Project 2

```
data <- read_csv("C:/Users/Ivy Yuan/Documents/R/ECON132/naics5811.csv")
```

```
## Parsed with column specification:
## cols(
##   .default = col_double()
## )
```

```
## See spec(...) for full column specifications.
```

```
# 6-digit industry
nrow(distinct(data,naics))
```

```
## [1] 473
```

```
# 3-digit industry
data <- data %>% mutate(three_digit = floor(naics/1000))
nrow(distinct(data,three_digit))
```

```
## [1] 21
```

There are 473 distinct 6-digit codes and 21 distinct 3-digit codes.

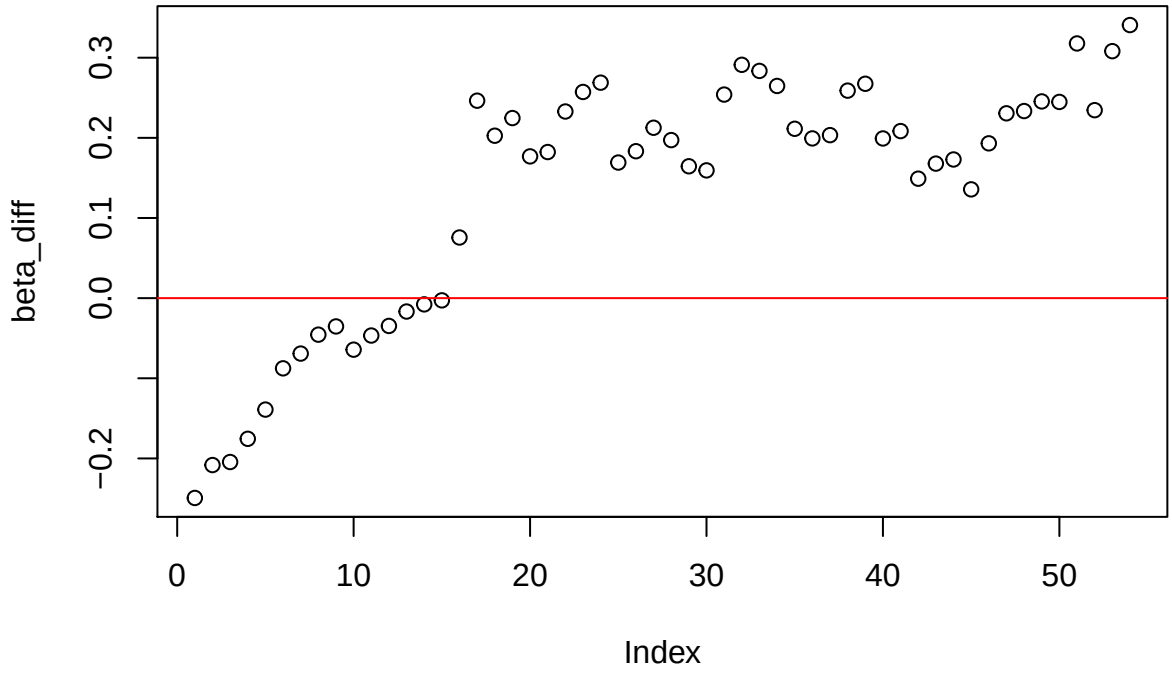
```
# OLS estimates
fit <- lm(log(vship) ~ log(prodh) + log(cap), data)
summary(fit)
```

```
##
## Call:
## lm(formula = log(vship) ~ log(prodh) + log(cap), data = data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.62193 -0.49378  0.06871  0.52053  2.23201
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept) 0.865908   0.025850   33.50   <2e-16 ***
## log(prodh)  0.119975   0.005472   21.93   <2e-16 ***
## log(cap)    0.882702   0.004552  193.91   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7064 on 25383 degrees of freedom
##   (156 observations deleted due to missingness)
## Multiple R-squared:  0.7336, Adjusted R-squared:  0.7336
## F-statistic: 3.495e+04 on 2 and 25383 DF,  p-value: < 2.2e-16
```

With an estimated coefficient of 0.8827, log(cap) has a stroger impact on the output.

```
# beta2-beta1 in different years
beta1 <- c()
beta2 <- c()
for (yr in seq(1958,2011)){
  year_set <- filter(data, year == yr)
  fit <- lm(log(vship) ~ log(prodh) + log(cap), year_set)
```

```
  beta1 <- c(beta1, fit$coefficients[2])
  beta2 <- c(beta2, fit$coefficients[3])
}
beta_diff <- beta2 - beta1
plot(beta_diff)
abline(h=0, col="red")
```



Description of the plot: As time progresses, the difference between beta2 and beta1 increases from being negative to positive, signifying that the effect on the output by capital becomes more significant than that of the labor. This also suggests that the relative efficiency of capital starts from being lower and progresses to become higher compare to labor.

