Work2

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Data Prep

```
df_combo <- read_excel("BDB_Combo.xlsx")
df_player <- read_excel("BDB_Player_v2.xlsx")
```

```
what_i_want <- c("DATASET","DATE", "PLAYER FULL NAME", "OWN TEAM","VENUE", "MIN", "PER","AVG_PER","OMIT
  "H", "TRAVEL","1.0 days", "M1", "M2", "M3", "OEFF - All games", "DEFF - All games",
  "OEFF - Not included","DEFF - Not included", "Bubble", "Venue -1", "Dummy at Home Yesterday", "Close

df_player <- df_player %>% select( what_i_want)
```

```
## Note: Using an external vector in selections is ambiguous.
## i Use ‘all_of(what_i_want)‘ instead of ‘what_i_want‘ to silence this message.
## i See <https://tidyselect.r-lib.org/reference/faq-external-vector.html>.
## This message is displayed once per session.
```

```
# Filter out Bubble, calculate PER_diff, include polynomial regressions
df_player <- df_player %>% filter( DATASET != '2019-2020 Regular Season') %>% mutate(
  PER_diff = PER - OMIT_PER,
  M1_sq = M1^2,
  M1_cu = M1^3,
  M2_sq = M2^2,
  M2_cu = M2^3,
  M1.IV.Avg.Min.Sq = `Avg Min`^2
)
```

```
# Merge with for Team Last played
df_combo <- df_combo %>% rename(
    'OWN TEAM' = 'TEAMS',
    'TEAM_OEFF' = 'OEFF',
    'TEAM_DEFF' = 'DEFF',
    'TEAM_REST_DAYS' = 'REST DAYS',
    'TDF'= 'DATE-DIFF'
)

df_combo <- df_combo %>% select(
  c('DATASET', 'DATE', 'OWN TEAM', 'VENUE','TEAM_OEFF', 'TEAM_DEFF', 'TEAM_REST_DAYS', 'TDF')
  )
```

```
df_final <- merge(df_combo, df_player, by = c("DATASET","DATE","OWN TEAM","VENUE"))

df_final <- dummy_cols(df_final, select_columns = "TDF")


df_final <- df_final %>% rename(
    'TDF_1' = 'TDF_1.0 days',
    'TDF_2' = 'TDF_2.0 days',
    'OO' = 'OEFF - Not included',
    'OD' = 'DEFF - Not included'
) %>% mutate(
  iv.1 = `TDF_1`*`Avg Min`,
  iv.2 = `TDF_1`*`Avg Min`^2,
  iv.3 = `TDF_1`*`Avg Min`^3
)
```

OLS

OLD:

$$PER_{diff} = H + T + OEFF + DEFF + M1 + M2 + M3 + days_1 + days_2 + days_3 + days_4 + \epsilon$$

NEW:

$$\triangle PER = \alpha + \beta_H H + \beta_T T + \beta_{OO} OO + \beta_{OD} OD + \beta_{M_1} M_1 + \beta_{M_1^2} M_1^2 + \beta_{M_1^3} M_1^3 + \epsilon$$

$$\triangle PER = \alpha + \beta_H H + \beta_T T + \beta_{OO} OO + \beta_{OD} OD + \beta_{M_1} M_1 + \beta_{M_1^2} M_1^2 + \beta_{M_1^3} M_1^3 + \beta_{M_2} M_2 + \beta_{M_2^2} M_2^2 + \beta_{M_2^3} M_2^3 + \epsilon$$

$$\triangle PER = \alpha + \beta_H H + \beta_T T + \beta_{OO} OO + \beta_{OD} OD + \beta_{M_1} \hat{M}_1 + \beta_{M_1^2} \hat{M}_1^2 + \beta_{M_1^3} \hat{M}_1^3 + \epsilon$$

$$\triangle PER = \alpha + \beta_H H + \beta_T T + \beta_{OO} OO + \beta_{OD} OD + \sum_{n=1}^{4} \beta_{Q_n} Q_n * (\beta_{M_1} M_1 + \beta_{M_1^2} M_1^2 + \beta_{M_1^3} M_1^3) + \epsilon$$

$$M_1^n = \delta + \beta_{IV}(Team_{-1} * Avg.Min_i^n)$$

```
base.lm = lm(
  data = df_final,
  PER_diff ~ H+TRAVEL+OO+OD+M1 + M1_sq + M1_cu
  )

without_lockout_lm <- df_final %>% filter( DATASET != '2011-2012 Regular Season') %>% lm(
    PER_diff ~ H+TRAVEL+OO+OD+M1+ M1_sq + M1_cu, data = .
)

M1.M2 <-  df_final %>% filter( DATASET != '2011-2012 Regular Season') %>% lm(
```

```
  PER_diff ~ H+TRAVEL+OO+OD+M1 + M1_sq + M1_cu + M2, data =.
  )

M1.M2.complete <-  df_final %>% filter( DATASET != '2011-2012 Regular Season') %>% lm(
  PER_diff ~ H+TRAVEL+OO+OD+M1 + M1_sq + M1_cu + M2 + M2_sq + M2_cu, data =.
  )
```

Base OLS on Q1 - Q4

```
df_final <- fastDummies::dummy_cols(df_final, select_columns = c("Season Stage"))

df_final <- df_final %>% mutate(combo_m1 = M1 + M1_sq + M1_cu )
```

