Coal Production

Team-The Best

Tuesday, October 11, 2016

Assignment:

Building off the data handling that we did in class, your group assignment is to estimate a supply or demand function, assuming no endogenaity, meaning that you can use OLS.

1. Look at the primer (http://users.stat.umn.edu/~sandy/alr4ed/links/alrprimer.pdf) if you need some help.
2. Convert the prices to real with the CPI. Again quandl has what you need.
3. Create a model, or multiple models, with the lm function. You can get as complicated as you like with the model, time trends, decades, log and square transformations.
4. Interpret each of the parameters in your model being very clear about units, e.g. a one dollar increase in the price per MBTU results in an ...

Cleaning up the data:

Load necessary Libraries

```
library(dplyr)
library(stringr)
library(Quandl)
library(zoo)
Quandl.api_key("DzG-XQvJrL7g8BoTG8oA")
```

Load necessary datatables (note: https would not work with knit)

```
Coal <-read.csv("http://www.eia.gov/totalenergy/data/browser/csv.cfm?tbl=T06.01")
CoalPrice <-Quandl("EPI/152")
CPI <-Quandl("RATEINF/CPI_USA",collapse="annual")
NaturalGasPrice<-Quandl("ODA/PNGASUS_USD",collapse="annual")
```

Prepare tables to be joined:

1) coal

```r
Coal$Year<-substr(as.character(Coal$YYYYMM),1,4)
Coal$Month<-substr(as.character(Coal$YYYYMM),5,6)
CoalProduction<-subset(Coal, Coal$Month==13 & Coal$MSN=="CLPRPUS")
ReducedCoalProd<-subset(CoalProduction,,c("Value" ,"Year"))
names(ReducedCoalProd)<-c("CoalShortTons", "Year")
ReducedCoalProd$CoalShortTons<-as.numeric(as.character(ReducedCoalProd$CoalShortTons))
```

2) coal price (I believe the data is in constant 2000 dollars and doesnt need adjusted)

```r
CoalPrice$Year<-substr(as.character(CoalPrice$Year),1,4)
```

3) CPI

```r
CPI$Year<-substr(as.character(CPI$Date),1,4)
compyearValue<-CPI$Value[CPI$Year==2016]
CPI$multiple<-compyearValue/CPI$Value
ReducedCPI<-subset(CPI,,c( "Year", "multiple"))
```

4)Natural Gas (The date had to be converted to 2016$ using CPI)

```r
NaturalGasPrice$Year<-substr(as.character(NaturalGasPrice$Date),1,4)
NaturalGasPrice<-inner_join(NaturalGasPrice,ReducedCPI)
```

```
## Joining, by = "Year"
```

```r
NaturalGasPrice$price2016<-NaturalGasPrice$Value*NaturalGasPrice$multiple
NaturalGasPriceReduced<-subset(NaturalGasPrice,,c("Year", "price2016"))
names(NaturalGasPriceReduced)<-c( "Year","NGprice2016" )
```

Join the tables and add log columns:

Coal (short Tons) vs. Coal Price (2010 $) Full Years

```r
CoalProdCoalPrice<-inner_join(ReducedCoalProd,CoalPrice)
```

```
## Joining, by = "Year"
```

```r
names(CoalProdCoalPrice)<-c( "CoalShortTons","Year","coalPrice2010")
CoalProdCoalPrice$logCoalProd<-log(CoalProdCoalPrice$CoalShortTons)
CoalProdCoalPrice$logCoalPrice<-log(CoalProdCoalPrice$coalPrice2010)
CoalProdCoalPrice$DateFactor<-ifelse(CoalProdCoalPrice$Year>1975,1,0)
CoalProdCoalPrice$DateFactor<-as.factor(CoalProdCoalPrice$DateFactor)
```

Coal (short Tons) vs. Coal Price (2010 $) post 1975

```
CoalProdCoalPrice_post1975<-subset(CoalProdCoalPrice,CoalProdCoalPrice$Year>1975)
```

