Regression
Final

Kevin Zollicoffer

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Introduction

Regression final assignment using R

The complete source for this assigment is available on Github:

`https://github.com/zollie/PASS`

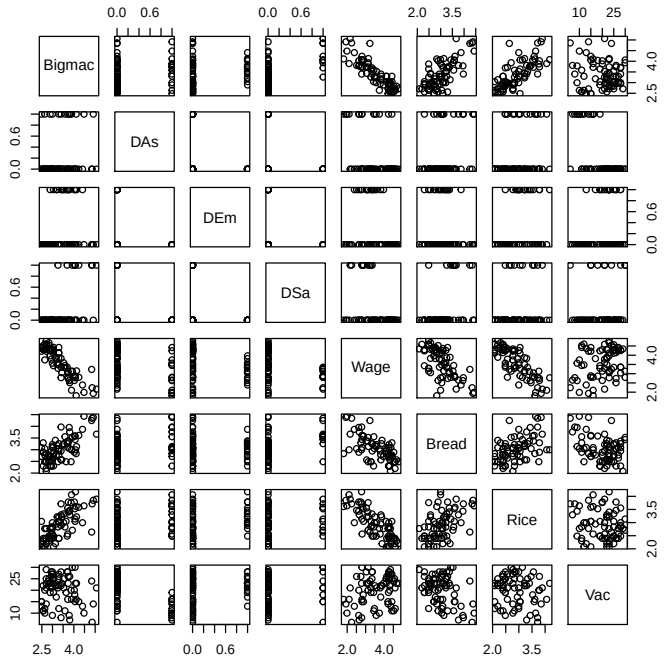
Problem 5.5

```
> ubs <- read.csv("~/R/PASS/Regression/RegressionFinal/ubs.csv")
> ubs$Region = factor(ubs$Region)
> head(ubs)
```

```
       City Region DAs DEm DSa Bigmac  Wage Bread  Rice Vac
1 Amsterdam NaWeOc   0   0   0  2.944 4.263 2.303 2.398  26
2    Athens NaWeOc   0   0   0  3.401 3.829 2.565 3.296  22
3  Auckland NaWeOc   0   0   0  2.944 3.786 2.944 2.565  21
4   Bangkok   Asia   1   0   0  3.807 2.653 3.761 3.296   7
5 Barcelona NaWeOc   0   0   0  3.045 4.119 2.833 2.079  23
6   Beijing   Asia   1   0   0  3.784 2.625 3.951 3.434   9
```

a

```
> pairs(cbind(ubs$Bigmac,
+             ubs$DAs, ubs$DEm, ubs$DSa,
+             ubs$Wage, ubs$Bread,
+             ubs$Rice, ubs$Vac),
+       labels=cbind("Bigmac",
+                    "DAs", "DEm", "DSa",
+                    "Wage", "Bread",
+                    "Rice", "Vac"))
```



There seems to be clear linear relationships with Wage and Bigmac (negative), Bread and Bigmac, and Rice and Bigmac. The predictive power for Vac of Bigmac is less clear.

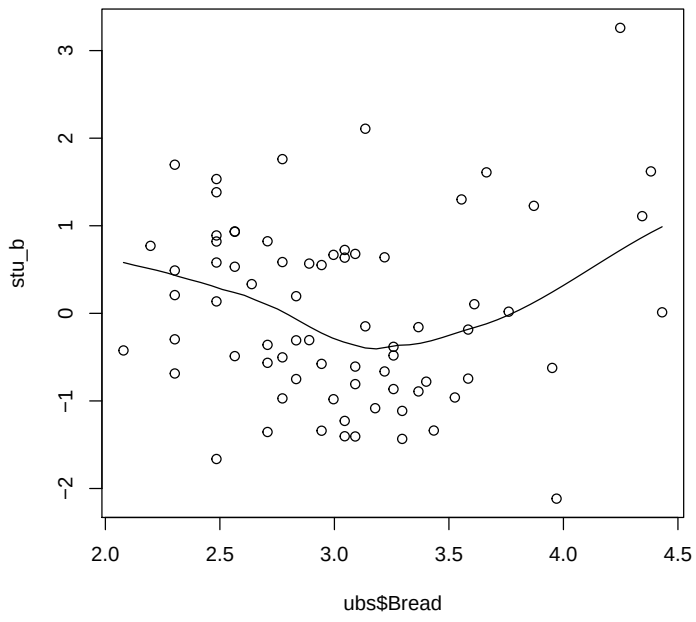
There seems to be some correlation between Wage and Bread, and Wage and Rice.