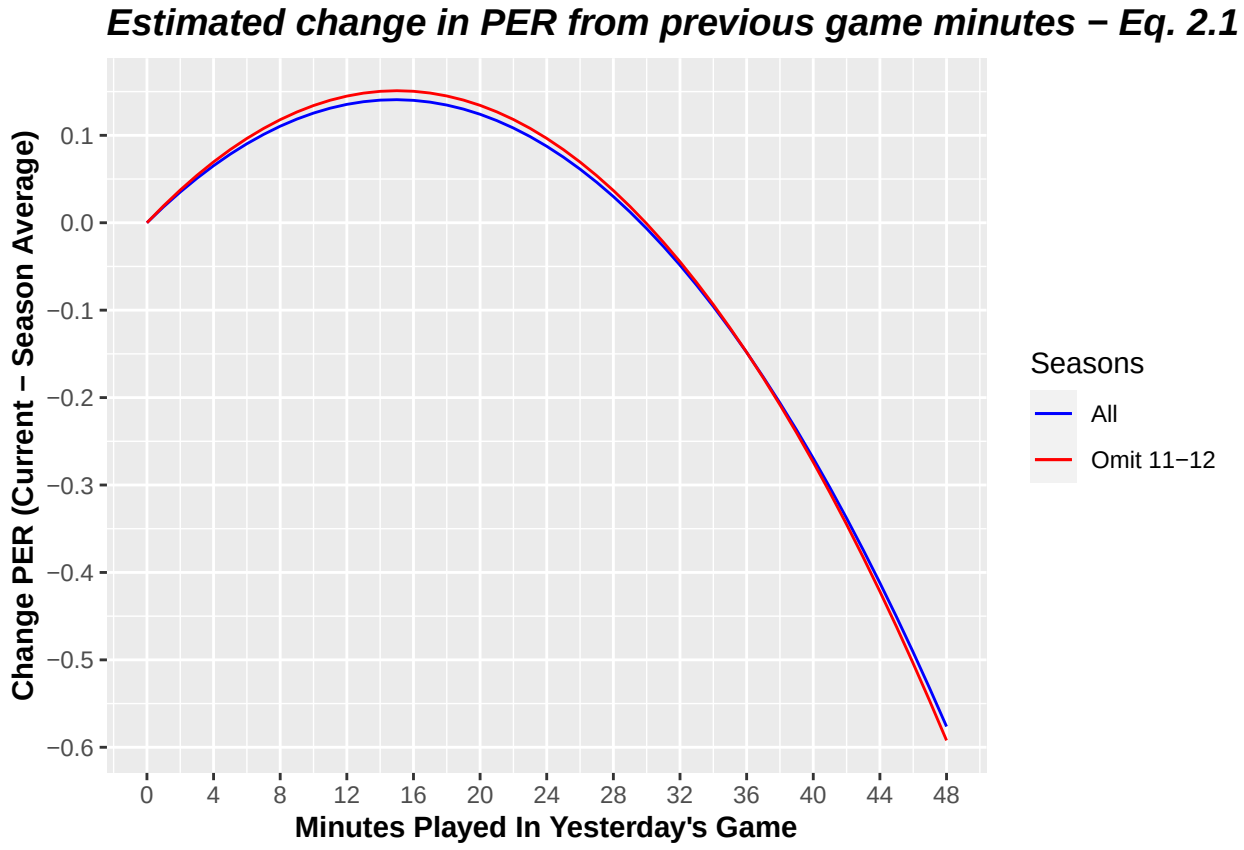
```
v1.Q1.test <- df_final  %>% filter( DATASET != '2011-2012 Regular Season') %>% lm(
   PER_diff ~ H+TRAVEL+OO+OD+(M1 + M1_sq + M1_cu)*`Season Stage_Q1`+(M1 + M1_sq + M1_cu)*`Season Stage_
   data = .
)

v1.Q1.lm <- df_final  %>% filter( DATASET != '2011-2012 Regular Season') %>% lm(
   PER_diff ~ H+TRAVEL+OO+OD+(M1 + M1_sq + M1_cu)*`Season Stage_Q1`,
   data = .
)

v1.Q2.lm <- df_final  %>% filter( DATASET != '2011-2012 Regular Season') %>% lm(
   PER_diff ~ H+TRAVEL+OO+OD+(M1 + M1_sq + M1_cu)*`Season Stage_Q2`,
   data = .
)
v1.Q3.lm <- df_final  %>% filter( DATASET != '2011-2012 Regular Season') %>% lm(
   PER_diff ~ H+TRAVEL+OO+OD+(M1 + M1_sq + M1_cu)*`Season Stage_Q3`,
   data = .
)
v1.Q4.lm <- df_final  %>% filter( DATASET != '2011-2012 Regular Season') %>% lm(
   PER_diff ~ H+TRAVEL+OO+OD+(M1 + M1_sq + M1_cu)*`Season Stage_Q4`,
   data = .
)

v2.Q1.lm <- df_final  %>% filter( DATASET != '2011-2012 Regular Season') %>% lm(
   PER_diff ~ H+TRAVEL+OO+OD+(M1 + M1_sq + M1_cu + M2 + M2_sq + M2_cu)*`Season Stage_Q1`,
   data = .
)

v2.Q2.lm <- df_final  %>% filter( DATASET != '2011-2012 Regular Season') %>% lm(
   PER_diff ~ H+TRAVEL+OO+OD+(M1 + M1_sq + M1_cu + M2 + M2_sq + M2_cu)*`Season Stage_Q2`,
   data = .
)
v2.Q3.lm <- df_final  %>% filter( DATASET != '2011-2012 Regular Season') %>% lm(
   PER_diff ~ H+TRAVEL+OO+OD+(M1 + M1_sq + M1_cu + M2 + M2_sq + M2_cu)*`Season Stage_Q3`,
   data = .
)
v2.Q4.lm <- df_final  %>% filter( DATASET != '2011-2012 Regular Season') %>% lm(
   PER_diff ~ H+TRAVEL+OO+OD+(M1 + M1_sq + M1_cu + M2 + M2_sq + M2_cu)*`Season Stage_Q4`,
```

```
   data = .
)


df_final %>% filter( DATASET != '2011-2012 Regular Season')%>% group_by(`Season Stage`) %>% summarise(co
```

```
## # A tibble: 4 x 2
##   `Season Stage` count
##   <chr>          <int>
## 1 Q1             31439
## 2 Q2             32626
## 3 Q3             31308
## 4 Q4             29266
```

Visuals

```
# Q.lm$coefficients

# Avg_OEFF
avg_oeff <- mean(df_final$OO)
avg_deff <- mean(df_final$OD)

# mean(df_final$`DEFF - ALL games`)

H <- 1
Travel <- 1

x <- 0:48

y.base <- base.lm$coefficients[6]*x + base.lm$coefficients[7]*x^2 +  base.lm$coefficients[8]*x^3
y.no.lock <- without_lockout_lm$coefficients[6]*x + without_lockout_lm$coefficients[7]*x^2 +  without_lo

ggplot() + geom_line( aes( x= x, y = y.base, color="blue")) + geom_line( aes( x= x, y = y.no.lock, colo
  scale_x_continuous(breaks = seq(0,48,4)) +
  coord_cartesian(xlim=c(0,48)) +
  scale_y_continuous(breaks = seq(-1,1,.1)) +
  xlab("Minutes Played In Yesterday's Game") +
  ylab("Change PER (Current - Season Average)") +
  ggtitle("Estimated change in PER from previous game minutes - Eq. 2.1") +
  theme(
    plot.title = element_text(size=14, face="bold.italic"),
    axis.title.x = element_text(size=11, face="bold"),
    axis.title.y = element_text(size=11, face="bold")
  )+scale_color_manual(labels = c("All", "Omit 11-12"), values=c("blue","red"))+guides(color=guide_leger
```




```
library(pracma)
```

```
## Warning: package 'pracma' was built under R version 4.0.5
```

```
##
## Attaching package: 'pracma'
```

```
## The following object is masked from 'package:car':
##
##     logit
```

```
## The following object is masked from 'package:purrr':
##
##     cross
```

```
R <- matrix(0,1,length(without_lockout_lm$coefficients))
R[1,6:8] <- 1
r <- matrix(c(0,1),1,1)
df_hyp <- 1
B = without_lockout_lm$coefficients
V = vcov(without_lockout_lm)

wald.stat <- t(R%*%B-r)%*%inv(R%*%V%*%t(R))%*%(R%*%B-r)
wald.pvalue <- pchisq(wald.stat,df_hyp,lower.tail = FALSE)
```

```
print(wald.stat)
```

```
##           [,1]
## [1,] 0.6303609
```

```
print(wald.pvalue)
```

```
##          [,1]
## [1,] 0.427223
```

```
wald.test(
  Sigma = vcov(without_lockout_lm),
  b = without_lockout_lm$coefficients,
  Terms = 6:8)
```

```
## Wald test:
## ----------
##
## Chi-squared test:
## X2 = 16.5, df = 3, P(> X2) = 0.00092
```

```
print("
      Durbin-Watson Test
      ")
```

```
## [1] "\n      Durbin-Watson Test\n      "
```

```
durbinWatsonTest(base.lm)
```

```
##  lag Autocorrelation D-W Statistic p-value
##    1      -0.0334883      2.066977       0
##  Alternative hypothesis: rho != 0
```

```
durbinWatsonTest(without_lockout_lm)
```

```
##  lag Autocorrelation D-W Statistic p-value
##    1     -0.03360838      2.067217       0
##  Alternative hypothesis: rho != 0
```

```
durbinWatsonTest(M1.M2)
```

```
##  lag Autocorrelation D-W Statistic p-value
##    1     -0.03359651      2.067193       0
##  Alternative hypothesis: rho != 0
```