Coal (short Tons) vs. Natural Gas Price (2016 $)

```
CoalProdNGPrice<-inner_join(ReducedCoalProd,NaturalGasPriceReduced)
```

```
## Joining, by = "Year"
```

```
CoalProdNGPrice$logCoalProd<-log(CoalProdNGPrice$CoalShortTons)
CoalProdNGPrice$logNGPrice<-log(CoalProdNGPrice$NGprice2016)
```

Cleaned up Tables:

Coal (short Tons) vs. Coal Price (2010 $)

```
CoalProdCoalPrice
```

```
##    CoalShortTons Year coalPrice2010 logCoalProd logCoalPrice DateFactor
## 1       480570.0 1949         32.05    13.08273     3.467297          0
## 2       560388.0 1950         31.40    13.23638     3.446808          0
## 3       576335.0 1951         29.86    13.26444     3.396520          0
## 4       507424.0 1952         29.24    13.13710     3.375538          0
## 5       488239.0 1953         28.67    13.09856     3.355851          0
## 6       420789.0 1954         26.12    12.94989     3.262701          0
## 7       490838.0 1955         25.02    13.10387     3.219676          0
## 8       529774.0 1956         25.83    13.18021     3.251537          0
## 9       518042.0 1957         26.35    13.15781     3.271468          0
## 10      431617.0 1958         24.73    12.97529     3.208017          0
## 11      432677.0 1959         23.85    12.97775     3.171784          0
## 12      434329.0 1960         22.96    12.98156     3.133754          0
## 13      420423.0 1961         22.23    12.94902     3.101443          0
## 14      439043.0 1962         21.42    12.99235     3.064325          0
## 15      477195.0 1963         20.87    13.07568     3.038313          0
## 16      504182.0 1964         20.79    13.13069     3.034472          0
## 17      526954.0 1965         20.19    13.17487     3.005187          0
## 18      546822.0 1966         19.93    13.21188     2.992226          0
## 19      564882.0 1967         19.63    13.24437     2.977059          0
## 20      556706.0 1968         19.07    13.22979     2.948116          0
## 21      570978.0 1969         19.43    13.25511     2.966818          0
## 22      612661.0 1970         23.03    13.32557     3.136798          0
## 23      560919.0 1971         24.73    13.23733     3.208017          0
## 24      602492.0 1972         25.59    13.30883     3.242202          0
## 25      598568.0 1973         26.97    13.30230     3.294725          0
## 26      610023.0 1974         45.56    13.32125     3.819030          0
## 27      654641.0 1975         50.92    13.39184     3.930256          0
```

```
## 28      684913.0 1976          48.66    13.43705     3.884857          1
## 29      697205.0 1977          46.66    13.45483     3.842887          1
## 30      670164.0 1978          47.77    13.41528     3.866398          1
## 31      781134.0 1979          47.93    13.56850     3.869742          1
## 32      829700.0 1980          45.61    13.62882     3.820127          1
## 33      823775.0 1981          44.66    13.62165     3.799078          1
## 34      838112.0 1982          43.44    13.63891     3.771381          1
## 35      782091.0 1983          39.84    13.56973     3.684871          1
## 36      895920.8 1984          37.85    13.70561     3.633631          1
## 37      883638.1 1985          36.15    13.69180     3.587677          1
## 38      890314.7 1986          33.39    13.69933     3.508256          1
## 39      918762.2 1987          31.52    13.73078     3.450622          1
## 40      950265.3 1988          29.16    13.76450     3.372798          1
## 41      980728.8 1989          27.78    13.79605     3.324316          1
## 42     1029075.5 1990          26.67    13.84417     3.283539          1
## 43      995983.9 1991          25.45    13.81149     3.236716          1
## 44      997544.9 1992          24.34    13.81305     3.192121          1
## 45      945424.3 1993          22.46    13.75939     3.111736          1
## 46     1033504.3 1994          21.50    13.84847     3.068053          1
## 47     1032973.8 1995          20.44    13.84795     3.017494          1
## 48     1063855.5 1996          19.71    13.87741     2.981126          1
## 49     1089931.8 1997          19.01    13.90163     2.944965          1
## 50     1117535.2 1998          18.32    13.92664     2.907993          1
## 51     1100431.4 1999          16.99    13.91121     2.832625          1
## 52     1073611.6 2000          16.78    13.88654     2.820188          1
## 53     1127688.8 2001          16.97    13.93568     2.831447          1
## 54     1094283.0 2002          17.27    13.90561     2.848971          1
## 55     1071752.6 2003          16.84    13.88481     2.823757          1
## 56     1112098.9 2004          18.27    13.92176     2.905260          1
## 57     1131498.1 2005          19.43    13.93905     2.966818          1
```