b

```
> model_b <- lm(Bigmac ~ DAs+DEm+DSa+Wage+Bread+Rice+Vac, data=ubs)
> stu_b <- rstudent(model_b)
> summary(model_b)

Call:
lm(formula = Bigmac ~ DAs + DEm + DSa + Wage + Bread + Rice +
    Vac, data = ubs)

Residuals:
     Min       1Q   Median       3Q      Max
-0.44853 -0.16851 -0.03561  0.14513  0.63157

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
```

```
(Intercept)  3.929449   0.631421   6.223 3.99e-08 ***
DAs         -0.207525   0.114411  -1.814   0.0743 .
DEm         -0.104153   0.094352  -1.104   0.2737
DSa          0.181246   0.118389   1.531   0.1306
Wage        -0.576032   0.084254  -6.837 3.37e-09 ***
Bread        0.309707   0.074294   4.169 9.25e-05 ***
Rice         0.102046   0.088928   1.148   0.2554
Vac          0.015415   0.005814   2.651   0.0101 *
---
Signif. codes:  0 âĂŸ***âĂŹ 0.001 âĂŸ**âĂŹ 0.01 âĂŸ*âĂŹ 0.05 âĂŸ.âĂŹ 0.1 âĂŸ âĂŹ 1

Residual standard error: 0.2331 on 65 degrees of freedom
Multiple R-squared:  0.8807,        Adjusted R-squared:  0.8678
F-statistic: 68.54 on 7 and 65 DF,  p-value: < 2.2e-16
```

```
> plot(ubs$Bread, stu_b)

> scatter.smooth(ubs$Bread, stu_b, span=.75)
```



The zero mean assumption can be tested with a loess line as above.

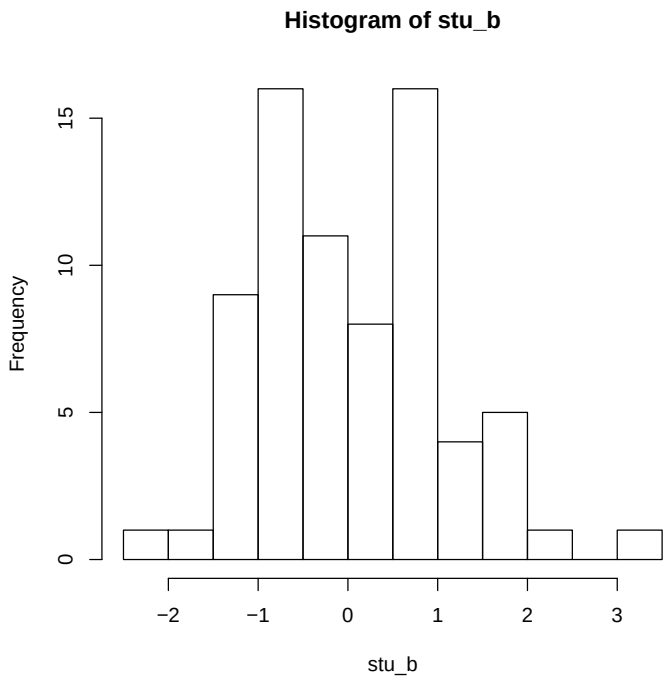
The constant variance assumption can be checked by ensuring the studentized

residuals are distributed evenly about the mean. That is, they have a mean of 0 and a standard deviation of 1.

The independence assumption can be checked with a quick glance at a residual scatter plot to ensure there are no non-random patterns.

