ECOM20001 Econometrics 1 Assignment 2

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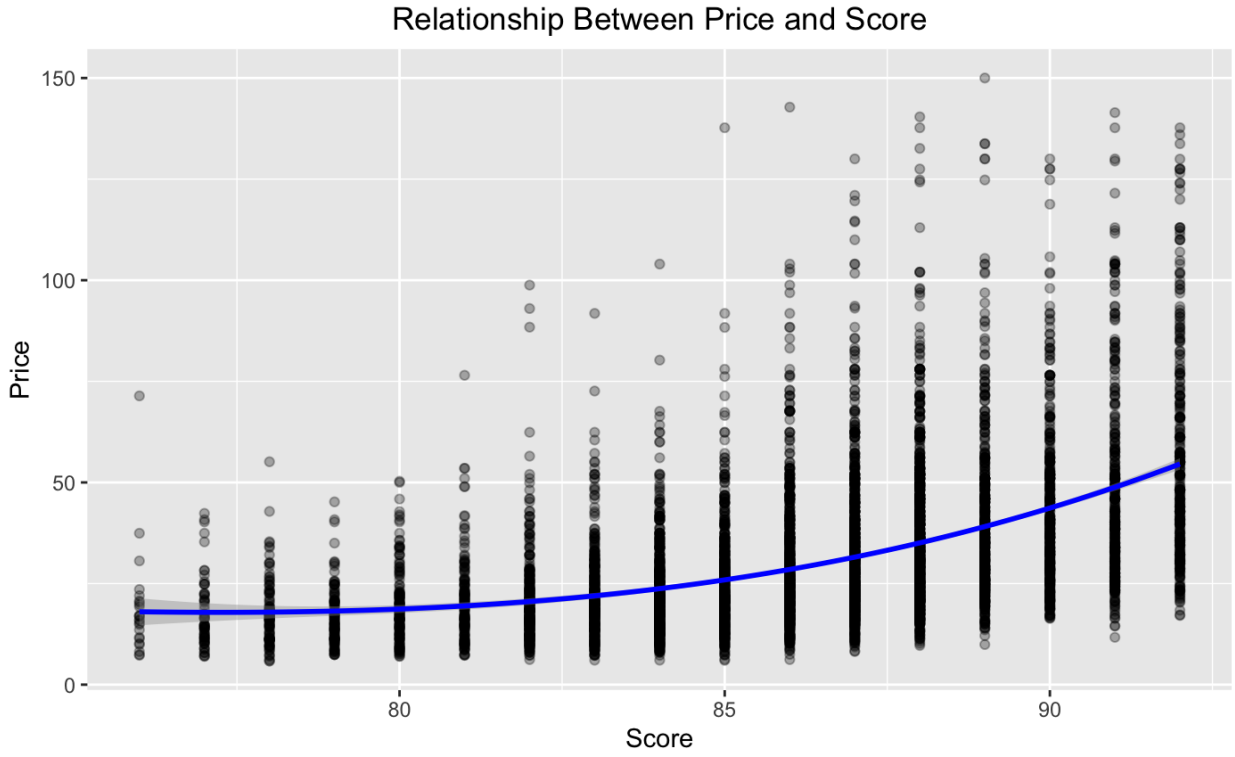
Q1

The relationship between price and score appears to be non-linear as the fitted line is by inspection not straight (linear). Visually, there are no inflection points within the domain (the range of the attribute 'Score' in the wine data).



Q2

Price = -197.188 + 2.653 Score

Price = 1,330.419 - 33.230 Score + 0.210 Score^2

Price = -1,704.065 + 74.251 Score - 1.057 Score^2 + 0.005 Score^3

Detailed version:

	Dependent variable:		
	Price		
	(1)	(2)	(3)
score	2.653***	-33.230***	74.251
	(0.064)	(2.369)	(67.408)
score2		0.210***	-1.057
		(0.014)	(0.802)
score3			0.005
			(0.003)
Constant	-197.188***	1,330.419***	-1,704.065
	(5.388)	(99.432)	(1,886.575)
Observations	6,979	6,979	6,979
R2	0.221	0.249	0.249
Adjusted R2	0.221	0.249	0.249
Residual Std. Error	16.609 (df = 6977)	16.309 (df = 6976)	16.308 (df = 6975)
F Statistic	1,981.860*** (df = 1; 6977)	1,157.354*** (df = 2; 6976)	772.648*** (df = 3; 6975)
Note:			*p<0.1; **p<0.05; ***p<0.01