IV

```
df_final <- df_final %>% filter( DATASET != '2011-2012 Regular Season')

base.iv <- AER::ivreg(
  PER_diff ~ H + TRAVEL +OO+OD + M1 + M1_sq + M1_cu | H + TRAVEL +OO+OD + iv.1 + iv.2 + iv.3,
  data = df_final)

summary(base.iv)
```

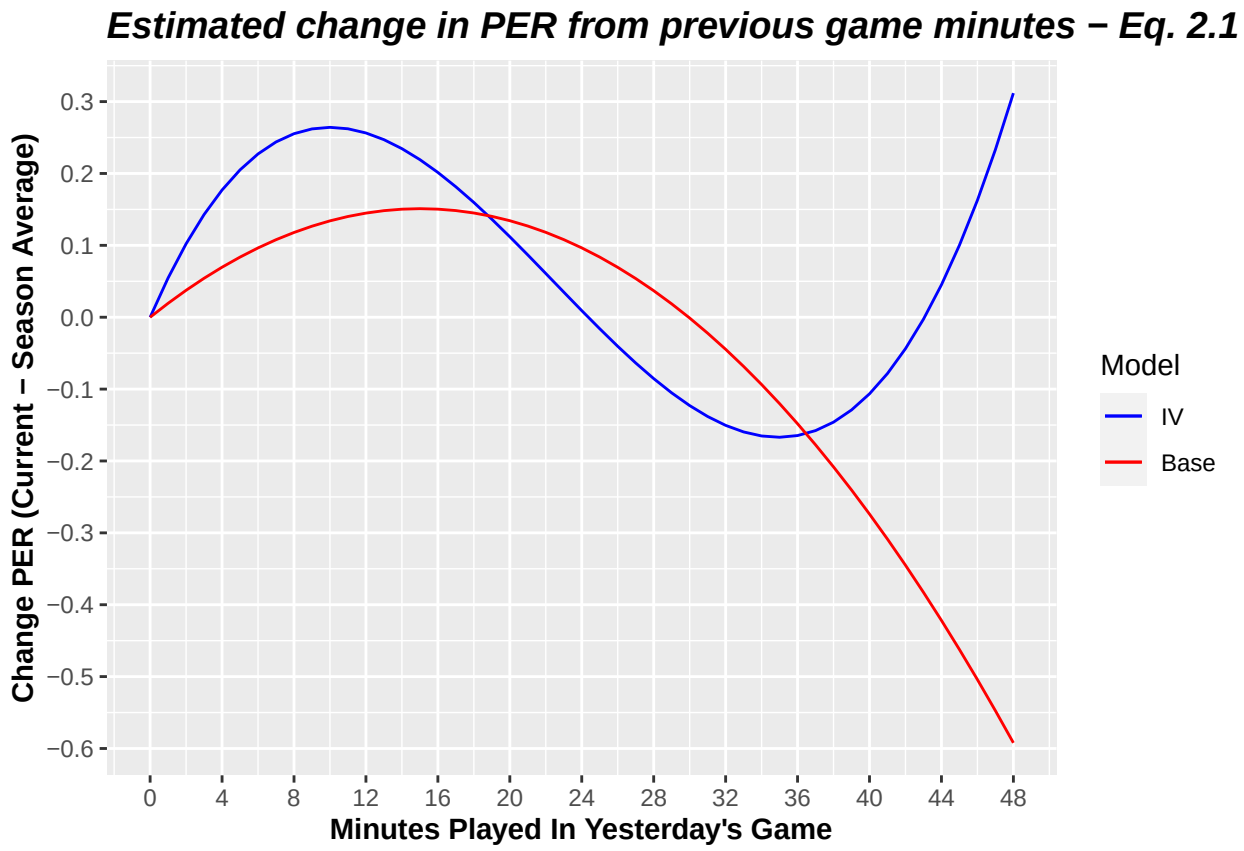
```
##
## Call:
## AER::ivreg(formula = PER_diff ~ H + TRAVEL + OO + OD + M1 + M1_sq +
##     M1_cu | H + TRAVEL + OO + OD + iv.1 + iv.2 + iv.3, data = df_final)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -30.5815  -4.6523  -0.3199   4.3263  44.2724
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -1.306e+01  9.059e-01 -14.420  < 2e-16 ***
## H            6.798e-01  4.735e-02  14.358  < 2e-16 ***
## TRAVEL       2.501e-02  5.522e-02   0.453    0.651
## OO          -3.760e-02  5.539e-03  -6.789 1.13e-11 ***
## OD           1.557e-01  5.957e-03  26.132  < 2e-16 ***
## M1           5.837e-02  9.497e-02   0.615    0.539
## M1_sq       -3.751e-03  5.965e-03  -0.629    0.529
## M1_cu        5.564e-05  9.041e-05   0.615    0.538
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 6.821 on 124631 degrees of freedom
## Multiple R-Squared: 0.00836, Adjusted R-squared: 0.008305
## Wald test: 150.8 on 7 and 124631 DF,  p-value: < 2.2e-16
```

```
base.iv$coefficients[6:8]
```

```
##            M1         M1_sq         M1_cu
##  5.836784e-02 -3.751393e-03  5.563987e-05
```

```
y.iv <- base.iv$coefficients[6]*x + base.iv$coefficients[7]*x^2 +  base.iv$coefficients[8]*x^3

ggplot() + geom_line( aes( x= x, y = y.iv, color="blue")) + geom_line( aes( x= x, y = y.no.lock, color=
  scale_x_continuous(breaks = seq(0,48,4)) +
  coord_cartesian(xlim=c(0,48)) +
  scale_y_continuous(breaks = seq(-1,1,.1)) +
  xlab("Minutes Played In Yesterday's Game") +
  ylab("Change PER (Current - Season Average)") +
  ggtitle("Estimated change in PER from previous game minutes - Eq. 2.1") +
  theme(
```

```
    plot.title = element_text(size=14, face="bold.italic"),
    axis.title.x = element_text(size=11, face="bold"),
    axis.title.y = element_text(size=11, face="bold")
  )+scale_color_manual(labels = c("IV", "Base"), values=c("blue","red"))+guides(color=guide_legend(titl
```