```
# 3-digit max and min beta2-beta1 estimate difference
threed_beta1 <- c()
threed_beta2 <- c()
three_digit <- c()
for (i in unique(data$three_digit)){
  # In the for-loop, filter data with each unique 3-digit code
  digit_set <- filter(data, three_digit == i)
  fit <- lm(log(vship) ~ log(prodh) + log(cap), digit_set)
  threed_beta1 <- c(threed_beta1, fit$coefficients[2])
  threed_beta2 <- c(threed_beta2, fit$coefficients[3])
  three_digit <- c(three_digit, i)
}
threed_diff = threed_beta2-threed_beta1
threed <- cbind(as.data.frame(threed_diff),as.data.frame(three_digit))
```

```r
max(threed$threed_diff)
```

```
## [1] 1.810259
```

```r
min(threed$threed_diff)
```

```
## [1] 0.3094269
```

```r
threed[which.max(threed$threed_diff),]
```

```
##    threed_diff three_digit
## 10    1.810259         324
```

Three digit is 324 when difference is the maximum, which refers to Petroleum and Coal Products Manufacturing.

```r
threed[which.min(threed$threed_diff),]
```

```
##   threed_diff three_digit
## 5   0.3094269         315
```

Three digit is 315 when difference is the minimum, which refers to Apparel Manufacturing.

The relative efficiency for capital is the highest for the petroleum manufacturing industry and lowest for the apparel manufacturing industry. This aligns with my expectations because the petroleum industry relies more heavily on capital (machines and instruments), whereas the apparel industry is quite labor intensive, which is shown by its lowest difference between beta2 and beta1.

Endogeneity problem with regression estimates

Beta1 may be biased because of the endogeneity problem. Some omitted variables in the error term may still be correlated to labor. For example, productivity is a variable in the error term, and a highly productive firm may achieve the same level of output with fewer workers. Since productivity is correlated with labor, omitting it from the model may cause us to underestimate the true beta1.

IV model

```r
data <- data %>% mutate(hwage = prodw/prodh)
fit2 <- ivreg(log(vship) ~ log(prodh) + log(cap) | hwage + log(cap), data = data)
summary(fit2)
```

```
##
## Call:
## ivreg(formula = log(vship) ~ log(prodh) + log(cap) | hwage +
##     log(cap), data = data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -4.86726 -0.60335  0.03566  0.64336  3.99285
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.64107    0.03785   16.94   <2e-16 ***
## log(prodh)  -0.80761    0.01404  -57.53   <2e-16 ***
## log(cap)     1.35841    0.00890  152.62   <2e-16 ***
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.031 on 25383 degrees of freedom
## Multiple R-Squared: 0.432,   Adjusted R-squared: 0.4319
## Wald test: 1.793e+04 on 2 and 25383 DF,  p-value: < 2.2e-16
```

For the IV estimates, beta1 decreases to become negative (-0.81) while for beta2, it increases from 0.883 to 1.36 (relative to OLS). A negative and statistically significant beta1 means that, according to the model, an increase in labor should lead to a decrease in output.

Wage is supposed to be a reasonable instrument, since (1) wage is correlated with labor, (2) it does not directly affect output, and (3) it is reasonable to argue that wage has zero covariance with the error term. IV estimates should be more credible than the OLS ones, because the IV approach attempts to address the endogeneity problem. However, the fact that beta1 is negative, which does not seem to reflect the reality (more labor should lead to more output), perhaps at the end, we should agree that wage is not the best instrument to use and we should consider switching to another instrument.

In the case when we have chosen the wrong instrument, the estimates given by OLS is probably more credible that the ones given by the IV model.

Fixed Effect Model

```
fit3 <- lm(log(vship) ~ log(prodh) + log(cap) + factor(naics) + factor(year),data)