Coal (short Tons) vs. Coal Price (2010 $) post 1975

```
CoalProdCoalPrice_post1975
```

```
##    CoalShortTons Year coalPrice2010 logCoalProd logCoalPrice DateFactor
## 28      684913.0 1976          48.66    13.43705     3.884857          1
## 29      697205.0 1977          46.66    13.45483     3.842887          1
## 30      670164.0 1978          47.77    13.41528     3.866398          1
## 31      781134.0 1979          47.93    13.56850     3.869742          1
## 32      829700.0 1980          45.61    13.62882     3.820127          1
## 33      823775.0 1981          44.66    13.62165     3.799078          1
## 34      838112.0 1982          43.44    13.63891     3.771381          1
## 35      782091.0 1983          39.84    13.56973     3.684871          1
## 36      895920.8 1984          37.85    13.70561     3.633631          1
## 37      883638.1 1985          36.15    13.69180     3.587677          1
## 38      890314.7 1986          33.39    13.69933     3.508256          1
## 39      918762.2 1987          31.52    13.73078     3.450622          1
## 40      950265.3 1988          29.16    13.76450     3.372798          1
## 41      980728.8 1989          27.78    13.79605     3.324316          1
## 42     1029075.5 1990          26.67    13.84417     3.283539          1
## 43      995983.9 1991          25.45    13.81149     3.236716          1
```

```
## 44      997544.9 1992         24.34    13.81305     3.192121           1
## 45      945424.3 1993         22.46    13.75939     3.111736           1
## 46     1033504.3 1994         21.50    13.84847     3.068053           1
## 47     1032973.8 1995         20.44    13.84795     3.017494           1
## 48     1063855.5 1996         19.71    13.87741     2.981126           1
## 49     1089931.8 1997         19.01    13.90163     2.944965           1
## 50     1117535.2 1998         18.32    13.92664     2.907993           1
## 51     1100431.4 1999         16.99    13.91121     2.832625           1
## 52     1073611.6 2000         16.78    13.88654     2.820188           1
## 53     1127688.8 2001         16.97    13.93568     2.831447           1
## 54     1094283.0 2002         17.27    13.90561     2.848971           1
## 55     1071752.6 2003         16.84    13.88481     2.823757           1
## 56     1112098.9 2004         18.27    13.92176     2.905260           1
## 57     1131498.1 2005         19.43    13.93905     2.966818           1
```

Coal (short Tons) vs. Natural Gas Price (2016 $)

```
CoalProdNGPrice
```

```
##    CoalShortTons Year NGprice2016 logCoalProd logNGPrice
## 1       995983.9 1991    3.231168    13.81149  1.1728436
## 2       997544.9 1992    3.751128    13.81305  1.3220567
## 3       945424.3 1993    3.502115    13.75939  1.2533671
## 4      1033504.3 1994    2.719049    13.84847  1.0002820
## 5      1032973.8 1995    4.189430    13.84795  1.4325647
## 6      1063855.5 1996    5.785939    13.87741  1.7554307
## 7      1089931.8 1997    3.479154    13.90163  1.2467891
## 8      1117535.2 1998    2.527560    13.92664  0.9272546
## 9      1100431.4 1999    3.363069    13.91121  1.2128540
## 10     1073611.6 2000   12.333335    13.88654  2.5123057
## 11     1127688.8 2001    3.298609    13.93568  1.1935009
## 12     1094283.0 2002    6.324222    13.90561  1.8443870
## 13     1071752.6 2003    8.024077    13.88481  2.0824467
## 14     1112098.9 2004    8.327970    13.92176  2.1196198
## 15     1131498.1 2005   15.971197    13.93905  2.7707869
## 16     1162749.7 2006    8.032412    13.96630  2.0834848
## 17     1146635.3 2007    8.176131    13.95234  2.1012191
## 18     1171808.7 2008    6.690743    13.97406  1.9007249
## 19     1074923.4 2009    5.966981    13.88776  1.7862411
## 20     1084368.1 2010    4.670271    13.89651  1.5412170
## 21     1095627.5 2011    3.372574    13.90684  1.2156762
## 22     1016458.4 2012    3.503683    13.83184  1.2538146
## 23      984841.8 2013    4.330309    13.80024  1.4656388
## 24     1000048.8 2014    3.518243    13.81556  1.2579619
## 25      896977.4 2015    1.955133    13.70679  0.6704581
```