IV - 1st Stage

```
iv.1.lm <- df_final %>% lm(M1 ~ iv.1, data = .)
iv.2.lm <- df_final %>% lm(M1_sq ~ iv.2, data = .)
iv.3.lm <- df_final %>% lm(M1_cu ~ iv.3, data = .)
```

```
stargazer(base.lm,
        type = 'latex',
        digits = 6,
        digits.extra = 2)
```

% Table created by stargazer v.5.2.3 by Marek Hlavac, Social Policy Institute. E-mail: marek.hlavac at gmail.com % Date and time: Sun, May 29, 2022 - 9:18:34 PM

Table 1:

	Dependent variable:
	PER_diff
H	0.678596***
	(0.045894)
TRAVEL	0.010159
	(0.053238)
OO	−0.042201***
	(0.005301)
OD	0.150160***
	(0.005652)
M1	0.018799
	(0.025044)
M1_sq	−0.000621
	(0.001479)
M1_cu	−0.0000004
	(0.000022)
Constant	−11.944240***
	(0.848328)
Observations	131,812
R^2	0.008427
Adjusted R^2	0.008375
Residual Std. Error	6.820279 (df = 131804)
F Statistic	160.026600*** (df = 7; 131804)
Note:	*p<0.1; **p<0.05; ***p<0.01

```
stargazer(base.lm, without_lockout_lm,
        type = 'latex',
         digits = 6,
        digits.extra = 2,
        notes = "(1) Includes 11-12 NBA Season. (2) Omits 11-12 NBA Season")
```

% Table created by stargazer v.5.2.3 by Marek Hlavac, Social Policy Institute. E-mail: marek.hlavac at gmail.com % Date and time: Sun, May 29, 2022 - 9:18:34 PM

Table 2:

	Dependent variable:	
	PER_diff	
	(1)	(2)
H	0.678596***	0.680459***
	(0.045894)	(0.047193)
TRAVEL	0.010159	0.026445
	(0.053238)	(0.054776)
OO	−0.042201***	−0.037613***
	(0.005301)	(0.005538)
OD	0.150160***	0.155785***
	(0.005652)	(0.005956)
M1	0.018799	0.020042
	(0.025044)	(0.025898)
M1_sq	−0.000621	−0.000661
	(0.001479)	(0.001528)
M1_cu	−0.0000004	−0.0000003
	(0.000022)	(0.000022)
Constant	−11.944240***	−13.076650***
	(0.848328)	(0.905770)
Observations	131,812	124,639
R^2	0.008427	0.008505
Adjusted R^2	0.008375	0.008450
Residual Std. Error	6.820279 (df = 131804)	6.820832 (df = 124631)
F Statistic	160.026600*** (df = 7; 131804)	152.729800*** (df = 7; 124631)

Note: *p<0.1; **p<0.05; ***p<0.01
(1) Includes 11-12 NBA Season. (2) Omits 11-12 NBA Season

```
stargazer(without_lockout_lm, M1.M2.complete,
        type = 'latex',
          digits = 6,
        digits.extra = 2,
        notes = "(1) Base Regression (2) All the things")
```

% Table created by stargazer v.5.2.3 by Marek Hlavac, Social Policy Institute. E-mail: marek.hlavac at gmail.com % Date and time: Sun, May 29, 2022 - 9:18:34 PM

```
stargazer(iv.1.lm, iv.2.lm, iv.3.lm,
        type = 'latex',
        title = "IV - 1st Stage ",
         digits = 6,
        digits.extra = 2,
        notes = "(1) M1 on Team Played * Avg Min (2) M1 squared (3) M1 cubed ")
```

% Table created by stargazer v.5.2.3 by Marek Hlavac, Social Policy Institute. E-mail: marek.hlavac at gmail.com % Date and time: Sun, May 29, 2022 - 9:18:34 PM

```
stargazer(v1.Q1.test, type='text')
```

```
##
## ================================================
##                            Dependent variable:
##                        ---------------------------
##                                  PER_diff
## ------------------------------------------------
## H                                0.689***
##                                   (0.047)
##
## TRAVEL                            0.044
##                                   (0.055)
##
## OO                               -0.037***
##                                   (0.006)
##
## OD                               0.156***
##                                   (0.006)
##
## M1                                0.051
##                                   (0.055)
##
## M1_sq                             -0.003
##                                   (0.003)
##
## M1_cu                             0.00003
##                                  (0.00005)
##
## `Season Stage_Q1`                -0.492***
##                                   (0.063)
##
## `Season Stage_Q2`                -0.240***
```

Table 3:

	Dependent variable:	
	PER_diff	
	(1)	(2)
H	0.680459***	0.688110***
	(0.047193)	(0.047267)
TRAVEL	0.026445	0.037168
	(0.054776)	(0.054907)
OO	−0.037613***	−0.037427***
	(0.005538)	(0.005538)
OD	0.155785***	0.155759***
	(0.005956)	(0.005956)
M1	0.020042	0.028182
	(0.025898)	(0.026122)
M1_sq	−0.000661	−0.000932
	(0.001528)	(0.001533)
M1_cu	−0.0000003	0.000003
	(0.000022)	(0.000022)
M2		0.000450
		(0.017003)
M2_sq		−0.000067
		(0.000985)
M2_cu		0.000005
		(0.000014)
Constant	−13.076650***	−13.182870***
	(0.905770)	(0.906468)
Observations	124,639	124,639
R^2	0.008505	0.008610
Adjusted R^2	0.008450	0.008530
Residual Std. Error	6.820832 (df = 124631)	6.820554 (df = 124628)
F Statistic	152.729800*** (df = 7; 124631)	108.233000*** (df = 10; 124628)
Note:		*p<0.1; **p<0.05; ***p<0.01
		(1) Base Regression (2) All the things