sequential hypothesis

- Model 3:
  H0: coef(score3) = 0, H1: coef(score3) != 0
  The p value of coefficient of score3 >0.05, hence failing to reject H0 at 5% significance level, which means the cubic relationship between price and score is not statistically significant when tested against a quadratic fitted relationship. Therefore, we process to the next level of testing — quadratic model.
- Model 2:
  H0: coef(score2) = 0, H1: coef(score2) != 0
  The p value of coefficient of score2 <0.05, hence we reject H0 at 5% significance level, which means the quadratic relationship between price and score is statistically significant when tested against a linearly fitted relationship. Hence, we stop the sequential hypothesis testing, and conclude that a quadratic relationship is appropriate for modeling the relationship between price and score.

Q3

	Col 1 coef	***Col 1 SE***	**Col 2 coef**	***Col 2 SE***	**Col 3 coef**	***Col 3 SE***
Constant	1330.419	*99.432*	1250.858	*98.386*	1363.257	*89.152*
Score	-33.230	*2.369*	-31.170	*2.343*	-33.431	*2.125*
Score squared	0.210	*0.014*	0.198	*0.014*	0.208	*0.013*
Wine type pinotnoir			-3.903	*0.934*	-3.381	*0.897*
Wine type cabernet			-3.365	*0.961*	-3.969	*0.866*
Wine type merlot			-8.069	*0.918*	-8.282	*0.828*
Wine type syrah			-11.429	*0.992*	-11.898	*0.939*

Note: for column 3, the wine region and year dummies are controlled but not included in the table above.

```
================================================================================================
                                        Dependent variable:
                    ---------------------------------------------------------------------------
                                                Price
                              (1)                 (2)                 (3)
------------------------------------------------------------------------------------------------
score                     -33.230***          -31.170***          -33.431***
                           (2.369)             (2.343)             (2.125)

score2                     0.210***            0.198***            0.208***
                           (0.014)             (0.014)             (0.013)

pinotnoir                                      -3.903***           -3.381***
                                               (0.934)             (0.897)

cabernet                                       -3.365***           -3.969***
                                               (0.961)             (0.866)

merlot                                         -8.069***           -8.282***
                                               (0.918)             (0.828)

syrah                                          -11.428***          -11.898***
                                               (0.992)             (0.939)
```

Constant	1,330.419***	1,250.858***	1,363.257***
	(99.432)	(98.386)	(89.152)
Observations	6,979	6,979	6,979
R2	0.249	0.275	0.415
Adjusted R2	0.249	0.274	0.413
Residual Std. Error	16.309 (df = 6976)	16.031 (df = 6972)	14.415 (df = 6955)
F Statistic	1,157.354*** (df = 2; 6976)	440.614*** (df = 6; 6972)	214.724*** (df = 23; 6955)
Note:			*p<0.1; **p<0.05; ***p<0.01

Q4

H0: coefficient (score^2) = 0 H1: coefficient (score^2) ≠ 0

Reject the hypothesis that the coefficient on score^2 is 0 at 5% significance level, because the p-value 2.2e-16 < 0.05. Hence we conclude that the non-linear relationship between price and score is statistically significant in column 3.
Test statistic = 271.55 following F distribution on F 1, 6955

Q5

Test regression coefficient on [wine types] pinotnoir, cabernet, merlot and syrah are jointly equal to each other
H0: coefficient(pinotnoir) = coefficient(cabernet) = coefficient(merlot) = coefficient(syrah)
H1: at least one of the above condition does not hold
P-value = 2.2e-16 < 0.05, hence we reject the hypothesis that coefficients on [wine types] pinotnoir, cabernet, merlot and syrah are jointly equal to each other. We conclude that wine types have statistically significant different impacts on a wine's price at 5% significance level, holding other factors fixed.
Test statistic = 115.91 following F distribution on 3, 6955 df

Q6

	score changes from price=80 to price=85	**score changes from price=85 to price=90**
Partial effect on price ($)	6.1	16.6
SE	0.389	0.551
Confidence interval	[5.350, 6.850]	[15.520, 17.680]

The partial effect on the price of changing score from 80 to 85 is $6.1 which is lower than that from 85 to 90 that is $16.6. Even though the price change in both cases is $5, there is a greater partial effect because of the nonlinearity nature of the relationship as demonstrated in previous questions. The sequential testing shows it is statistically significant to say that the relationship between price and score is quadratic. As foreshadowed/shown in the Question 1 Graph, as score increases, the partial effect on price of changing one unit of score also increases; which corresponds to the results from this question.