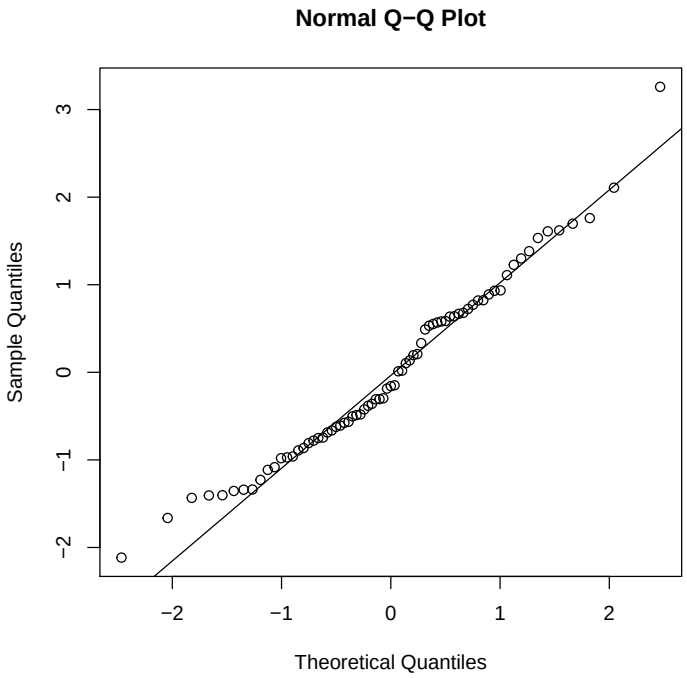
The normailty assumption can be checked with histograms and QQ plots as below.

```
> hist(stu_b)
```



To check the constant vriance assumption we can use a histogram ...

```
> qqnorm(stu_b)
> qqline(stu_b)
```



c

```
> DasWage <- ubs$DAs*ubs$Wage
> DasBread <- ubs$DAs*ubs$Bread
> DasRice <- ubs$DAs*ubs$Rice
> DasVac <- ubs$DAs*ubs$Vac
> DemWage <- ubs$DEm*ubs$Wage
> DemBread <- ubs$DEm*ubs$Bread
> DemRice <- ubs$DEm*ubs$Rice
> DemVac <- ubs$DEm*ubs$Vac
> DsaWage <- ubs$DSa*ubs$Wage
> DsaBread <- ubs$DSa*ubs$Bread
> DsaRice <- ubs$DSa*ubs$Rice
> DsaVac <- ubs$DSa*ubs$Vac
```

```
> model_c <- lm(Bigmac ~ DAs+DEm+DSa+Wage+Bread+Rice
+               +Vac+DasWage+DasBread+DasRice+DasVac
+               +DemWage+DemBread+DemRice+DemVac+DsaWage
+               +DsaBread+DsaRice+DsaVac, data=ubs)
> summary(model_c)

Call:
lm(formula = Bigmac ~ DAs + DEm + DSa + Wage + Bread + Rice +
```

```
    Vac + DasWage + DasBread + DasRice + DasVac + DemWage + DemBread +
    DemRice + DemVac + DsaWage + DsaBread + DsaRice + DsaVac,
    data = ubs)

Residuals:
     Min       1Q   Median       3Q      Max
-0.32656 -0.12469 -0.01427  0.10780  0.49710

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.683085   0.996793   3.695 0.000522 ***
DAs         -0.738972   1.459567  -0.506 0.614749
DEm          0.555744   1.383537   0.402 0.689532
DSa         -0.984978   2.907659  -0.339 0.736134
Wage        -0.478023   0.154255  -3.099 0.003106 **
Bread        0.082348   0.107430   0.767 0.446765
Rice         0.221956   0.122558   1.811 0.075804 .
Vac          0.022065   0.007127   3.096 0.003131 **
DasWage     -0.103942   0.188635  -0.551 0.583933
DasBread     0.567501   0.183594   3.091 0.003176 **
DasRice     -0.463639   0.202251  -2.292 0.025882 *
DasVac       0.054241   0.021818   2.486 0.016104 *
DemWage     -0.051375   0.214087  -0.240 0.811278
DemBread     0.208266   0.175752   1.185 0.241303
DemRice     -0.011267   0.203540  -0.055 0.956064
DemVac      -0.045066   0.015387  -2.929 0.005005 **
DsaWage     -0.130008   0.460941  -0.282 0.779005
DsaBread     0.690651   0.189595   3.643 0.000614 ***
DsaRice     -0.160711   0.384538  -0.418 0.677684
DsaVac      -0.007723   0.013443  -0.575 0.568045
---
Signif. codes:  0 âĂŸ***âĂŹ 0.001 âĂŸ**âĂŹ 0.01 âĂŸ*âĂŹ 0.05 âĂŸ.âĂŹ 0.1 âĂŸ âĂŹ 1

Residual standard error: 0.1903 on 53 degrees of freedom
Multiple R-squared:  0.9351,        Adjusted R-squared:  0.9119
F-statistic: 40.21 on 19 and 53 DF,  p-value: < 2.2e-16
```

