+r(3))^3/((1+r(2))^2)-1
f3 = 0.093716
>> f4 = (1+r(4))^4/((1+r(3))^3)-1
f4 = 0.1092
>> f = [ f1 f2 f3 f4]
f=
   0.080894   0.072562   0.093716   0.109226
```

or in percent

```
>> f*100
ans =
    8.0894    7.2562    9.3716   10.9226
```

1. B. The forward rate f_3 we already calculated as 9.37%. Or calculate directly as $862.57/788.66 - 1 = 9.37\%$
2. D. $r_3 = 8.2356$, or calculated directly as $(1000/788.66)^{1/3} - 1 \approx 8.24\%$.
3. Use the discount factors to price a bond with a 10 percent coupon and cash flows $B_0 = d_1C_1 + d_2C_2 + d_3C_3 + d_4C_4$

   ```
   > CFlow = [ 100 100 100 1100]
   > Bondprice = d*CFlow'
   Bondprice = 1039.7
   ```

   Anyway, given the correct bond price is $B_0 = 1,039.7$, the correct answer here is E, none of the above.
4. For the bond you purchased, one year from now it will have three years remaining, with cashflows

   ```
   Cflow = [ 90 90 1090]
   ```

   If the implied forward rates stay the same, the term structure will be the same one year from now, and we can use the same discount factors to price the bond

   ```
   Bondprice = Cflow*d(1:3)'
   Bondprice = 1020.5
   ```

   Since the bond price is $1,020.5$, the correct answer is again E, none of the above.
   Note that the statement about the forward rate is unclear, and open for alternative interpretations. Another possible interpretation is that the forward rates correctly predicted the future spot rates, leading to new spot rates

   $$\text{"new"}[r_1, r_2, r_3] = [f_2, f_3, f_4]$$

   That assumption gives a new bondprice

```
>> r=[ f2 f3 f4]
r =
   0.072562   0.093716   0.109226
>> t=[1 2 3 ];
>> newd = ((1./((1.+r).^t)))
newd =
   0.9323   0.8360   0.7327
>> Cflow = [ 90 90 1090]
Cflow =
     90     90   1090
>> BondPrice = newd*Cflow'
BondPrice = 957.82
```

Solution to Exercise 8.

[3]

A. Duration is negatively correlated with coupon rate and yield to maturity.

Solution to Exercise 9.

[3]

D. The duration of a zero-coupon bond is equal to the maturity of the bond.

Solution to Exercise 10.

[3]

C. Duration is the best measure of bond price sensitivity; the longer the duration the higher the price sensitivity.

Solution to Exercise 11.

[3]

D. The longer the maturity and the lower the coupon, the greater the duration

Solution to Exercise 12.

[3]

C. As time passes the durations of assets and liabilities fall at different rates, requiring portfolio rebalancing. Further, every change in interest rates creates changes in the durations of portfolio assets and liabilities.

Solution to Exercise 13.

Estimation results

	Dependent variable:	
	r_i	$r_i - r_f$
	(1)	(2)
r_m	1.622^{***}	
	(0.312)	
$r_m - r_f$		1.618^{***}
		(0.312)
Constant (α)	0.019^{**}	0.019^{**}
	(0.009)	(0.009)
Observations	60	60
Adjusted R^2	0.306	0.305
Residual Std. Error (df = 58)	0.068	0.068
Note:	*p<0.1; **p<0.05; ***p<0.01	

Solution to Exercise 14.

Folketrygdfondet - performance [8]

The Sharpe ratios

	Rp	Rmew	Rmvw	RmOSEAX
Sharpe 98-22	0.1126	0.1070	0.2416	
Sharpe 13-22	0.2714	0.2080	0.3590	0.2158
Sharpe 18-22	0.1839	0.1769	0.2938	0.1628

Alpha against the equally weighted portfolio

	Dependent variable: eRp					
	1998-2022		1913-2022		1918-2022	
	(1)	(2)	(3)	(4)	(5)	(6)
eRmew	0.652^{***}	0.776^{***}	0.548^{***}	0.649^{***}	0.571^{***}	0.644^{***}
	(0.025)	(0.021)	(0.034)	(0.030)	(0.035)	(0.031)
smb		-0.381^{***}		-0.229^{***}		-0.170^{***}
		(0.028)		(0.031)		(0.033)
hml		-0.050^{**}		-0.042^{*}		-0.036
		(0.023)		(0.022)		(0.025)
Constant	0.001	0.006^{***}	0.003^{*}	0.006^{***}	0.001	0.003
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	294	294	114	114	54	54
Adjusted R^2	0.707	0.823	0.698	0.804	0.832	0.897
Note:				*p<0.1; **p<0.05; ***p<0.01		

Alpha against the equally weighted portfolio

	Dependent variable: eRp					
	1998-2022		1913-2022		1918-2022	
	(1)	(2)	(3)	(4)	(5)	(6)
eRmvw	0.899^{***}	0.903^{***}	0.807^{***}	0.825^{***}	0.807^{***}	0.837^{***}
	(0.016)	(0.016)	(0.026)	(0.024)	(0.037)	(0.032)
smb		-0.050^{***}		-0.065^{***}		-0.057^{**}
		(0.017)		(0.019)		(0.025)
hml		-0.014		-0.050^{***}		-0.081^{***}
		(0.015)		(0.015)		(0.020)
Constant	-0.006^{***}	-0.006^{***}	-0.002^{**}	-0.002^{*}	-0.004^{**}	-0.004^{**}
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Observations	294	294	114	114	54	54
Adjusted R^2	0.917	0.919	0.893	0.912	0.898	0.933
Note:					*p<0.1; **p<0.05; ***p<0.01	

Appendix: R code

The Sharpe ratios:

```
library(xtable)
```

```
outdir <- "../../results/2023_02_performance_measurement/"
source ("read_monthly_returns.R")

tabl <- matrix(nrow=3,ncol=4)
rownames(tabl) <- c("Sharpe 98-22",
                    "Sharpe 13-22",
                    "Sharpe 18-22")
colnames(tabl) <- c("Rp","Rmew","Rmvw","RmOSEAX")
eRp <- data$Rp-data$Rf
Sharpe_p <- mean(eRp)/sd(eRp)
print(Sharpe_p)
tabl[1,1] <- Sharpe_p

eRm <- data$Rmew-data$Rf
Sharpe_m <- mean(eRm)/sd(eRm)
print(Sharpe_m)
tabl[1,2] <- Sharpe_m

eRm <- na.omit(data$Rmvw-data$Rf)
Sharpe_m <- mean(eRm)/sd(eRm)
print(Sharpe_m)
tabl[1,3] <- Sharpe_m

data <- window(data,start=as.yearmon("2013-01"))
eRp <- data$Rp-data$Rf
Sharpe_p <- mean(eRp)/sd(eRp)
print(Sharpe_p)
tabl[2,1] <- Sharpe_p

eRm <- data$Rmew-data$Rf
Sharpe_m <- mean(eRm)/sd(eRm)
print(Sharpe_m)
tabl[2,2] <- Sharpe_m

eRm <- na.omit(data$Rmvw-data$Rf)
Sharpe_m <- mean(eRm)/sd(eRm)
print(Sharpe_m)
tabl[2,3] <- Sharpe_m

eRm <- data$Rm_OSEAX-data$Rf
eRm <- na.omit(eRm)
Sharpe_m <- mean(eRm)/sd(eRm)
tabl[2,4] <- Sharpe_m

data <- window(data,start=as.yearmon("2018-01"))
eRp <- data$Rp-data$Rf
Sharpe_p <- mean(eRp)/sd(eRp)
print(Sharpe_p)
tabl[3,1] <- Sharpe_p

eRm <- data$Rmew-data$Rf
Sharpe_m <- mean(eRm)/sd(eRm)
print(Sharpe_m)
tabl[3,2] <- Sharpe_m

eRm <- na.omit(data$Rmvw-data$Rf)
```

```
Sharpe_m <- mean(eRm)/sd(eRm)
print(Sharpe_m)
tabl[3,3] <- Sharpe_m

eRm <- data$Rm_OSEAX-data$Rf
eRm <- na.omit(eRm)
Sharpe_m <- mean(eRm)/sd(eRm)
tabl[3,4] <- Sharpe_m

filename <- paste0(outdir,"sharpe_ratios.tex")
print.xtable(xtable(tabl,digits=4),
             file=filename,
             floating=FALSE)
```

The alpha calculation