Q7

	constant	**log(score)**	**Wine type pinotnoir**	**Wine type cabernet**	**Wine type merlot**	**Wine type syrah**
Coefficient	-22.256	5.709	-0.050	-0.107	-0.193	-0.294
SE	0.608	0.137	0.022	0.020	0.020	0.024

elasticity of price with respect to score = 5.71%

```
================================================
                        Dependent variable:
                    ---------------------------
                              log(Price)
------------------------------------------------
log(score)                     5.709***
                               (0.137)

pinotnoir                      -0.050**
                               (0.022)

cabernet                       -0.107***
                               (0.020)

merlot                         -0.193***
                               (0.020)

syrah                          -0.294***
                               (0.024)

Constant                      -22.256***
                               (0.608)

------------------------------------------------
Observations                     6,979
R2                               0.487
Adjusted R2                      0.486
Residual Std. Error       0.378 (df = 6956)
F Statistic          300.642*** (df = 22; 6956)
================================================
Note:                *p<0.1; **p<0.05; ***p<0.01
```

Note: for this table, the wine region and year dummies are controlled but not included in the table above.

Q8

H0: coefficient(log(score)) = 1; H1: coefficient(log(score)) != 1
P-value = 2.2e-16 < 0.05, hence we reject the hypothesis that coefficient of log(score) = 1. We conclude that the elasticity of price with respect to score is not equal to 1% at 5% significance level.
Test statistic = 1179.5 following F distribution on 1, 6956 df.

Q9

	Col 1 coef	***Col 1 SE***	**Col 2 coef**	***Col 2 SE***
Constant	-22.256	*0.608*	-27.395	*2.427*
log(score)	5.709	*0.137*	6.859	*0.543*
Wine type pinotnoir	-0.050	*0.022*	5.872	*2.668*
Wine type cabernet	-0.107	*0.020*	0.338	*2.580*
Wine type merlot	-0.193	*0.020*	11.452	*2.575*
Wine type syrah	-0.294	*0.024*	11.367	*3.087*
Interaction between log(score) and wine type pinotnoir			-1.326	*0.597*
Interaction between log(score) and wine type cabernet			-0.098	*0.577*
Interaction between log(score) and wine type			-2.613	*0.576*

merlot				
Interaction between log(score) and wine type syrah			-2.610	*0.691*

```
=================================================================
                                Dependent variable:
                    ---------------------------------------------
                                        Price
                                (1)                 (2)
-----------------------------------------------------------------
log(score)                    5.709***            6.859***
                              (0.137)             (0.543)

pinotnoir                     -0.050**            5.872**
                              (0.022)             (2.668)

cabernet                      -0.107***            0.338
                              (0.020)             (2.580)

merlot                        -0.193***           11.452***
                              (0.020)             (2.575)

syrah                         -0.294***           11.367***
                              (0.024)             (3.087)

log(score):pinotnoir                              -1.326**
                                                  (0.597)

log(score):cabernet                               -0.098
                                                  (0.577)

log(score):merlot                                 -2.613***
                                                  (0.576)

log(score):syrah                                  -2.610***
                                                  (0.691)

Constant                     -22.256***           -27.395***
                              (0.608)             (2.427)

-----------------------------------------------------------------
Observations                   6,979               6,979
R2                             0.487               0.494
Adjusted R2                    0.486               0.492
Residual Std. Error      0.378 (df = 6956)   0.376 (df = 6952)
F Statistic          300.642*** (df = 22; 6956) 260.631*** (df = 26; 6952)
=================================================================
Note:                                 *p<0.1; **p<0.05; ***p<0.01
```

The elastic w respect to wine type pinotnoir = 6.859-1.326 = 5.533 %
The elastic w respect to wine type cabernet = 6.859-0.098 = 6.761 %

The elast w respect to wine type merlot = 6.859-2.613 = 4.246 %
The elast w respect to wine type syrah = 6.859-2.601 = 4.258 %