The 3 interactions with largest p-value are ...

1. DemWage
2. DemRice
3. DsaWage

d

```
> model_d <- lm(Bigmac ~ DAs+DEm+DSa+Wage+Bread+Rice+Vac+DasWage+DasBread+DasRice+DasVac+Dem
> summary(model_d)

Call:
lm(formula = Bigmac ~ DAs + DEm + DSa + Wage + Bread + Rice +
    Vac + DasWage + DasBread + DasRice + DasVac + DemBread +
    DemVac + DsaBread + DsaRice + DsaVac, data = ubs)

Residuals:
     Min       1Q   Median       3Q      Max
-0.32589 -0.12401 -0.01427  0.10882  0.49611

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.873477   0.707313   5.476 1.06e-06 ***
DAs         -0.929363   1.256451  -0.740  0.46259
DEm          0.282447   0.565201   0.500  0.61922
DSa         -1.752632   0.898657  -1.950  0.05615 .
Wage        -0.511492   0.100893  -5.070 4.66e-06 ***
Bread        0.075781   0.102562   0.739  0.46306
Rice         0.209768   0.092579   2.266  0.02735 *
Vac          0.022123   0.006832   3.238  0.00203 **
DasWage     -0.070473   0.146160  -0.482  0.63157
DasBread     0.574068   0.177613   3.232  0.00206 **
DasRice     -0.451451   0.182008  -2.480  0.01616 *
DasVac       0.054183   0.021215   2.554  0.01340 *
DemBread     0.224488   0.158454   1.417  0.16210
DemVac      -0.045118   0.013701  -3.293  0.00172 **
DsaBread     0.714585   0.166165   4.300 6.89e-05 ***
DsaRice     -0.076633   0.179529  -0.427  0.67112
DsaVac      -0.007269   0.012880  -0.564  0.57475
---
Signif. codes:  0 âĂŸ***âĂŹ 0.001 âĂŸ**âĂŹ 0.01 âĂŸ*âĂŹ 0.05 âĂŸ.âĂŹ 0.1 âĂŸ âĂŹ 1

Residual standard error: 0.1854 on 56 degrees of freedom
Multiple R-squared:  0.935,        Adjusted R-squared:  0.9164
F-statistic: 50.33 on 16 and 56 DF,  p-value: < 2.2e-16

> anova(model_d, model_c)

Analysis of Variance Table

Model 1: Bigmac ~ DAs + DEm + DSa + Wage + Bread + Rice + Vac + DasWage +
    DasBread + DasRice + DasVac + DemBread + DemVac + DsaBread +
    DsaRice + DsaVac
```

```
Model 2: Bigmac ~ DAs + DEm + DSa + Wage + Bread + Rice + Vac + DasWage +
    DasBread + DasRice + DasVac + DemWage + DemBread + DemRice +
    DemVac + DsaWage + DsaBread + DsaRice + DsaVac
  Res.Df    RSS Df Sum of Sq      F Pr(>F)
1     56 1.9243
2     53 1.9198  3 0.0045205 0.0416 0.9886
```