summary(fit3)
```

```
##
## Call:
## lm(formula = log(vship) ~ log(prodh) + log(cap) + factor(naics) +
##     factor(year), data = data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.08733 -0.09159 -0.00312  0.09170  1.18995
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)           2.329557   0.035956  64.789  < 2e-16 ***
## log(prodh)            0.786447   0.003595 218.754  < 2e-16 ***
## log(cap)              0.284490   0.004476  63.559  < 2e-16 ***
## factor(naics)311119   0.114775   0.034594   3.318 0.000909 ***
## factor(naics)311211   0.097554   0.034528   2.825 0.004726 **
## factor(naics)311212   0.219210   0.034986   6.266 3.77e-10 ***
## factor(naics)311213   0.071433   0.035166   2.031 0.042236 *
## factor(naics)311221  -0.100052   0.034720  -2.882 0.003959 **
## factor(naics)311222   1.071372   0.034641  30.928  < 2e-16 ***
## factor(naics)311223  -0.054163   0.034717  -1.560 0.118740
## factor(naics)311225   0.389702   0.034540  11.283  < 2e-16 ***
## factor(naics)311230  -0.241065   0.034534  -6.980 3.02e-12 ***
## factor(naics)311311  -0.749099   0.034617 -21.640  < 2e-16 ***
## factor(naics)311312   0.087655   0.034599   2.533 0.011300 *
## factor(naics)311313  -0.622646   0.034562 -18.015  < 2e-16 ***
## factor(naics)311320  -0.172419   0.034682  -4.971 6.69e-07 ***
## factor(naics)311330  -0.790279   0.034616 -22.830  < 2e-16 ***
## factor(naics)311340  -0.851745   0.034640 -24.589  < 2e-16 ***
## factor(naics)311411  -0.919874   0.034666 -26.535  < 2e-16 ***
```

```
## factor(naics)311412 -0.808914   0.034662 -23.337  < 2e-16 ***
## factor(naics)311421 -0.893722   0.034872 -25.629  < 2e-16 ***
## factor(naics)311422 -0.444316   0.034549 -12.861  < 2e-16 ***
## factor(naics)311423 -0.670975   0.034614 -19.385  < 2e-16 ***
## factor(naics)311511 -0.056614   0.034828  -1.626 0.104060
## factor(naics)311512  0.460442   0.034865  13.206  < 2e-16 ***
## factor(naics)311513  0.114533   0.034662   3.304 0.000954 ***
## factor(naics)311514  0.186802   0.034559   5.405 6.53e-08 ***
## factor(naics)311520 -0.412034   0.034539 -11.929  < 2e-16 ***
## factor(naics)311611 -0.111861   0.035154  -3.182 0.001465 **
## factor(naics)311612 -0.472054   0.034838 -13.550  < 2e-16 ***
## factor(naics)311613 -0.632415   0.034562 -18.298  < 2e-16 ***
## factor(naics)311615 -1.009135   0.035151 -28.709  < 2e-16 ***
## factor(naics)311711 -0.629014   0.035052 -17.945  < 2e-16 ***
## factor(naics)311712 -0.669066   0.035126 -19.048  < 2e-16 ***
## factor(naics)311811 -1.706901   0.052930 -32.248  < 2e-16 ***
## factor(naics)311812 -1.022058   0.035065 -29.148  < 2e-16 ***
## factor(naics)311813 -0.735486   0.035132 -20.935  < 2e-16 ***
## factor(naics)311821 -0.737018   0.034687 -21.248  < 2e-16 ***
## factor(naics)311822 -0.366256   0.034615 -10.581  < 2e-16 ***
## factor(naics)311823 -0.502982   0.035026 -14.360  < 2e-16 ***
## factor(naics)311830 -0.907752   0.035759 -25.385  < 2e-16 ***
## factor(naics)311911 -0.169786   0.034901  -4.865 1.15e-06 ***
## factor(naics)311919 -0.451959   0.034593 -13.065  < 2e-16 ***
## factor(naics)311920  0.182363   0.034683   5.258 1.47e-07 ***
## factor(naics)311930  0.729616   0.034690  21.032  < 2e-16 ***
## factor(naics)311941 -0.270273   0.034568  -7.819 5.55e-15 ***
## factor(naics)311942 -0.109089   0.034731  -3.141 0.001686 **
## factor(naics)311991 -0.745957   0.035117 -21.242  < 2e-16 ***
## factor(naics)311999 -0.449701   0.034659 -12.975  < 2e-16 ***
## factor(naics)312111 -0.243461   0.034947  -6.967 3.33e-12 ***
## factor(naics)312112 -0.658501   0.035137 -18.741  < 2e-16 ***
## factor(naics)312113 -1.313046   0.035225 -37.276  < 2e-16 ***
## factor(naics)312120 -0.368854   0.035048 -10.524  < 2e-16 ***
## factor(naics)312130 -0.113513   0.034564  -3.284 0.001024 **
## factor(naics)312140  0.028109   