Model and Results

1) Model log(coal Production)~log(coal Price) (all years)

The first model was simply to look to see if there was a statistically significant elasticity between coal production and coal for the year 1949 to 2005

regression code

```
logcoal_logCoalPrice<-lm(CoalProdCoalPrice$logCoalProd~CoalProdCoalPrice$logCoalPrice)
```

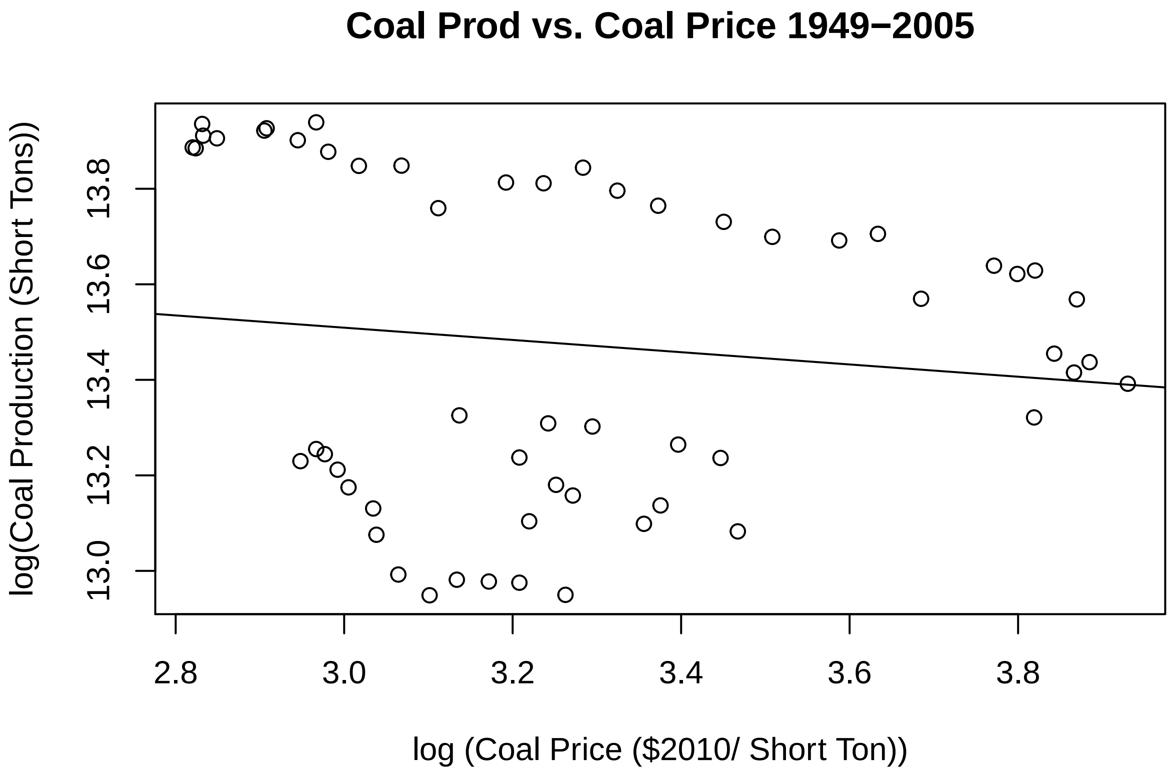
summary results

```
summary(logcoal_logCoalPrice)
```

```
##
## Call:
## lm(formula = CoalProdCoalPrice$logCoalProd ~ CoalProdCoalPrice$logCoalPrice)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.54716 -0.29831  0.04139  0.32851  0.42560
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                     13.8941     0.4516  30.764   <2e-16 ***
## CoalProdCoalPrice$logCoalPrice  -0.1283     0.1374  -0.934    0.354
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.3341 on 55 degrees of freedom
## Multiple R-squared:  0.01562,    Adjusted R-squared:  -0.002282
## F-statistic: 0.8725 on 1 and 55 DF,  p-value: 0.3543
```