The p-value of .9886 $>$ .05 therefore we cannot reject H_0. We can remove the 3 interactions with the largest p-value as statistically $DemWage = DemRice = DsaWage = 0$

e

```
> model_e <- lm(Bigmac ~ DAs+DEm+DSa+Wage+Bread
+               +Rice+Vac+DasBread+DasRice+DasVac
+               +DemBread+DemVac+DsaBread, data=ubs)
> summary(model_e)

Call:
lm(formula = Bigmac ~ DAs + DEm + DSa + Wage + Bread + Rice +
    Vac + DasBread + DasRice + DasVac + DemBread + DemVac + DsaBread,
    data = ubs)

Residuals:
     Min       1Q   Median       3Q      Max
-0.31559 -0.11941 -0.00559  0.10736  0.49558

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.110961   0.553962   7.421 5.23e-10 ***
DAs         -1.512860   0.632105  -2.393 0.019894 *
DEm          0.212223   0.542260   0.391 0.696935
DSa         -2.219990   0.508840  -4.363 5.23e-05 ***
Wage        -0.541401   0.071295  -7.594 2.67e-10 ***
Bread        0.065805   0.098576   0.668 0.507019
Rice         0.189425   0.073788   2.567 0.012809 *
Vac          0.020716   0.005185   3.995 0.000182 ***
DasBread     0.608153   0.163987   3.709 0.000463 ***
DasRice     -0.394569   0.137903  -2.861 0.005830 **
DasVac       0.057814   0.019994   2.892 0.005358 **
DemBread     0.226347   0.154589   1.464 0.148451
DemVac      -0.042906   0.012967  -3.309 0.001600 **
DsaBread     0.729123   0.153530   4.749 1.35e-05 ***
---
Signif. codes:  0 âĂŸ***âĂŹ 0.001 âĂŸ**âĂŹ 0.01 âĂŸ*âĂŹ 0.05 âĂŸ.âĂŹ 0.1 âĂŸ âĂŹ 1
```

```
Residual standard error: 0.1816 on 59 degrees of freedom
Multiple R-squared:  0.9342,        Adjusted R-squared:  0.9197
F-statistic: 64.47 on 13 and 59 DF,  p-value: < 2.2e-16
```

```
> anova(model_e, model_d)

Analysis of Variance Table

Model 1: Bigmac ~ DAs + DEm + DSa + Wage + Bread + Rice + Vac + DasBread +
    DasRice + DasVac + DemBread + DemVac + DsaBread
Model 2: Bigmac ~ DAs + DEm + DSa + Wage + Bread + Rice + Vac + DasWage +
    DasBread + DasRice + DasVac + DemBread + DemVac + DsaBread +
    DsaRice + DsaVac
  Res.Df    RSS Df Sum of Sq      F Pr(>F)
1     59 1.9464
2     56 1.9243  3  0.022104 0.2144  0.886
```

The p-value of .886 $>$ .05 therefore we cannot reject H_0. We can remove the 3 interactions considered here.

f

```
> model_f <- lm(Bigmac ~ DAs+DEm+DSa+Wage+Bread+Rice+
+                 Vac+DasBread+DasRice+DasVac+DemBread+DemVac+DsaBread, data=ubs)
> summary(model_f)

Call:
lm(formula = Bigmac ~ DAs + DEm + DSa + Wage + Bread + Rice +
    Vac + DasBread + DasRice + DasVac + DemBread + DemVac + DsaBread,
    data = ubs)

Residuals:
     Min       1Q   Median       3Q      Max
-0.31559 -0.11941 -0.00559  0.10736  0.49558

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  4.110961   0.553962   7.421 5.23e-10 ***
DAs         -1.512860   0.632105  -2.393 0.019894 *
DEm          0.212223   0.542260   0.391 0.696935
DSa         -2.219990   0.508840  -4.363 5.23e-05 ***
Wage        -0.541401   0.071295  -7.594 2.67e-10 ***
Bread        0.065805   0.098576   0.668 0.507019
Rice         0.189425   0.073788   2.567 0.012809 *
Vac          0.020716   0.005185   3.995 0.000182 ***
DasBread     0.608153   0.163987   3.709 0.000463 ***
DasRice     -0.394569   0.137903  -2.861 0.005830 **
```

```
DasVac       0.057814   0.019994   2.892 0.005358 **
DemBread     0.226347   0.154589   1.464 0.148451
DemVac      -0.042906   0.012967  -3.309 0.001600 **
DsaBread     0.729123   0.153530   4.749 1.35e-05 ***
---
Signif. codes:  0 âĂŸ***âĂŹ 0.001 âĂŸ**âĂŹ 0.01 âĂŸ*âĂŹ 0.05 âĂŸ.âĂŹ 0.1 âĂŸ âĂŹ 1

Residual standard error: 0.1816 on 59 degrees of freedom
Multiple R-squared:  0.9342,        Adjusted R-squared:  0.9197
F-statistic: 64.47 on 13 and 59 DF,  p-value: < 2.2e-16
```