Table 4: IV - 1st Stage

	Dependent variable:		
	M1	M1_sq	M1_cu
	(1)	(2)	(3)
iv.1	0.993812***		
	(0.000748)		
iv.2		1.026763***	
		(0.001214)	
iv.3			1.073824***
			(0.001727)
Constant	0.026095**	3.764133***	287.655600***
	(0.011030)	(0.586900)	(28.180770)
Observations	124,639	124,639	124,639
R^2	0.934109	0.851546	0.756307
Adjusted R^2	0.934109	0.851545	0.756305
Residual Std. Error (df = 124637)	3.452479	185.003400	8,967.009000
F Statistic (df = 1; 124637)	1,766,927.000000***	714,931.100000***	386,814.200000***

Note: *p<0.1; **p<0.05; ***p<0.01
(1) M1 on Team Played * Avg Min (2) M1 squared (3) M1 cubed

```
##                                (0.062)
##
## `Season Stage_Q3`             -0.069
##                                (0.062)
##
## `Season Stage_Q4`
##
##
## M1:`Season Stage_Q1`           0.063
##                                (0.075)
##
## M1_sq:`Season Stage_Q1`       -0.003
##                                (0.004)
##
## M1_cu:`Season Stage_Q1`       0.00003
##                               (0.0001)
##
## M1:`Season Stage_Q2`          -0.103
##                                (0.073)
##
## M1_sq:`Season Stage_Q2`        0.006
##                                (0.004)
##
## M1_cu:`Season Stage_Q2`       -0.0001
##                               (0.0001)
##
```

```
## M1:‘Season Stage_Q3‘              -0.080
##                                   (0.078)
##
## M1_sq:‘Season Stage_Q3‘            0.005
##                                   (0.005)
##
## M1_cu:‘Season Stage_Q3‘           -0.0001
##                                  (0.0001)
##
## M1:‘Season Stage_Q4‘
##
##
## M1_sq:‘Season Stage_Q4‘
##
##
## M1_cu:‘Season Stage_Q4‘
##
##
## Constant                        -12.976***
##                                   (0.906)
##
## ------------------------------------------------
## Observations                      124,639
## R2                                 0.009
## Adjusted R2                        0.009
## Residual Std. Error          6.819 (df = 124619)
## F Statistic              61.016*** (df = 19; 124619)
## ================================================
## Note:                    *p<0.1; **p<0.05; ***p<0.01
```

```
stargazer(v1.Q1.lm,v1.Q2.lm,v1.Q3.lm,v1.Q4.lm,
        type = 'text',
        title = "OLS on Quarter of the Seasons - 2",
         digits = 6,
        digits.extra = 2)
```

```
##
## OLS on Quarter of the Seasons - 2
## ================================================================================================
##                                                  Dependent variable:
##                                  ------------------------------------------------------------
##                                                       PER_diff
##                                      (1)           (2)           (3)           (4)
## ------------------------------------------------------------------------------------------------
## H                                 0.689303***   0.680616***   0.682371***   0.681071***
##                                   (0.047195)    (0.047199)    (0.047196)    (0.047189)
##
## TRAVEL                             0.043915      0.026047      0.031015      0.028147
##                                   (0.054807)    (0.054780)    (0.054789)    (0.054772)
##
## OO                                -0.037439***  -0.037599***  -0.037583***  -0.037662***
##                                   (0.005537)    (0.005538)    (0.005538)    (0.005538)
##
## OD                                0.156226***   0.155849***   0.155918***   0.156051***
```

```
##                                (0.005955)    (0.005956)    (0.005956)    (0.005956)
##
## M1                              -0.014169     0.048730      0.035003      0.011490
##                                (0.030100)    (0.030889)    (0.029351)    (0.029372)
##
## M1_sq                           0.001165     -0.002345     -0.001478     -0.000049
##                                (0.001771)    (0.001836)    (0.001729)    (0.001732)
##
## M1_cu                           -0.000024     0.000023      0.000011     -0.000010
##                                (0.000026)    (0.000027)    (0.000025)    (0.000025)
##
## `Season Stage_Q1`             -0.384862***
##                                (0.050245)
##
## M1:`Season Stage_Q1`           0.128451**
##                                (0.059119)
##
## M1_sq:`Season Stage_Q1`        -0.006796*
##                                (0.003518)
##
## M1_cu:`Season Stage_Q1`         0.000089*
##                                (0.000052)
##
## `Season Stage_Q2`                            -0.048766
##                                             (0.049541)
##
## M1:`Season Stage_Q2`                        -0.101202*
##                                             (0.057075)
##
## M1_sq:`Season Stage_Q2`                      0.005873*
##                                             (0.003338)
##
## M1_cu:`Season Stage_Q2`                     -0.000080*
##                                             (0.000048)
##
## `Season Stage_Q3`                                        0.179886***
##                                                         (0.050240)
##
## M1:`Season Stage_Q3`                                     -0.064486
##                                                         (0.062364)
##
## M1_sq:`Season Stage_Q3`                                   0.003552
##                                                         (0.003697)
##
## M1_cu:`Season Stage_Q3`                                  -0.000049
##                                                         (0.000054)
##
## `Season Stage_Q4`                                                     0.266412***
##                                                                      (0.051375)
##
## M1:`Season Stage_Q4`                                                  0.039363
##                                                                      (0.062165)
##
## M1_sq:`Season Stage_Q4`                                              -0.002778
```

```
##                                                                                (0.003678)
##
## M1_cu:‘Season Stage_Q4‘                                                         0.000043
##                                                                                (0.000054)
##
## Constant                                -13.063200*** -13.072040*** -13.143580*** -13.164200***
##                                          (0.905560)    (0.905852)    (0.905938)    (0.905825)
##
## ------------------------------------------------------------------------------------------
## Observations                               124,639       124,639       124,639       124,639
## R2                                        0.009059      0.008544      0.008622      0.008743
## Adjusted R2                               0.008972      0.008456      0.008534      0.008656
## Residual Std. Error (df = 124627)         6.819035      6.820809      6.820541      6.820122
## F Statistic (df = 11; 124627)          103.577400*** 97.632630***  98.528770***  99.932600***
## ==========================================================================================
## Note:                                                        *p<0.1; **p<0.05; ***p<0.01
```

```
stargazer(v2.Q1.lm,v2.Q2.lm,v2.Q3.lm,v2.Q4.lm,
        type = 'text',
        title = "OLS on Quarter of the Seasons - 2",
         digits = 6,
        digits.extra = 2
          )
```

```