0.034564   0.813 0.416099
## factor(naics)312210  0.114010   0.034734   3.282 0.001031 **
## factor(naics)312221  0.432056   0.034589  12.491  < 2e-16 ***
## factor(naics)312229 -0.424449   0.034956 -12.142  < 2e-16 ***
## factor(naics)313111 -1.518522   0.034824 -43.606  < 2e-16 ***
## factor(naics)313112 -1.037043   0.034731 -29.859  < 2e-16 ***
## factor(naics)313113 -1.169765   0.035421 -33.024  < 2e-16 ***
## factor(naics)313210 -1.645009   0.035290 -46.613  < 2e-16 ***
## factor(naics)313221 -1.460660   0.035031 -41.696  < 2e-16 ***
## factor(naics)313222 -1.551596   0.035858 -43.270  < 2e-16 ***
## factor(naics)313230 -0.895397   0.034668 -25.828  < 2e-16 ***
## factor(naics)313241 -1.185184   0.034801 -34.056  < 2e-16 ***
## factor(naics)313249 -1.033182   0.035070 -29.461  < 2e-16 ***
## factor(naics)313311 -1.297060   0.034719 -37.359  < 2e-16 ***
## factor(naics)313312 -1.088482   0.034753 -31.321  < 2e-16 ***
## factor(naics)313320 -0.831453   0.034635 -24.006  < 2e-16 ***
## factor(naics)314110 -0.752640   0.034740 -21.665  < 2e-16 ***
## factor(naics)314121 -1.273187   0.035751 -35.613  < 2e-16 ***
## factor(naics)314129 -0.967010   0.035261 -27.424  < 2e-16 ***
```

```
## factor(naics)314911 -1.013474   0.036032 -28.127  < 2e-16 ***
## factor(naics)314912 -1.066201   0.036012 -29.607  < 2e-16 ***
## factor(naics)314991 -1.105234   0.035515 -31.120  < 2e-16 ***
## factor(naics)314992 -0.659151   0.034860 -18.908  < 2e-16 ***
## factor(naics)314999 -1.277330   0.035058 -36.435  < 2e-16 ***
## factor(naics)315111 -1.641015   0.034766 -47.201  < 2e-16 ***
## factor(naics)315119 -1.515016   0.035196 -43.045  < 2e-16 ***
## factor(naics)315191 -1.430203   0.034934 -40.940  < 2e-16 ***
## factor(naics)315192 -1.363730   0.035082 -38.873  < 2e-16 ***
## factor(naics)315211 -2.048100   0.036997 -55.359  < 2e-16 ***
## factor(naics)315212 -2.047419   0.037290 -54.906  < 2e-16 ***
## factor(naics)315221 -1.059636   0.036611 -28.943  < 2e-16 ***
## factor(naics)315222 -1.195098   0.035620 -33.551  < 2e-16 ***
## factor(naics)315223 -1.224794   0.035535 -34.467  < 2e-16 ***
## factor(naics)315224 -1.095182   0.035200 -31.113  < 2e-16 ***
## factor(naics)315225 -1.204987   0.036680 -32.852  < 2e-16 ***
## factor(naics)315228 -1.215577   0.035928 -33.834  < 2e-16 ***
## factor(naics)315231 -0.962643   0.035407 -27.188  < 2e-16 ***
## factor(naics)315232 -0.646246   0.035622 -18.142  < 2e-16 ***
## factor(naics)315233 -0.670890   0.035375 -18.965  < 2e-16 ***
## factor(naics)315234 -0.615620   0.035343 -17.418  < 2e-16 ***
## factor(naics)315239 -0.679598   0.035662 -19.057  < 2e-16 ***
## factor(naics)315291 -1.121430   0.036117 -31.050  < 2e-16 ***
## factor(naics)315292 -0.611846   0.036835 -16.611  < 2e-16 ***
## factor(naics)315299 -1.106344   0.036945 -29.946  < 2e-16 ***
## factor(naics)315991 -1.402193   0.036317 -38.610  < 2e-16 ***
## factor(naics)315992 -1.208237   0.036886 -32.756  < 2e-16 ***
## factor(naics)315993 -0.620842   0.037930 -16.368  < 2e-16 ***
## factor(naics)315999 -1.098271   0.035623 -30.830  < 2e-16 ***
## factor(naics)316110 -0.763692   0.034942 -21.856  < 2e-16 ***
## factor(naics)316211 -1.284904   0.035517 -36.177  < 2e-16 ***
## factor(naics)316212 -1.028826   0.037445 -27.476  < 2e-16 ***
## factor(naics)316213 -1.192448   0.035617 -33.480  < 2e-16 ***
## factor(naics)316214 -1.486860   0.035655 -41.701  < 2e-16 ***
## factor(naics)316219 -1.449264   0.036072 -40.177  < 2e-16 ***
## factor(naics)316991 -1.024094   0.035957 -28.481  < 2e-16 ***
## factor(naics)316992 -1.011902   0.036807 -27.492  < 2e-16 ***
## factor(naics)316993 -1.038280   0.036875 -28.156  < 2e-16 ***
## factor(naics)316999 -1.177705   0.035908 -32.798  < 2e-16 ***
## factor(naics)321113 -1.311833   0.035098 -37.377  < 2e-16 ***
## factor(naics)321114 -0.570573   0.034933 -16.333  < 2e-16 ***
## factor(naics)321211 -1.112217   0.035073 -31.711  < 2e-16 ***
## factor(naics)321212 -1.115958   0.034768 -32.098  < 2e-16 ***
## factor(naics)321213 -0.180005   0.036163  -4.978 6.48e-07 ***
## factor(naics)321214 -0.904189   0.035786 -25.266  < 2e-16 ***
## factor(naics)321219 -1.082741   0.034575 -31.316  < 2e-16 ***
## factor(naics)321911 -0.934228   0.035109 -26.610  < 2e-16 ***
## factor(naics)321912 -1.334018   0.034785 -38.351  < 2e-16 ***
## factor(naics)321918 -1.111479   0.035200 -31.576  < 2e-16 ***
## factor(naics)321920 -1.429905   0.035101 -40.737  < 2e-16 ***
## factor(naics)321991 -0.857744   0.035159 -24.396  < 2e-16 ***
## factor(naics)321992 -0.741849   0.035156 -21.101  < 2e-16 ***
## factor(naics)321999 -1.419097   0.035037 -40.502  < 2e-16 ***
## factor(naics)322110 -0.813485   0.034919 -23.296  < 2e-16 ***
```

```
## factor(naics)322121 -0.979939   0.035577 -27.544  < 2e-16 ***
## factor(naics)322122 -0.772959   0.034697 -22.278  < 2e-16 ***
## factor(naics)322130 -0.844960   0.035158 -24.033  < 2e-16 ***
## factor(naics)322211 -0.853663   0.034923 -24.444  < 2e-16 ***
## factor(naics)322212 -1.072480   0.034744 -30.868  < 2e-16 ***
## factor(naics)322213 -1.466013   0.035363 -41.456  < 2e-16 ***
## factor(naics)322214 -0.955420   0.034853 -27.413  < 2e-16 ***
## factor(naics)322215 -0.950035   0.034565 -27.485  < 2e-16 ***
## factor(naics)322221 -0.593510   0.035088 -16.915  < 2e-16 ***
## factor(naics)322222 -0.592208   0.034611 -17.111  < 2e-16 ***
## factor(naics)322223 -0.877392   0.035777 -24.524  < 2e-16 ***
## factor(naics)322224 -0.756262   0.035116 -21.536  < 2e-16 ***
## factor(naics)322225 -0.442258   0.035221 -12.557  < 2e-16 ***
## factor(naics)322226 -0.374696   0.035107 -10.673  < 2e-16 ***
## factor(naics)322231 -0.857217   0.034887 -24.571  < 2e-16 ***
## factor(naics)322232 -1.095546   0.034955 -31.342  < 2e-16 ***
## factor(naics)322233 -0.900572   0.034836 -25.852  < 2e-16 ***
## factor(naics)322291 -0.345459   0.034550  -9.999  < 2e-16 ***
## factor(naics)322299 -1.003674   0.034721 -28.907  < 2e-16 ***
## factor(naics)323110 -1.259258   0.035352 -35.621  < 2e-16 ***
## factor(naics)323111 -1.083836   0.034672 -31.260  < 2e-16 ***
## factor(naics)323112 -1.054512   0.034665 -30.420  < 2e-16 ***
## factor(naics)323113 -1.373833   0.034985 -39.269  < 2e-16 ***
## factor(naics)323114 -1.425355   0.035070 -40.643  < 2e-16 ***
## factor(naics)323115 -1.179793   0.035697 -33.050  < 2e-16 ***
## factor(naics)323116 -0.948904   0.034741 -27.314  < 2e-16 ***
## factor(naics)323117 -1.296103   0.034923 -37.113  < 2e-16 ***
## factor(naics)323118 -1.050221   0.035275 -29.772  < 2e-16 ***
## factor(naics)323119 -1.387738   0.034815 -39.860  < 2e-16 ***
## factor(naics)323121 -1.752217   0.035244 -49.717  < 2e-16 ***
## factor(naics)323122 -1.335237   0.034969 -38.184  < 2e-16 ***
## factor(naics)324110  0.870844   0.036614  23.784  < 2e-16 ***
## factor(naics)324121 -0.318518   0.034549  -9.219  < 2e-16 ***
## factor(naics)324122 -0.289043   0.034671  -8.337  < 2e-16 ***
## factor(naics)324191  0.304765   0.034675   8.789  < 2e-16 ***
## factor(naics)324199 -0.474872   0.034682 -13.692  < 2e-16 ***
## factor(naics)325110  0.747539   0.035577  21.012  < 2e-16 ***
## factor(naics)325120 -0.433500   0.034843 -12.442  < 2e-16 ***
## factor(naics)325131 -0.503310   0.034641 -14.529  < 2e-16 ***
## factor(naics)325132 -0.737801   0.034565 -21.345  < 2e-16 ***
## factor(naics)325181 -0.475851   0.034668 -13.726  < 2e-16 ***
## factor(naics)325182 -0.272788   0.034940  -7.807 6.07e-15 ***
## factor(naics)325188 -0.511763   0.034900 -14.664  < 2e-16 ***
## factor(naics)325191 -0.511936   0.034923 -14.659  < 2e-16 ***
## factor(naics)325192 -0.019915   0.034856  -0.571 0.567768
## factor(naics)325193  0.153393   0.034991   4.384 1.17e-05 ***
## factor(naics)325199 -0.297093   0.035754  -8.309  < 2e-16 ***
## factor(naics)325211 -0.224580   0.035219  -6.377 1.84e-10 ***
## factor(naics)325212 -0.100281   0.034572  -2.901 0.003728 **
## factor(naics)325221 -1.139122   0.034570 -32.952  < 2e-16 ***
## factor(naics)325222 -0.842840   0.034819 -24.206  < 2e-16 ***
## factor(naics)325311 -0.170212   0.034743  -4.899 9.69e-07 ***
## factor(naics)325312 -0.319389   0.034653  -9.217  < 2e-16 ***
## factor(naics)325314 -0.266714   0.034583  -7.712 1.28e-14 ***
```