$H_0 : DemBread = 0$ $H_a : D_{Em} \neq 0$

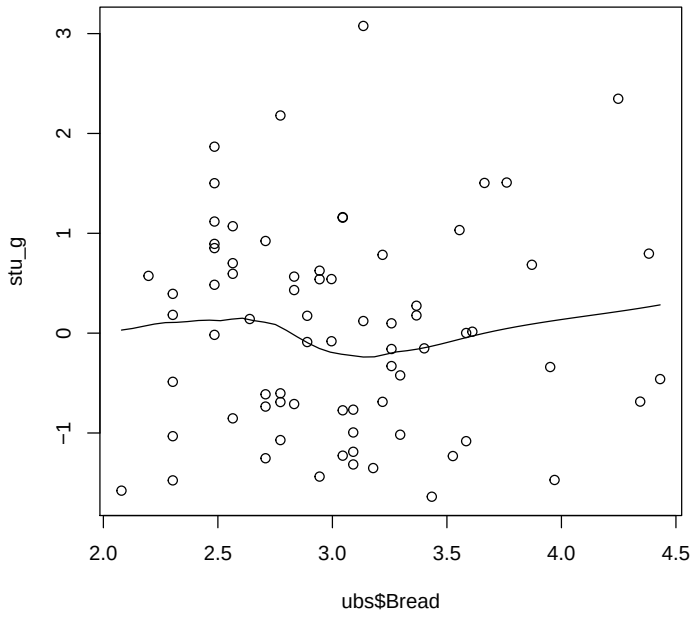
$.1484 > .05$ therefore we do not reject H_0

g

```
> model_g <- lm(Bigmac ~ DAs+DEm+DSa+Wage+Bread+Rice+
+ Vac+DasBread+DasRice+DasVac+DemVac+DsaBread, data=ubs)
> summary(model_g)

Call:
lm(formula = Bigmac ~ DAs + DEm + DSa + Wage + Bread + Rice +
    Vac + DasBread + DasRice + DasVac + DemVac + DsaBread, data = ubs)

Residuals:
     Min       1Q   Median       3Q      Max
-0.27016 -0.12943  0.00022  0.10108  0.51102

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.861757   0.532170   7.257 9.12e-10 ***
DAs         -1.207924   0.602473  -2.005 0.049487 *
DEm          0.876811   0.299504   2.928 0.004821 **
DSa         -1.991641   0.488946  -4.073 0.000138 ***
Wage        -0.547934   0.071831  -7.628 2.11e-10 ***
Bread        0.154348   0.078586   1.964 0.054162 .
Rice         0.195452   0.074372   2.628 0.010889 *
Vac          0.021595   0.005199   4.153 0.000105 ***
DasBread     0.515727   0.152786   3.375 0.001297 **
DasRice     -0.406481   0.138969  -2.925 0.004856 **
DasVac       0.056577   0.020165   2.806 0.006759 **
DemVac      -0.043681   0.013079  -3.340 0.001446 **
DsaBread     0.641239   0.142652   4.495 3.24e-05 ***
---
Signif. codes:  0 âĂŸ***âĂŹ 0.001 âĂŸ**âĂŹ 0.01 âĂŸ*âĂŹ 0.05 âĂŸ.âĂŹ 0.1 âĂŸ âĂŹ 1
```

```
Residual standard error: 0.1834 on 60 degrees of freedom
Multiple R-squared:  0.9318,        Adjusted R-squared:  0.9182
F-statistic: 68.36 on 12 and 60 DF,  p-value: < 2.2e-16
```

```
> stu_g <- rstudent(model_g)
> plot(ubs$Bread, stu_g)

> scatter.smooth(ubs$Bread, stu_g, span=.75)
```