##
## OLS on Quarter of the Seasons - 2
## ==========================================================================================
##                                                  Dependent variable:
##                                     ---------------------------------------------------
##                                                        PER_diff
##                                         (1)           (2)           (3)           (4)
## ------------------------------------------------------------------------------------------
## H                                    0.694298***   0.688125***   0.689010***   0.687077***
##                                      (0.047277)    (0.047273)    (0.047271)    (0.047272)
##
## TRAVEL                               0.051964      0.037334      0.040236      0.037362
##                                      (0.054943)    (0.054914)    (0.054921)    (0.054908)
##
## OO                                  -0.037355***  -0.037450***  -0.037467***  -0.037521***
##                                      (0.005537)    (0.005538)    (0.005538)    (0.005538)
##
## OD                                   0.156146***   0.155741***   0.155905***   0.156008***
##                                      (0.005955)    (0.005956)    (0.005956)    (0.005956)
##
## M1                                   -0.005960     0.060154*     0.042548      0.016467
##                                      (0.030364)    (0.031149)    (0.029612)    (0.029615)
##
## M1_sq                                0.000894      -0.002728     -0.001728     -0.000216
##                                      (0.001775)    (0.001840)    (0.001734)    (0.001737)
##
## M1_cu                                -0.000022     0.000027      0.000014      -0.000008
##                                      (0.000026)    (0.000027)    (0.000025)    (0.000025)
##
## M2                                   -0.016279     0.015987      0.002571      0.000017
```

```
##                                  (0.019482)    (0.020148)    (0.019414)    (0.019525)
##
## M2_sq                             0.000794      -0.000937     -0.000015     -0.000157
##                                  (0.001124)    (0.001174)    (0.001123)    (0.001131)
##
## M2_cu                            -0.000006      0.000017      0.000001      0.000006
##                                  (0.000016)    (0.000017)    (0.000016)    (0.000016)
##
## `Season Stage_Q1`               -0.341231***
##                                  (0.087401)
##
## M1:`Season Stage_Q1`             0.124066**
##                                  (0.059588)
##
## M1_sq:`Season Stage_Q1`          -0.006657*
##                                  (0.003526)
##
## M1_cu:`Season Stage_Q1`           0.000087*
##                                  (0.000052)
##
## M2:`Season Stage_Q1`              0.059586
##                                  (0.039972)
##
## M2_sq:`Season Stage_Q1`          -0.003061
##                                  (0.002336)
##
## M2_cu:`Season Stage_Q1`           0.000035
##                                  (0.000034)
##
## `Season Stage_Q2`                                0.065393
##                                                 (0.088683)
##
## M1:`Season Stage_Q2`                            -0.113178**
##                                                 (0.057563)
##
## M1_sq:`Season Stage_Q2`                          0.006270*
##                                                 (0.003347)
##
## M1_cu:`Season Stage_Q2`                         -0.000085*
##                                                 (0.000048)
##
## M2:`Season Stage_Q2`                            -0.051863
##                                                 (0.037729)
##
## M2_sq:`Season Stage_Q2`                          0.002824
##                                                 (0.002167)
##
## M2_cu:`Season Stage_Q2`                         -0.000041
##                                                 (0.000031)
##
## `Season Stage_Q3`                                                 0.158043*
##                                                                  (0.090401)
##
## M1:`Season Stage_Q3`                                             -0.062080
```

```
##                                                                                  (0.062845)
##
## M1_sq:‘Season Stage_Q3‘                                                           0.003468
##                                                                                  (0.003706)
##
## M1_cu:‘Season Stage_Q3‘                                                           -0.000048
##                                                                                  (0.000054)
##
## M2:‘Season Stage_Q3‘                                                              -0.002804
##                                                                                  (0.040233)
##
## M2_sq:‘Season Stage_Q3‘                                                           -0.000564
##                                                                                  (0.002340)
##
## M2_cu:‘Season Stage_Q3‘                                                           0.000019
##                                                                                  (0.000034)
##
## ‘Season Stage_Q4‘                                                                                  0.160529*
##                                                                                                   (0.097562)
##
## M1:‘Season Stage_Q4‘                                                                               0.050411
##                                                                                                   (0.062758)
##
## M1_sq:‘Season Stage_Q4‘                                                                            -0.003143
##                                                                                                   (0.003689)
##
## M1_cu:‘Season Stage_Q4‘                                                                            0.000047
##                                                                                                   (0.000054)
##
## M2:‘Season Stage_Q4‘                                                                               -0.003167
##                                                                                                   (0.039726)
##
## M2_sq:‘Season Stage_Q4‘                                                                            0.000569
##                                                                                                   (0.002298)
##
## M2_cu:‘Season Stage_Q4‘                                                                            -0.000010
##                                                                                                   (0.000033)
##
## Constant                                -13.151010*** -13.196430*** -13.236860*** -13.231570***
##                                          (0.906500)    (0.906641)    (0.906846)    (0.906831)
##
## ------------------------------------------------------------------------------------------------
## Observations                              124,639       124,639       124,639       124,639
## R2                                       0.009207      0.008681      0.008784      0.008852
## Adjusted R2                              0.009072      0.008545      0.008649      0.008717
## Residual Std. Error (df = 124621)        6.818692      6.820502      6.820147      6.819913
## F Statistic (df = 17; 124621)         68.118840***  64.192280***  64.961090***  65.470400***
## ================================================================================================
## Note:                                                          *p<0.1; **p<0.05; ***p<0.01
```