```
## factor(naics)325320  0.197189   0.034564   5.705 1.18e-08 ***
## factor(naics)325411 -0.360838   0.034674 -10.407  < 2e-16 ***
## factor(naics)325412 -0.136412   0.035114  -3.885 0.000103 ***
## factor(naics)325413 -0.474095   0.034693 -13.665  < 2e-16 ***
## factor(naics)325414 -0.544818   0.034727 -15.689  < 2e-16 ***
## factor(naics)325510 -0.155916   0.034621  -4.503 6.72e-06 ***
## factor(naics)325520 -0.288879   0.034574  -8.355  < 2e-16 ***
## factor(naics)325611  0.123986   0.034588   3.585 0.000338 ***
## factor(naics)325612 -0.159437   0.034528  -4.618 3.90e-06 ***
## factor(naics)325613  0.096192   0.034678   2.774 0.005543 **
## factor(naics)325620 -0.056410   0.034630  -1.629 0.103342
## factor(naics)325910 -0.214805   0.034898  -6.155 7.61e-10 ***
## factor(naics)325920 -1.013997   0.034771 -29.163  < 2e-16 ***
## factor(naics)325991 -0.596618   0.034697 -17.195  < 2e-16 ***
## factor(naics)325992 -0.398912   0.034619 -11.523  < 2e-16 ***
## factor(naics)325998 -0.404507   0.034572 -11.700  < 2e-16 ***
## factor(naics)326111 -0.998480   0.034641 -28.823  < 2e-16 ***
## factor(naics)326112 -0.728542   0.034693 -21.000  < 2e-16 ***
## factor(naics)326113 -0.832534   0.034605 -24.058  < 2e-16 ***
## factor(naics)326121 -1.182686   0.034650 -34.132  < 2e-16 ***
## factor(naics)326122 -0.567273   0.034812 -16.295  < 2e-16 ***
## factor(naics)326130 -0.839390   0.035032 -23.961  < 2e-16 ***
## factor(naics)326140 -1.005098   0.034628 -29.026  < 2e-16 ***
## factor(naics)326150 -1.015480   0.034623 -29.330  < 2e-16 ***
## factor(naics)326160 -1.152169   0.034596 -33.303  < 2e-16 ***
## factor(naics)326191 -0.912948   0.035791 -25.508  < 2e-16 ***
## factor(naics)326192 -0.627440   0.034906 -17.975  < 2e-16 ***
## factor(naics)326199 -1.381787   0.035502 -38.921  < 2e-16 ***
## factor(naics)326211 -0.952570   0.034907 -27.289  < 2e-16 ***
## factor(naics)326212 -1.027027   0.053169 -19.316  < 2e-16 ***
## factor(naics)326220 -1.062535   0.034699 -30.621  < 2e-16 ***
## factor(naics)326291 -1.294991   0.034762 -37.253  < 2e-16 ***
## factor(naics)326299 -1.036477   0.034774 -29.806  < 2e-16 ***
## factor(naics)327111 -1.132874   0.035524 -31.890  < 2e-16 ***
## factor(naics)327112 -1.669337   0.035114 -47.540  < 2e-16 ***
## factor(naics)327113 -1.427763   0.034892 -40.919  < 2e-16 ***
## factor(naics)327121 -1.611688   0.034663 -46.496  < 2e-16 ***
## factor(naics)327122 -1.401077   0.035073 -39.947  < 2e-16 ***
## factor(naics)327123 -1.558221   0.035179 -44.294  < 2e-16 ***
## factor(naics)327124 -1.018970   0.034833 -29.253  < 2e-16 ***
## factor(naics)327125 -0.933308   0.034652 -26.934  < 2e-16 ***
## factor(naics)327211 -1.187811   0.034550 -34.379  < 2e-16 ***
## factor(naics)327212 -1.427830   0.034618 -41.245  < 2e-16 ***
## factor(naics)327213 -1.327844   0.034655 -38.316  < 2e-16 ***
## factor(naics)327215 -1.118601   0.034708 -32.229  < 2e-16 ***
## factor(naics)327310 -0.907634   0.034813 -26.072  < 2e-16 ***
## factor(naics)327320 -0.996835   0.034878 -28.581  < 2e-16 ***
## factor(naics)327331 -0.994655   0.034551 -28.788  < 2e-16 ***
## factor(naics)327332 -1.117508   0.034745 -32.163  < 2e-16 ***
## factor(naics)327390 -1.378397   0.034745 -39.672  < 2e-16 ***
## factor(naics)327410 -1.012707   0.034705 -29.180  < 2e-16 ***
## factor(naics)327420 -0.722319   0.034586 -20.885  < 2e-16 ***
## factor(naics)327910 -0.789061   0.034587 -22.814  < 2e-16 ***
## factor(naics)327991 -1.418149   0.035200 -40.288  < 2e-16 ***
```