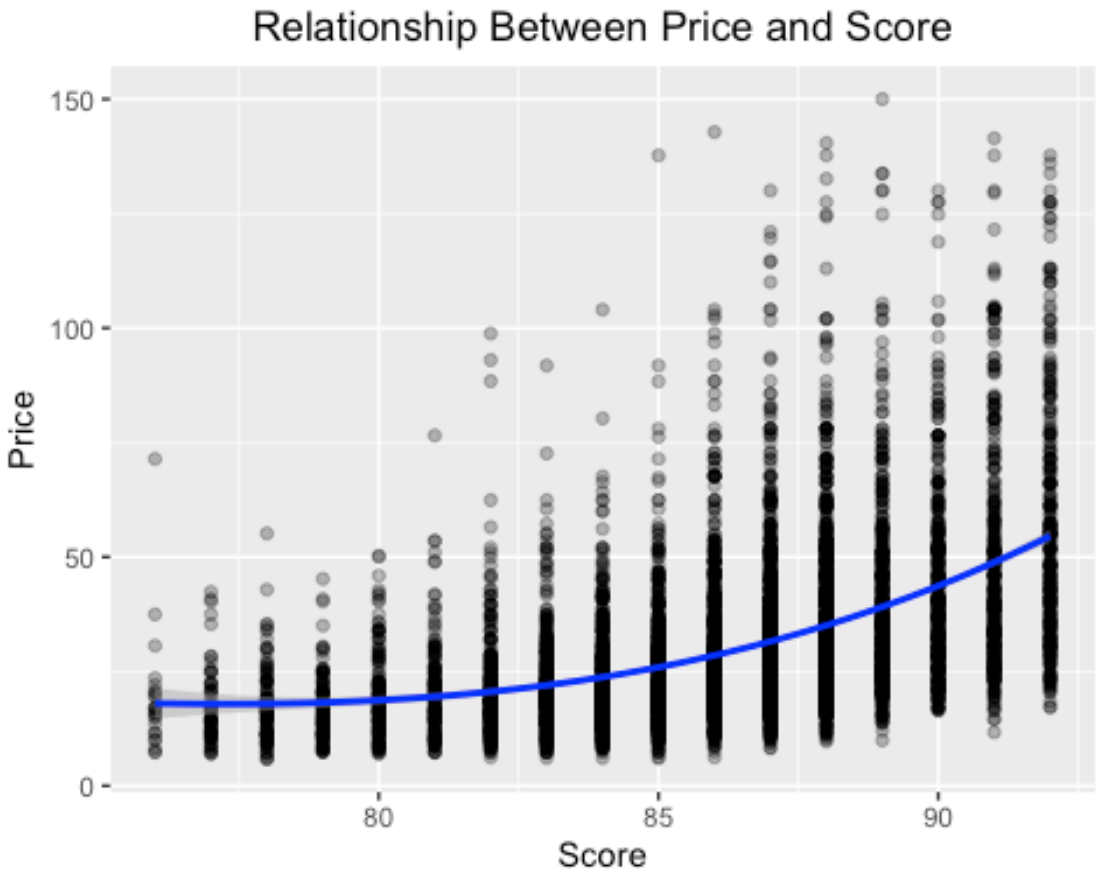
Q10
H0: coef(log(score)*pinotnoir) = coef(log(score)*cabernet) = coef(log(score)*merlot) = coef(log(score)*syrah)
H1: one or more of above are not equal to each other

P-value = 2.2e-16 < 0.05, hence we reject the hypothesis that coefficient of interaction of log(score) and pinotnoir = coefficient of interaction of log(score) and cabernet = coefficient of interaction of log(score) and merlot = coefficient of interaction of log(score) and syrah. We conclude that the elasticity of price with respect to score is not the same for the 4 wine types at 5% significance level.
Test statistic = 26.781 following F distribution on 3, 6952 df.

```
library(stargazer)

##
## Please cite as:

##  Hlavac, Marek (2022). stargazer: Well-Formatted Regression and Summary Statistics Tables.

##  R package version 5.2.3. https://CRAN.R-project.org/package=stargazer

library(AER)

## Loading required package: car

## Loading required package: carData

## Loading required package: lmtest

## Loading required package: zoo

##
## Attaching package: 'zoo'

## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric

## Loading required package: sandwich

## Loading required package: survival

library(ggplot2)

## Warning in register(): Can't find generic `scale_type` in package ggplot2 to
## register S3 method.

data = read.csv('as3_wine.csv')
```

Q1.

```
ggplot(data, aes(y=price, x=score)) +
  geom_point(alpha=.3) +
  stat_smooth(method = 'lm', formula= y ~poly(x,3), col='blue') +
  ggtitle('Relationship Between Price and Score') +
  theme(plot.title = element_text(hjust = 0.5)) +
  scale_x_continuous(name='Score') +
  scale_y_continuous(name='Price')
```