Comparing 1 and 2 days back

```
M1.M2.complete$coefficients
```

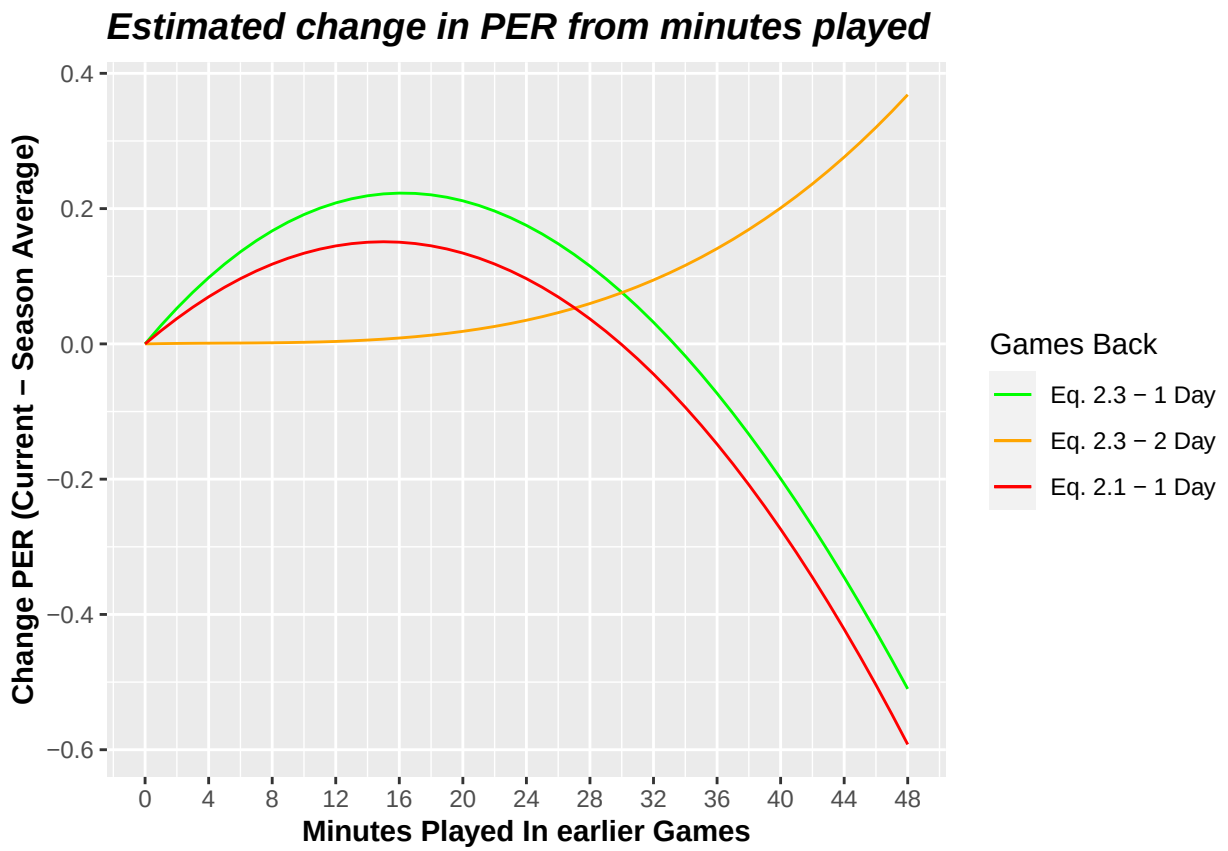
```
##   (Intercept)             H        TRAVEL            OO            OD
## -1.318287e+01  6.881103e-01  3.716794e-02 -3.742725e-02  1.557594e-01
##            M1         M1_sq         M1_cu            M2         M2_sq
##  2.818157e-02 -9.315299e-04  2.563579e-06  4.498154e-04 -6.664888e-05
##         M2_cu
##  4.524348e-06
```

```
M1.M2.complete$coefficients[11]
```

```
##        M2_cu
## 4.524348e-06
```

```
y.M1.M2.1d <- x*M1.M2.complete$coefficients[6] + x^2*M1.M2.complete$coefficients[7] + x^3*M1.M2.complet
y.M1.M2.2d <- x*M1.M2.complete$coefficients[9] + x^2*M1.M2.complete$coefficients[10] + x^3*M1.M2.comple
```

```
ggplot() +
  geom_line( aes( x= x, y = y.M1.M2.1d, color="green")) +
  geom_line( aes( x= x, y = y.M1.M2.2d, color="orange"))  +
  geom_line( aes( x= x, y = y.no.lock, color="red"))  +
  scale_x_continuous(breaks = seq(0,48,4)) +
  coord_cartesian(xlim=c(0,48)) +
  xlab("Minutes Played In earlier Games") +
  ylab("Change PER (Current - Season Average)") +
  ggtitle("Estimated change in PER from minutes played") +
  theme(
    plot.title = element_text(size=14, face="bold.italic"),
    axis.title.x = element_text(size=11, face="bold"),
    axis.title.y = element_text(size=11, face="bold")
  )+scale_color_manual(labels = c("Eq. 2.3 - 1 Day", "Eq. 2.3 - 2 Day","Eq. 2.1 - 1 Day"), values=c("gr
```




```
# plot(x, y.M1.M2.2d)
```

Quarter of the Season

```
v1.Q1.lm$coefficients[6:8]
```

```
##            M1         M1_sq         M1_cu
## -1.416874e-02  1.164963e-03 -2.440498e-05
```

```
v1.Q2.lm$coefficients[6:8]
```

```
##            M1         M1_sq         M1_cu
##  4.872987e-02 -2.345140e-03  2.312817e-05
```

```
v1.Q3.lm$coefficients[6:8]
```

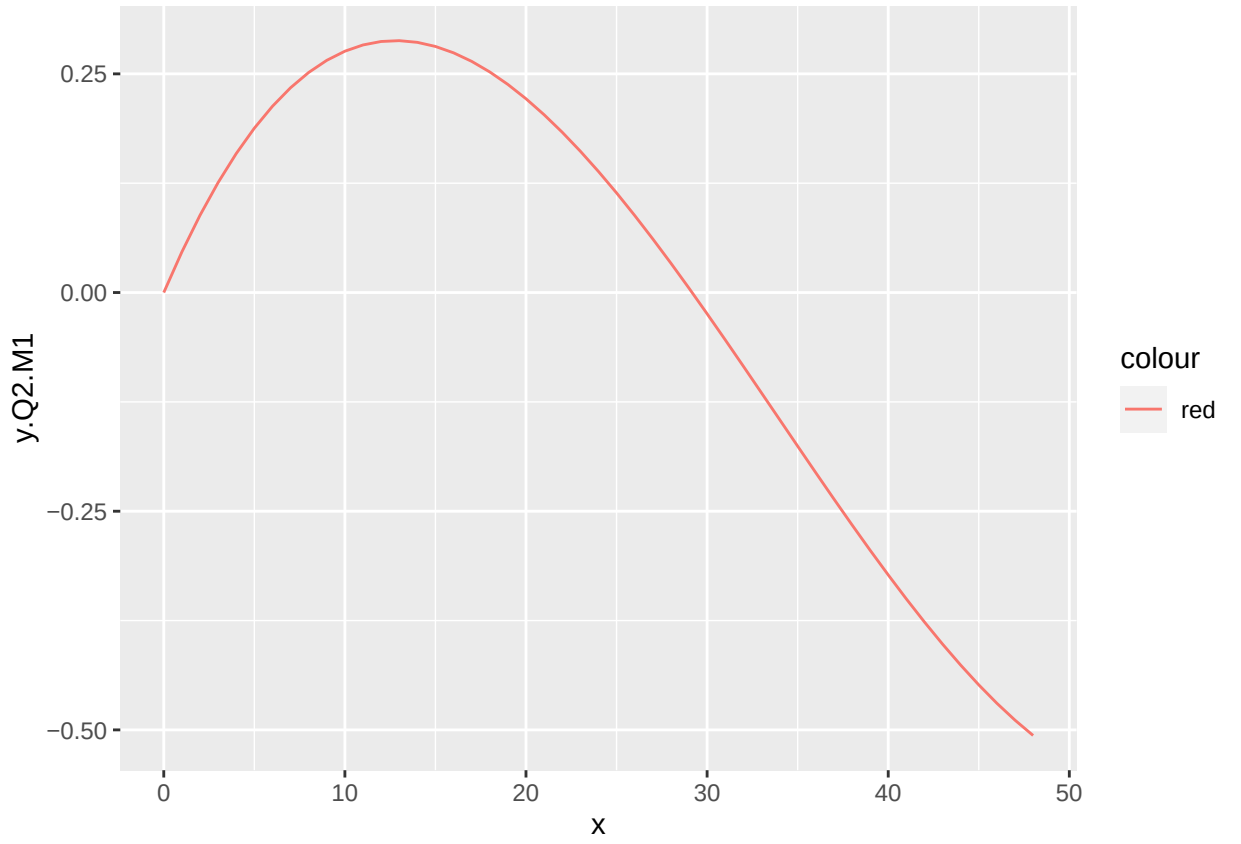
```
##            M1         M1_sq         M1_cu
##  3.500290e-02 -1.477988e-03  1.091602e-05
```

```
v1.Q4.lm$coefficients[6:8]
```