```
## factor(naics)327992 -0.842412   0.034584 -24.358  < 2e-16 ***
## factor(naics)327993 -0.956046   0.034579 -27.649  < 2e-16 ***
## factor(naics)327999 -0.992372   0.034620 -28.665  < 2e-16 ***
## factor(naics)331111 -0.987550   0.036529 -27.035  < 2e-16 ***
## factor(naics)331112 -0.671890   0.034652 -19.390  < 2e-16 ***
## factor(naics)331210 -0.610179   0.034583 -17.644  < 2e-16 ***
## factor(naics)331221 -0.313074   0.034529  -9.067  < 2e-16 ***
## factor(naics)331222 -0.856109   0.034617 -24.731  < 2e-16 ***
## factor(naics)331311 -0.246910   0.035161  -7.022 2.24e-12 ***
## factor(naics)331312 -0.602437   0.034787 -17.318  < 2e-16 ***
## factor(naics)331314  0.069019   0.034639   1.993 0.046323 *
## factor(naics)331315 -0.373341   0.034681 -10.765  < 2e-16 ***
## factor(naics)331316 -0.917488   0.034564 -26.544  < 2e-16 ***
## factor(naics)331319 -0.386254   0.034950 -11.052  < 2e-16 ***
## factor(naics)331411  0.366279   0.034645  10.572  < 2e-16 ***
## factor(naics)331419 -0.399190   0.034546 -11.555  < 2e-16 ***
## factor(naics)331421 -0.366631   0.034561 -10.608  < 2e-16 ***
## factor(naics)331422 -0.583218   0.035339 -16.503  < 2e-16 ***
## factor(naics)331423  0.127215   0.035174   3.617 0.000299 ***
## factor(naics)331491 -0.519384   0.034556 -15.030  < 2e-16 ***
## factor(naics)331492 -0.369756   0.034588 -10.690  < 2e-16 ***
## factor(naics)331511 -1.555910   0.035033 -44.412  < 2e-16 ***
## factor(naics)331512 -1.350436   0.034839 -38.762  < 2e-16 ***
## factor(naics)331513 -1.487499   0.034606 -42.984  < 2e-16 ***
## factor(naics)331521 -1.312549   0.034636 -37.896  < 2e-16 ***
## factor(naics)331522 -1.243710   0.034925 -35.611  < 2e-16 ***
## factor(naics)331524 -1.380420   0.034831 -39.631  < 2e-16 ***
## factor(naics)331525 -1.287273   0.034910 -36.875  < 2e-16 ***
## factor(naics)331528 -1.012293   0.035478 -28.533  < 2e-16 ***
## factor(naics)332111 -1.087186   0.034581 -31.439  < 2e-16 ***
## factor(naics)332112 -0.888737   0.034684 -25.624  < 2e-16 ***
## factor(naics)332114 -0.498762   0.035167 -14.183  < 2e-16 ***
## factor(naics)332115 -0.814717   0.035040 -23.251  < 2e-16 ***
## factor(naics)332116 -1.260804   0.034841 -36.188  < 2e-16 ***
## factor(naics)332117 -1.065230   0.035125 -30.327  < 2e-16 ***
## factor(naics)332211 -0.943645   0.034778 -27.134  < 2e-16 ***
## factor(naics)332212 -1.165370   0.034765 -33.521  < 2e-16 ***
## factor(naics)332213 -0.982406   0.035174 -27.930  < 2e-16 ***
## factor(naics)332214 -0.781849   0.035017 -22.328  < 2e-16 ***
## factor(naics)332311 -0.640246   0.034974 -18.306  < 2e-16 ***
## factor(naics)332312 -0.912986   0.034928 -26.139  < 2e-16 ***
## factor(naics)332313 -1.111728   0.034858 -31.893  < 2e-16 ***
## factor(naics)332321 -1.045898   0.034952 -29.924  < 2e-16 ***
## factor(naics)332322 -1.037334   0.034939 -29.690  < 2e-16 ***
## factor(naics)332323 -1.053286   0.035017 -30.079  < 2e-16 ***
## factor(naics)332410 -0.934867   0.034699 -26.942  < 2e-16 ***
## factor(naics)332420 -0.962016   0.034709 -27.717  < 2e-16 ***
## factor(naics)332431 -0.537465   0.034693 -15.492  < 2e-16 ***
## factor(naics)332439 -0.953654   0.034851 -27.364  < 2e-16 ***
## factor(naics)332510 -1.191960   0.034798 -34.254  < 2e-16 ***
## factor(naics)332611 -0.904525   0.035295 -25.627  < 2e-16 ***
## factor(naics)332612 -1.264829   0.034800 -36.346  < 2e-16 ***
## factor(naics)332618 -1.235207   0.034764 -35.531  < 2e-16 ***
## factor(naics)332710 -1.607679   0.035244 -45.616  < 2e-16 ***
```

```