Q2.

```
# create nonlinear variables
data$score2 = data$score * data$score
data$score3 = data$score2 * data$score

# fit linear regressions
lm2_1 = lm(price ~ score,  data = data)
lm2_2 = lm(price ~ score + score2,  data = data)
lm2_3 = lm(price ~ score + score2 + score3,  data = data)


# get covar and se
cov2_1 = vcovHC(lm2_1, type="HC1")
cov2_2 = vcovHC(lm2_2, type="HC1")
cov2_3 = vcovHC(lm2_3, type="HC1")

se2_1 = sqrt(diag(cov2_1))
se2_2 = sqrt(diag(cov2_2))
se2_3 = sqrt(diag(cov2_3))

# get stargazer summary
stargazer(lm2_1, lm2_2, lm2_3, type='text',
          se = list(se2_1, se2_2, se2_3),
          digits = 3,
          dep.var.labels = c("Price"),
            out='Q2_output.txt')
```

```
##
##
================================================================================================
=======
##                                                 Dependent variable:
##                     ---------------------------------------------------------------------------
----------
##                                                         Price
##                                 (1)                       (2)                        (3)
## ------------------------------------------------------------------------------------------------
----------
## score                         2.653***                 -33.230***                  74.251
##                                (0.064)                   (2.369)
(67.408)
##
## score2                                                   0.210***                   -1.057
##                                                           (0.014)
(0.802)
##
## score3                                                                               0.005
##
(0.003)
##
## Constant                     -197.188***               1,330.419***                -
1,704.065
##                                (5.388)                   (99.432)
(1,886.575)
##
## ------------------------------------------------------------------------------------------------
----------
## Observations                    6,979                     6,979                      6,979
## R2                              0.221                     0.249                      0.249
## Adjusted R2                     0.221                     0.249                      0.249
## Residual Std. Error     16.609 (df = 6977)         16.309 (df = 6976)         16.308 (df =
6975)
## F Statistic         1,981.860*** (df = 1; 6977) 1,157.354*** (df = 2; 6976) 772.648*** (df
= 3; 6975)
##
================================================================================================
=======
## Note:                                                                      *p<0.1; **p<0.05;
***p<0.01
```

Q3.

```
# get the nonlinear regressions
lm3_1 = lm(price ~ score + score2,  data = data)
lm3_2 = lm(price ~ score + score2 + pinotnoir + cabernet + merlot + syrah,  data = data)
lm3_3 = lm(price ~ score + score2 + pinotnoir + cabernet + merlot + syrah + napa + bayarea +
sonoma + scoast + carn + sierra + mendo + wash + d1991 + d1992 + d1993 + d1994 + d1995 + d1996
+ d1997 + d1998 + d1999,  data = data)

# get covar and se
cov3_1 = vcovHC(lm3_1, type="HC1")
cov3_2 = vcovHC(lm3_2, type="HC1")
cov3_3 = vcovHC(lm3_3, type="HC1")

se3_1 = sqrt(diag(cov3_1))
se3_2 = sqrt(diag(cov3_2))
se3_3 = sqrt(diag(cov3_3))
```

```
# get stargazer summary
stargazer(lm3_1, lm3_2, lm3_3, type='text',
          se = list(se3_1, se3_2, se3_3),
          digits = 3,
          dep.var.labels = c("Price"),
            out='Q3_output.txt')

##
##
================================================================================================
======
##                                                 Dependent variable:
##                     ---------------------------------------------------------------------------
---------
##                                                        Price
##                                  (1)                     (2)                      (3)
## ------------------------------------------------------------------------------------------------
---------
## score                        -33.230***              -31.170***                -
33.431***
##                               (2.369)                 (2.343)                  (2.125)
##
## score2                        0.210***                0.198***                 0.208***
##                               (0.014)                 (0.014)                  (0.013)
##
## pinotnoir                                             -3.903***                -3.381***
##                                                       (0.934)                  (0.897)
##
## cabernet                                              -3.365***                -3.969***
##                                                       (0.961)                  (0.866)
##
## merlot                                                -8.069***                -8.282***
##                                                       (0.918)                  (0.828)
##
## syrah                                                -11.428***                -
11.898***
##                                                       (0.992)                  (0.939)
##
## napa                                                                          14.335***
##                                                                               (0.637)
##
## bayarea                                                                        9.192***
##                                                                               (0.856)
##
## sonoma                                                                         7.329***
##                                                                               (0.584)
##
## scoast                                                                         5.060***
##                                                                               (0.606)
##
## carn                                                                           6.483***
##                                                                               (0.752)
##
## sierra                                                                         4.839***
##                                                                               (1.114)
##
## mendo                                                                          2.819***
##                                                                               (0.810)
##
## wash                                                                           -0.002
##                                                                               (0.648)
```

```
##
## d1991                                                                                -
10.661***
##                                                                                       (0.834)
##
## d1992                                                                                -
10.244***
##                                                                                       (0.858)
##
## d1993                                                                               -9.089***
##                                                                                       (0.823)
##
## d1994                                                                               -8.892***
##                                                                                       (0.789)
##
## d1995                                                                               -5.273***
##                                                                                       (0.801)
##
## d1996                                                                               -3.600***
##                                                                                       (0.811)
##
## d1997                                                                                 -1.164
##                                                                                       (0.814)
##
## d1998                                                                                4.530***
##                                                                                       (0.906)
##
## d1999                                                                                1.844**
##                                                                                       (0.845)
##
## Constant                   1,330.419***              1,250.858***
1,363.257***
##                              (99.432)                  (98.386)                   (89.152)
##
## ---------------------------------------------------------------------------------------
---------
## Observations                  6,979                     6,979                      6,979
## R2                            0.249                     0.275                      0.415
## Adjusted R2                   0.249                     0.274                      0.413
## Residual Std. Error     16.309 (df = 6976)        16.031 (df = 6972)        14.415 (df =
6955)
## F Statistic         1,157.354*** (df = 2; 6976) 440.614*** (df = 6; 6972) 214.724*** (df =
23; 6955)
##
=======================================================================================
======
## Note:                                                                  *p<0.1; **p<0.05;
***p<0.01
```