plot

```
plot(CoalProdCoalPrice$logCoalPrice,CoalProdCoalPrice$logCoalProd,main="Coal Prod vs. Coal Price 1949-2
abline(logcoal_logCoalPrice)
```



interpretation

Hypothesis test: 1. H0: There is no significant difference between coal production and coal price in 2010 real dollars. 2. H1: There is a significant difference between coal production and coal price in 2010 real dollars.

The statistical data summmary indicates a high P-value of 0.3543, which means that changes in coal production are not associated with changes in coal price in real 2010 dollars. A R-squared of 0.01562 and an adjusted R-squared of -0.002282 incidcate that this particular model explains none of the variability of the response data around its mean.

Therefore, there is no significant relationship between coal production and coal price in 2010 real dollars. However examination of the plot reveals that there might be two different sets , and possibly two different elasticities

2) Model log(coal Production)~log(coal Price) post 1975

SInce the first model over all the years did nbot show statistical significance, we divided the historical data into two sets -pre and post 1975.

regression code

```
logcoal_logCoalPrice_1975<-lm(CoalProdCoalPrice_post1975$logCoalProd~CoalProdCoalPrice_post1975$logCoalP
```

summary results

```r
summary(logcoal_logCoalPrice_1975)
```

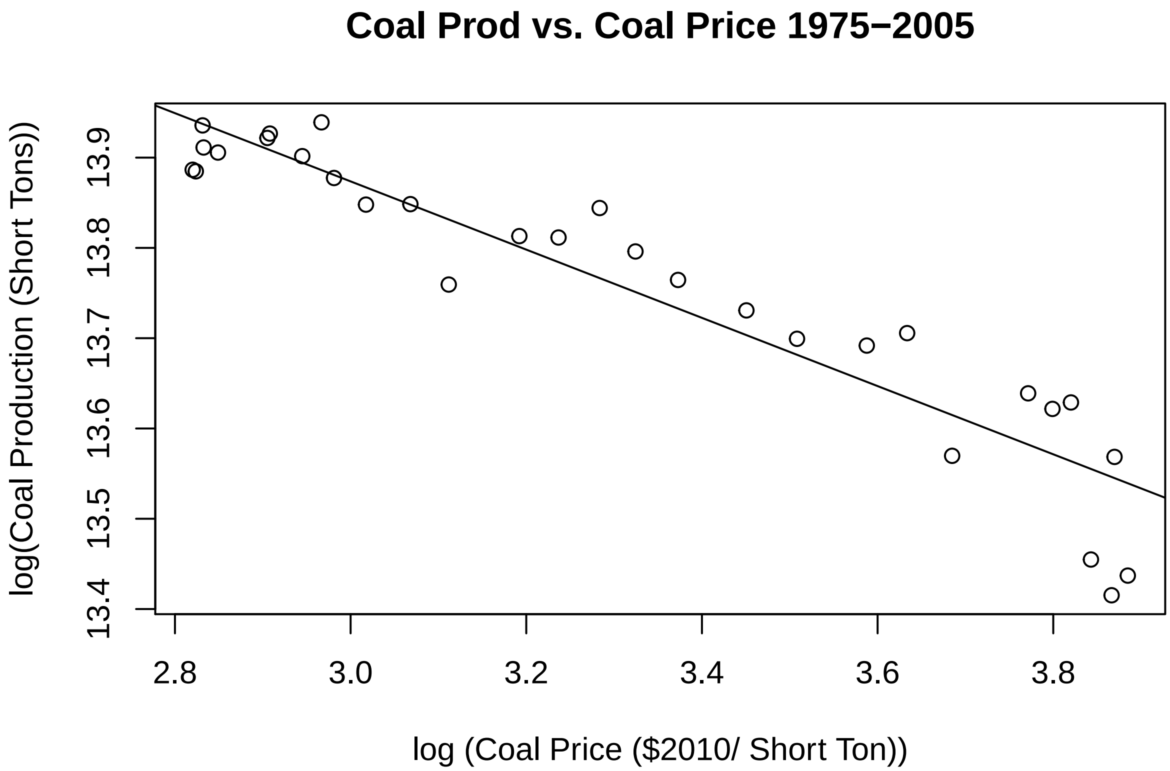
```
##
## Call:
## lm(formula = CoalProdCoalPrice_post1975$logCoalProd ~ CoalProdCoalPrice_post1975$logCoalPrice)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.13102 -0.02555  0.01214  0.03807  0.07764
##
## Coefficients:
##                                         Estimate Std. Error t value
## (Intercept)                             15.00723    0.08734   171.8
## CoalProdCoalPrice_post1975$logCoalPrice -0.37785    0.02624   -14.4
##                                         Pr(>|t|)
## (Intercept)                              < 2e-16 ***
## CoalProdCoalPrice_post1975$logCoalPrice 1.81e-14 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.05485 on 28 degrees of freedom
## Multiple R-squared:  0.881,  Adjusted R-squared:  0.8768
## F-statistic: 207.3 on 1 and 28 DF,  p-value: 1.805e-14
```

```r
confint(logcoal_logCoalPrice_1975)
```

```
##                                              2.5 %     97.5 %
## (Intercept)                             14.8283235 15.1861304
## CoalProdCoalPrice_post1975$logCoalPrice -0.4316067 -0.3241011
```