```
library(stargazer)

outdir <- "../../results/2023_02_performance_measurement/"

source ("read_monthly_returns.R")
head(data)
tail(data)

eRp <- data$Rp-data$Rf
eRmew <- data$Rmew-data$Rf
smb   <- data$SMB
hml   <- data$HML
regr <- lm (eRp~eRmew)
regr1 <- lm (eRp~eRmew+smb+hml)
summary(regr)
summary(regr1)

data <- window(data,start=as.yearmon("2013-01"))
eRp <- data$Rp-data$Rf
eRmew <- data$Rmew-data$Rf
smb   <- data$SMB
hml   <- data$HML
regr_13_22 <- lm (eRp~eRmew)
regr1_13_22 <- lm (eRp~eRmew+smb+hml)
summary(regr_13_22)
summary(regr1_13_22)

data <- window(data,start=as.yearmon("2018-01"))
eRp <- data$Rp-data$Rf
eRmew <- data$Rmew-data$Rf
smb   <- data$SMB
hml   <- data$HML
regr_18_22 <- lm (eRp~eRmew)
regr1_18_22 <- lm (eRp~eRmew+smb+hml)

summary(regr_18_22)
summary(regr1_18_22)

filename <- paste0(outdir,"alpha_ew.tex")
```

```
stargazer(regr,regr1,
          regr_13_22,regr1_13_22,
          regr_18_22,regr1_18_22,
          out=filename,
          float=FALSE
          )

source ("read_monthly_returns.R")

eRp <- data$Rp-data$Rf
eRmvw <- data$Rmvw-data$Rf
smb   <- data$SMB
hml   <- data$HML
regr <- lm (eRp~eRmvw)
regr1 <- lm (eRp~eRmvw+smb+hml)
summary(regr)
summary(regr1)

data <- window(data,start=as.yearmon("2013-01"))
eRp <- data$Rp-data$Rf
eRmvw <- data$Rmvw-data$Rf
smb   <- data$SMB
hml   <- data$HML
regr_13_22 <- lm (eRp~eRmvw)
regr1_13_22 <- lm (eRp~eRmvw+smb+hml)
summary(regr_13_22)
summary(regr1_13_22)

data <- window(data,start=as.yearmon("2018-01"))
eRp <- data$Rp-data$Rf
eRmvw <- data$Rmvw-data$Rf
smb   <- data$SMB
hml   <- data$HML
regr_18_22 <- lm (eRp~eRmvw)
regr1_18_22 <- lm (eRp~eRmvw+smb+hml)

summary(regr_18_22)
summary(regr1_18_22)

filename <- paste0(outdir,"alpha_vw.tex")
stargazer(regr,regr1,
          regr_13_22,regr1_13_22,
          regr_18_22,regr1_18_22,
          out=filename,
          float=FALSE
          )
```

Solution to Exercise 15.

Saving [6]

(a) $R_1 = 2.75\%$
$(1+R_2)^2 = (1+R_1)(1+0.03)$
$\rightarrow\ R_2 = 0.028749241$
$(1+R_3)^3 = (1+R_2)^2(1+0.035)$
$\rightarrow\ R_3 = 0.030828622$

(b) No-arbitrage prices

$$P_A = \frac{100}{1.03083^3} = 91.29365$$

$$P_B = \frac{7}{1.0275} + \frac{7}{1.02875^2} + \frac{107}{1.03083^3} = 111.13$$

(c) It is not necessary to calculate the yields, but here they are:
The yield on Bond A is $y_A = R_3 = 3.083\%$.
The yield y_B on bond B is given from

$$P_B = \frac{7}{1+y_B} + \frac{7}{(1+y_B)^2} + \frac{107}{(1+y_b)^3} = 111.13$$

$$y_B = 3.062\%$$

Bonds are priced according to no-arbitrage, which means that they are correctly priced in the sense that neither represents a better buy than the other. The fact that the yield on bond B is less than that of bond A follows because a fractionally larger share of the cash-flows on bond B comes earlier, and hence are discounted at a lower discount rate, than that of bond A.

(d) higher duration - higher sensitivity

(e) higher convexity - higher sensitivity

Solution to Exercise 16.

[2]

Calculating the YTM:

t	$=$	0	1	2	3
C_t	$=$	-97.5563	10	10	110

IRR $= 0.110016$

If the interest rate falls to 10%, the bond is a par. $B = 100$.