Q4)

```
# run linear hypothesis to test for non linearity
linearHypothesis(lm3_3, c('score2=0'), vcov = vcovHC(lm3_3, 'HC1'))

## Linear hypothesis test
##
## Hypothesis:
## score2 = 0
##
## Model 1: restricted model
## Model 2: price ~ score + score2 + pinotnoir + cabernet + merlot + syrah +
```

```
##     napa + bayarea + sonoma + scoast + carn + sierra + mendo +
##     wash + d1991 + d1992 + d1993 + d1994 + d1995 + d1996 + d1997 +
##     d1998 + d1999
##
## Note: Coefficient covariance matrix supplied.
##
##   Res.Df Df      F    Pr(>F)
## 1   6956
## 2   6955  1 271.55 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Q5)

```
# Test the specificed regression coefficients are jointly equal to each other
linearHypothesis(lm3_3, c('pinotnoir = cabernet', 'cabernet = merlot', 'merlot = syrah'), vcov
= vcovHC(lm3_3, 'HC1'))
```

```
## Linear hypothesis test
##
## Hypothesis:
## pinotnoir - cabernet = 0
## cabernet - merlot = 0
## merlot - syrah = 0
##
## Model 1: restricted model
## Model 2: price ~ score + score2 + pinotnoir + cabernet + merlot + syrah +
##     napa + bayarea + sonoma + scoast + carn + sierra + mendo +
##     wash + d1991 + d1992 + d1993 + d1994 + d1995 + d1996 + d1997 +
##     d1998 + d1999
##
## Note: Coefficient covariance matrix supplied.
##
##   Res.Df Df      F    Pr(>F)
## 1   6958
## 2   6955  3 115.91 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Q6)

```
# partial effect on price when score changes from 80 to 85
print('partial effects')
```

```
## [1] "partial effects"
```

```
(dprice6_1 = (-33.43 * (85) + 0.21 * (85**2)) - (-33.43 * (80) + 0.21 * (80**2)))
```

```
## [1] 6.1
```

```
# partial effect on price when score changes from 85 to 90
(dprice6_2 = (-33.43 * (90) + 0.21 * (90**2)) - (-33.43 * (85) + 0.21 * (85**2)))
```

```
## [1] 16.6
```

```
# get the changes in quadratic term
85**2 - 80**2
```

```
## [1] 825
```

```
90**2 - 85**2
```

```
## [1] 875

# get f statistics for the joint test of H0 = 5*score + 825* score^2 when score changes from
80 to 85
Ftest6_1 = linearHypothesis(lm3_3, c('5*score + 825* score2'), vcov = vcovHC(lm3_3, "HC1"))
Fstat6_1 = Ftest6_1[2,3]
# get f statistics for the joint test of H0 = 5*score + 875* score^2 when score changes from
85 to 90
Ftest6_2 = linearHypothesis(lm3_3, c('5*score + 875* score2'), vcov = vcovHC(lm3_3, "HC1"))
Fstat6_2 = Ftest6_2[2,3]


# get SE when score changes from 80 to 85
print('SE')

## [1] "SE"

(se_dprice6_1 = abs(dprice6_1)/sqrt(Fstat6_1))

## [1] 0.3828554

# get SE when score changes from 85 to 90
(se_dprice6_2 = abs(dprice6_2)/sqrt(Fstat6_2))

## [1] 0.5509774

# get 95% CI for the partial effects
print('CI')

## [1] "CI"

(dprice_ci95_6_1 = dprice6_1 + c(-1.96, 1.96) * se_dprice6_1)

## [1] 5.349603 6.850397

(dprice_ci95_6_2 = dprice6_2 + c(-1.96, 1.96) * se_dprice6_2)

## [1] 15.52008 17.67992
```