plot

```r
plot(CoalProdCoalPrice_post1975$logCoalPrice,CoalProdCoalPrice_post1975$logCoalProd,main="Coal Prod vs
abline(logcoal_logCoalPrice_1975)
```



interpretation

Hypothesis test: 1. H0: There is no significant difference between coal production and coal price in 1975 dollars. 2. H1: There is a significant difference between coal production and coal price in 1975 dollars.

The statistical data summmary indicates a low P-value of 1.805e-14, which means that changes in coal production are indeed associated with changes in coal price in 2010 dollars for the year 1975-2005. A R-squared of 0.881 and an adjusted R-squared of 0.8768 incidcate that this particular model explains most of the variability of the response data around its mean. SInce this is a log-log model the elasticity is defined as the slope of log coal price. It was calculated as -.37785 with a 95% confidence surrounding it of [-.43, -.32]. Therefore, a one dollar increase in coal price per MBTU results in 7.8419 MBTU (or 0.37785 Short tons) decrease in coal production due to OPEC inception and its cartel effect in 1975.

There is a significant difference between coal production and coal price in 2010 dollars for the years 1975-2005.

3) Model log(coal Production)~log(Natural Gas Price) (Henry Hud)

This model wants to test the theory that coal production is somehow related to the price of natural gas defined for the Henry Hubfor the year 1991-2015 in 2016 $.

Regression Code

```
logcoal_logNgPrice<-lm(CoalProdNGPrice$logCoalProd~CoalProdNGPrice$logNGPrice)
```