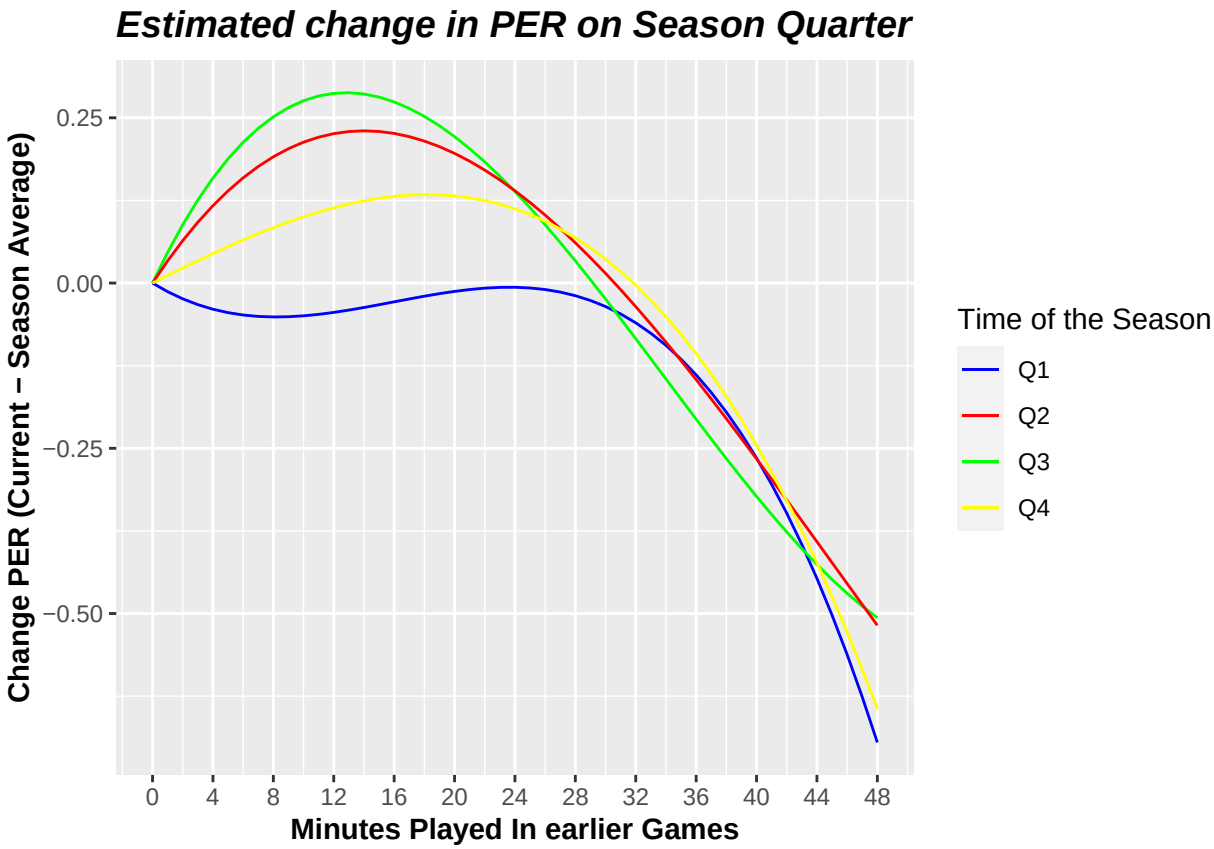
```
##            M1         M1_sq         M1_cu
##  1.148983e-02 -4.901703e-05 -9.789749e-06
```

```
y.Q1.M1<- x*v1.Q1.lm$coefficients[6] + x^2*v1.Q1.lm$coefficients[7] + x^3*v1.Q1.lm$coefficients[8]
y.Q2.M1<- x*v1.Q2.lm$coefficients[6] + x^2*v1.Q2.lm$coefficients[7] + x^3*v1.Q2.lm$coefficients[8]
y.Q3.M1<- x*v1.Q3.lm$coefficients[6] + x^2*v1.Q3.lm$coefficients[7] + x^3*v1.Q3.lm$coefficients[8]
y.Q4.M1<- x*v1.Q4.lm$coefficients[6] + x^2*v1.Q4.lm$coefficients[7] + x^3*v1.Q4.lm$coefficients[8]
```

```
ggplot()+geom_line( aes( x= x, y = y.Q2.M1, color="red"))
```




```
ggplot() +
  geom_line( aes( x= x, y = y.Q1.M1, color="blue")) +
  geom_line( aes( x= x, y = y.Q2.M1, color="red")) +
  geom_line( aes( x= x, y = y.Q3.M1, color="green")) +
  geom_line( aes( x= x, y = y.Q4.M1, color="yellow")) +
  scale_x_continuous(breaks = seq(0,48,4)) +
  coord_cartesian(xlim=c(0,48)) +
  xlab("Minutes Played In earlier Games") +
  ylab("Change PER (Current - Season Average)") +
  ggtitle("Estimated change in PER on Season Quarter") +
  theme(
    plot.title = element_text(size=14, face="bold.italic"),
    axis.title.x = element_text(size=11, face="bold"),
    axis.title.y = element_text(size=11, face="bold")
  )+scale_color_manual(labels = c("Q1", "Q2", "Q3", "Q4"), values=c("blue","red","green","yellow"))+gui
```


Estimated change in PER on Season Quarter
Change PER (Current – Season Average)
0.25
0.00
−0.25
−0.50
0
4
8
12
16
20
24
28
32
36
40
44
48
Minutes Played In earlier Games
Time of the Season
Q1
Q2
Q3
Q4