Q7)

```
# Run LM with log of these two variables
lm7_1 = lm(log(price) ~ log(score) + pinotnoir + cabernet + merlot + syrah + napa + bayarea +
sonoma + scoast + carn + sierra + mendo + wash + d1991 + d1992 + d1993 + d1994 + d1995 + d1996
+ d1997 + d1998 + d1999,  data = data)

# get covar and se
cov7_1 = vcovHC(lm7_1, type="HC1")

se7_1 = sqrt(diag(cov7_1))

# get stargazer summary
stargazer(lm7_1, type='text',
          se = list(se7_1),
          digits = 3,
          dep.var.labels = c("log(Price)"),
            out='Q7_output.txt')

##
## ===============================================
##                         Dependent variable:
```

```
##                      ---------------------------
##                              log(Price)
## ---------------------------------------------------
## log(score)                    5.709***
##                                (0.137)
##
## pinotnoir                     -0.050**
##                                (0.022)
##
## cabernet                      -0.107***
##                                (0.020)
##
## merlot                        -0.193***
##                                (0.020)
##
## syrah                         -0.294***
##                                (0.024)
##
## napa                          0.582***
##                                (0.021)
##
## bayarea                       0.422***
##                                (0.027)
##
## sonoma                        0.386***
##                                (0.021)
##
## scoast                        0.332***
##                                (0.022)
##
## carn                          0.355***
##                                (0.026)
##
## sierra                        0.262***
##                                (0.040)
##
## mendo                         0.208***
##                                (0.030)
##
## wash                          0.160***
##                                (0.024)
##
## d1991                         -0.334***
##                                (0.024)
##
## d1992                         -0.343***
##                                (0.024)
##
## d1993                         -0.296***
##                                (0.023)
##
## d1994                         -0.247***
##                                (0.022)
##
## d1995                         -0.144***
##                                (0.022)
##
## d1996                         -0.103***
##                                (0.022)
##
## d1997                         -0.048**
```

```
##                                (0.022)
##
## d1998                         0.089***
##                                (0.023)
##
## d1999                          0.038*
##                                (0.022)
##
## Constant                     -22.256***
##                                (0.608)
##
## ------------------------------------------------
## Observations                    6,979
## R2                              0.487
## Adjusted R2                     0.486
## Residual Std. Error       0.378 (df = 6956)
## F Statistic          300.642*** (df = 22; 6956)
## ================================================
## Note:                *p<0.1; **p<0.05; ***p<0.01
```

Q8)

```
# run linear hypothesis to test equivalency of effects
linearHypothesis(lm7_1, c('log(score) = 1'), vcov = vcovHC(lm7_1, 'HC1'))

## Linear hypothesis test
##
## Hypothesis:
## log(score) = 1
##
## Model 1: restricted model
## Model 2: log(price) ~ log(score) + pinotnoir + cabernet + merlot + syrah +
##     napa + bayarea + sonoma + scoast + carn + sierra + mendo +
##     wash + d1991 + d1992 + d1993 + d1994 + d1995 + d1996 + d1997 +
##     d1998 + d1999
##
## Note: Coefficient covariance matrix supplied.
##
##   Res.Df Df      F    Pr(>F)
## 1   6957
## 2   6956  1 1179.5 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Q9)

```
# Run LM with log of these two variables and interaction
lm9_1 = lm(log(price) ~ log(score) + log(score)*pinotnoir + log(score)*cabernet +
log(score)*merlot + log(score)*syrah + pinotnoir + cabernet + merlot + syrah + napa + bayarea
+ sonoma + scoast + carn + sierra + mendo + wash + d1991 + d1992 + d1993 + d1994 + d1995 +
d1996 + d1997 + d1998 + d1999,  data = data)

# get covar and se
cov9_1 = vcovHC(lm9_1, type="HC1")

se9_1 = sqrt(diag(cov9_1))