The zero mean regression assumption now appears met.

h

$\hat{Bigmac} = 3.861757 - 1.2709D_{As} + .8768D_{Em} - 1.99.16D_{Sa} - .5479Wage + .15348Bread + .195452Rice + .021595Vac + .515727DasBread - .406481DasRice + .056577DasVac - .043681DemVac + .641239DsaBread$

i

Yes, the economist is correct. The coefficient for Wage is negative meaning as Wage increases $\hat{Bigmac}$ decreases all else held constant.

j

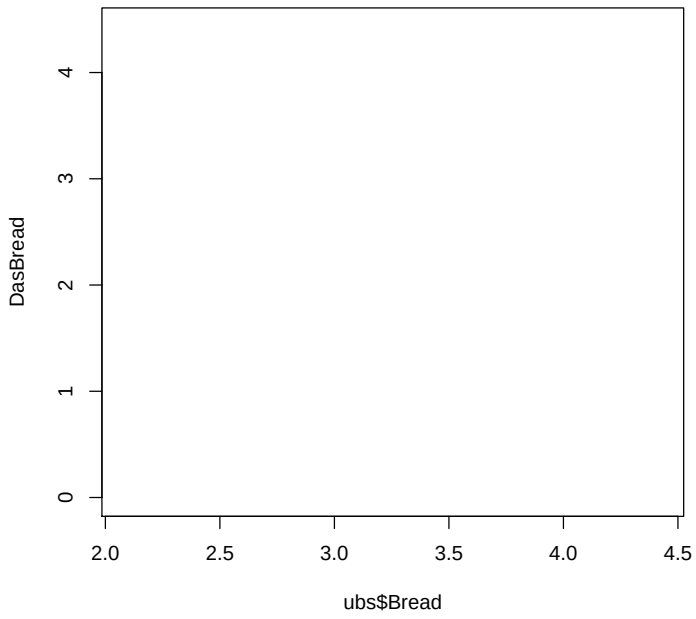
```
> mWage <- mean(ubs$Wage)
> mBread <- mean(ubs$Bread)
> mRice <- mean(ubs$Rice)
> mVac <- mean(ubs$Vac)
```

$\hat{Bigmac} = 3.861757 - 1.2709 D_{As} + .8768 D_{Em} - 1.99.16 D_{Sa} - mWage * Wage + .15348 * Bread + mRice * Rice + mVac * Vac + .15348 * DasBread - mRice * DasRice + mVac * DasVac - mVac * DemVac + .15348 * DsaBread$

```
> DasBread0 <- DasBread[ubs$DAs==0]
> DasBread1 <- DasBread[ubs$DAs==1]
> DsaBread0 <- DsaBread[ubs$DSa==0]
> DsaBread1 <- DsaBread[ubs$DSa==1]
> DasRice0 <- DasRice[ubs$DAs==0]
> DasRice1 <- DasRice[ubs$DAs==1]
```

***I am having trouble producing the predictor effect plots below*

```
> plot(ubs$Bread, DasBread, type="n")
> lines(sort(ubs$Bread[ubs$DasBread==0]), DasBread0[order(ubs$Bread[ubs$DasBread==0])])
> lines(sort(ubs$Bread[ubs$DasBread==1]), DasBread1[order(ubs$Bread[ubs$DasBread==1])])
>
```



k

$\hat{Bigmac} = 3.861757 - 1.2709 D_{As} + .8768 D_{Em} - 1.99.16 D_{Sa} - mWage * Wage + mBread * Bread + .195452 * Rice + mVac * Vac + mBread * DasBread - .195452 * DasRice + mVac * DasVac - mVac * DemVac + mBread * DsaBread$

i

$\hat{Bigmac} = 3.861757 - 1.2709 D_{As} + .8768 D_{Em} - 1.99.16 D_{Sa} - mWage * Wage + mBread * Bread + mRice * Rice + .021595 * Vac + mBread * DasBread - mRice * DasRice + .021595 * DasVac - .021595 * DemVac + mBread * DsaBread$