Summary Results

```r
summary(logcoal_logNgPrice)
```

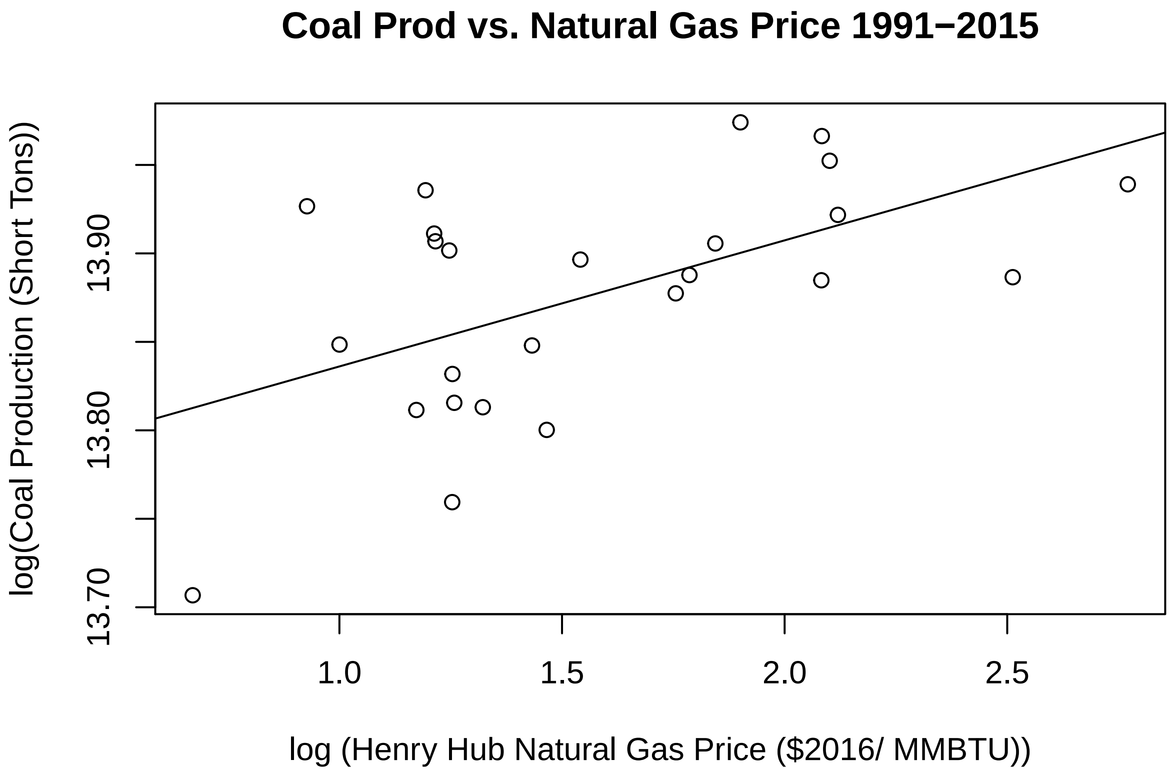
```
##
## Call:
## lm(formula = CoalProdNGPrice$logCoalProd ~ CoalProdNGPrice$logNGPrice)
##
## Residuals:
##       Min        1Q    Median        3Q       Max
## -0.105830 -0.036930 -0.004368  0.047940  0.095720
##
## Coefficients:
##                            Estimate Std. Error t value Pr(>|t|)
## (Intercept)                13.76484    0.03651 376.968  < 2e-16 ***
## CoalProdNGPrice$logNGPrice  0.07126    0.02222   3.207  0.00391 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.05576 on 23 degrees of freedom
## Multiple R-squared:  0.309,  Adjusted R-squared:  0.279
## F-statistic: 10.29 on 1 and 23 DF,  p-value: 0.00391
```

```r
confint(logcoal_logNgPrice)
```

```
##                                  2.5 %     97.5 %
## (Intercept)                13.68930263 13.8403752
## CoalProdNGPrice$logNGPrice  0.02529871  0.1172227
```

Plot

```r
plot(CoalProdNGPrice$logNGPrice,CoalProdNGPrice$logCoalProd,main="Coal Prod vs. Natural Gas Price 1991-
abline(logcoal_logNgPrice)
```



Intrepretation

Hypothesis Test: 1. H0: There is no significant difference between coal production and natural gas price in 2016 dollars. 2. H1: There is a significant difference between coal production and natural gas price in 2016 dollars.

The statistical data summmary indicates a low P-value of 0.00391, which means that changes in coal production are indeed associated with changes in natural gas price in 2016 dollars. A R-squared of 0.309 and an adjusted R-squared of 0.279 incidcate that this particular model explains there is a variability of the response data around its mean there are other factors to consider. SInce this is a log-log model the elasticity is calculated as .071 with a 95% confidence interval of [.025, .11] Therefore, a one dollar increase in natural gas price in 2016 dollars per MBTU results in 1.4789 MBTU (or 0.07126 Short tons) increase in coal production.

Based on the statistical data summary and observations, we can see that natural gas prices have been steadily decreasing since the mid 2005 due to prominent fracking activities, which results in a postive relationship between natural gas prices and coal production. Addtionally, if there is a spike in natural gas prices, then coal production will also increase due to the demand for substitue (coal) increases.

There is a significant difference between coal production and natural gas price in 2016 dollars.