# get stargazer summary
stargazer(lm7_1, lm9_1, type='text',
          se = list(se7_1, se9_1),
          digits = 3,
```

```
          dep.var.labels = c("Price"),
            out='Q9_output.txt')

##
## ================================================================================
##                                       Dependent variable:
##                          ---------------------------------------------------
##                                              Price
##                                    (1)                          (2)
## --------------------------------------------------------------------------------
## log(score)                        5.709***                     6.859***
##                                   (0.137)                      (0.543)
##
## pinotnoir                         -0.050**                     5.872**
##                                   (0.022)                      (2.668)
##
## cabernet                         -0.107***                      0.338
##                                   (0.020)                      (2.580)
##
## merlot                           -0.193***                    11.452***
##                                   (0.020)                      (2.575)
##
## syrah                            -0.294***                    11.367***
##                                   (0.024)                      (3.087)
##
## napa                              0.582***                     0.582***
##                                   (0.021)                      (0.021)
##
## bayarea                           0.422***                     0.422***
##                                   (0.027)                      (0.027)
##
## sonoma                            0.386***                     0.388***
##                                   (0.021)                      (0.021)
##
## scoast                            0.332***                     0.333***
##                                   (0.022)                      (0.022)
##
## carn                              0.355***                     0.356***
##                                   (0.026)                      (0.026)
##
## sierra                            0.262***                     0.267***
##                                   (0.040)                      (0.040)
##
## mendo                             0.208***                     0.212***
##                                   (0.030)                      (0.030)
##
## wash                              0.160***                     0.170***
##                                   (0.024)                      (0.024)
##
## d1991                            -0.334***                    -0.333***
##                                   (0.024)                      (0.024)
##
## d1992                            -0.343***                    -0.347***
##                                   (0.024)                      (0.024)
##
## d1993                            -0.296***                    -0.297***
##                                   (0.023)                      (0.023)
##
## d1994                            -0.247***                    -0.248***
##                                   (0.022)                      (0.022)
##
```

```
## d1995                          -0.144***                  -0.146***
##                                 (0.022)                    (0.022)
##
## d1996                          -0.103***                  -0.111***
##                                 (0.022)                    (0.022)
##
## d1997                           -0.048**                   -0.054**
##                                 (0.022)                    (0.022)
##
## d1998                           0.089***                   0.085***
##                                 (0.023)                    (0.023)
##
## d1999                            0.038*                     0.033
##                                 (0.022)                    (0.022)
##
## log(score):pinotnoir                                       -1.326**
##                                                            (0.597)
##
## log(score):cabernet                                         -0.098
##                                                            (0.577)
##
## log(score):merlot                                          -2.613***
##                                                            (0.576)
##
## log(score):syrah                                           -2.610***
##                                                            (0.691)
##
## Constant                       -22.256***                 -27.395***
##                                 (0.608)                    (2.427)
##
## ------------------------------------------------------------------------
## Observations                     6,979                      6,979
## R2                               0.487                      0.494
## Adjusted R2                      0.486                      0.492
## Residual Std. Error      0.378 (df = 6956)          0.376 (df = 6952)
## F Statistic          300.642*** (df = 22; 6956) 260.631*** (df = 26; 6952)
## ========================================================================
## Note:                                          *p<0.1; **p<0.05; ***p<0.01
```

Q10)

```
# run linear hypothesis to test equivalency of effects
linearHypothesis(lm9_1, c('log(score):pinotnoir = log(score):cabernet', 'log(score):cabernet =
log(score):merlot', 'log(score):merlot = log(score):syrah'), vcov = vcovHC(lm9_1, 'HC1'))
```

```
## Linear hypothesis test
##
## Hypothesis:
## log(score):pinotnoir - log(score):cabernet = 0
## log(score):cabernet - log(score):merlot = 0
## log(score):merlot - log(score):syrah = 0
##
## Model 1: restricted model
## Model 2: log(price) ~ log(score) + log(score) * pinotnoir + log(score) *
##     cabernet + log(score) * merlot + log(score) * syrah + pinotnoir +
##     cabernet + merlot + syrah + napa + bayarea + sonoma + scoast +
##     carn + sierra + mendo + wash + d1991 + d1992 + d1993 + d1994 +
##     d1995 + d1996 + d1997 + d1998 + d1999
##
## Note: Coefficient covariance matrix supplied.
##
```

```
##   Res.Df Df      F    Pr(>F)
## 1   6955
## 2   6952  3 26.781 < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```