## factor(naics)332721 -1.434137   0.034872 -41.125  < 2e-16 ***
## factor(naics)332722 -1.211832   0.034702 -34.921  < 2e-16 ***
## factor(naics)332811 -1.309847   0.034594 -37.864  < 2e-16 ***
## factor(naics)332812 -1.153516   0.034831 -33.118  < 2e-16 ***
## factor(naics)332813 -1.687823   0.034833 -48.455  < 2e-16 ***
## factor(naics)332911 -0.969103   0.034649 -27.969  < 2e-16 ***
## factor(naics)332912 -1.018578   0.034696 -29.358  < 2e-16 ***
## factor(naics)332913 -0.718910   0.034940 -20.576  < 2e-16 ***
## factor(naics)332919 -1.002352   0.034729 -28.862  < 2e-16 ***
## factor(naics)332991 -1.303649   0.034646 -37.628  < 2e-16 ***
## factor(naics)332992 -0.981833   0.035089 -27.981  < 2e-16 ***
## factor(naics)332993 -0.866912   0.034772 -24.931  < 2e-16 ***
## factor(naics)332994 -1.032497   0.035227 -29.310  < 2e-16 ***
## factor(naics)332995 -0.925456   0.034669 -26.694  < 2e-16 ***
## factor(naics)332996 -0.895153   0.034866 -25.674  < 2e-16 ***
## factor(naics)332997 -1.383875   0.035449 -39.039  < 2e-16 ***
## factor(naics)332998 -1.069814   0.034783 -30.757  < 2e-16 ***
## factor(naics)332999 -1.129414   0.034794 -32.460  < 2e-16 ***
## factor(naics)333111 -0.768618   0.034785 -22.096  < 2e-16 ***
## factor(naics)333112 -0.591472   0.034700 -17.045  < 2e-16 ***
## factor(naics)333120 -0.636516   0.034828 -18.276  < 2e-16 ***
## factor(naics)333131 -0.727855   0.034767 -20.935  < 2e-16 ***
## factor(naics)333132 -0.856132   0.034588 -24.753  < 2e-16 ***
## factor(naics)333210 -0.938869   0.034885 -26.913  < 2e-16 ***
## factor(naics)333220 -0.839455   0.035266 -23.804  < 2e-16 ***
## factor(naics)333291 -0.769162   0.034758 -22.129  < 2e-16 ***
## factor(naics)333292 -1.214371   0.034718 -34.978  < 2e-16 ***
## factor(naics)333293 -0.804660   0.034641 -23.229  < 2e-16 ***
## factor(naics)333294 -0.729540   0.035002 -20.843  < 2e-16 ***
## factor(naics)333295 -0.537002   0.034629 -15.507  < 2e-16 ***
## factor(naics)333298 -0.886176   0.034660 -25.567  < 2e-16 ***
## factor(naics)333311 -0.927770   0.035084 -26.444  < 2e-16 ***
## factor(naics)333312 -0.837776   0.035573 -23.551  < 2e-16 ***
## factor(naics)333313 -0.573570   0.034653 -16.552  < 2e-16 ***
## factor(naics)333314 -0.927389   0.034932 -26.549  < 2e-16 ***
## factor(naics)333315 -0.443397   0.034537 -12.838  < 2e-16 ***
## factor(naics)333319 -0.718673   0.034856 -20.618  < 2e-16 ***
## factor(naics)333411 -0.891532   0.035136 -25.373  < 2e-16 ***
## factor(naics)333412 -0.844721   0.035194 -24.002  < 2e-16 ***
## factor(naics)333414 -0.905708   0.034706 -26.096  < 2e-16 ***
## factor(naics)333415 -0.861460   0.034904 -24.681  < 2e-16 ***
## factor(naics)333511 -1.492685   0.034796 -42.898  < 2e-16 ***
## factor(naics)333512 -0.931369   0.034641 -26.886  < 2e-16 ***
## factor(naics)333513 -1.024067   0.034720 -29.495  < 2e-16 ***
## factor(naics)333514 -1.528278   0.034851 -43.852  < 2e-16 ***
## factor(naics)333515 -1.244214   0.034805 -35.748  < 2e-16 ***
## factor(naics)333516 -0.741105   0.035237 -21.032  < 2e-16 ***
## factor(naics)333518 -0.797072   0.035388 -22.524  < 2e-16 ***
## factor(naics)333611 -0.548127   0.034548 -15.866  < 2e-16 ***
## factor(naics)333612 -1.118749   0.034634 -32.302  < 2e-16 ***
## factor(naics)333613 -1.088252   0.034632 -31.424  < 2e-16 ***
## factor(naics)333618 -0.666711   0.034729 -19.197  < 2e-16 ***
## factor(naics)333911 -0.633440   0.034654 -18.279  < 2e-16 ***
## factor(naics)333912 -0.557922   0.034669 -16.093  < 2e-16 ***
```

```
## factor(naics)333913 -0.627043   0.035177 -17.825  < 2e-16 ***
## factor(naics)333921 -0.592412   0.035232 -16.815  < 2e-16 ***
## factor(naics)333922 -0.697311   0.034842 -20.013  < 2e-16 ***
## factor(naics)333923 -0.816422   0.034777 -23.476  < 2e-16 ***
## factor(naics)333924 -0.597202   0.034810 -17.156  < 2e-16 ***
## factor(naics)333991 -0.738498   0.034769 -21.240  < 2e-16 ***
## factor(naics)333992 -0.529690   0.034946 -15.157  < 2e-16 ***
## factor(naics)333993 -0.855328   0.034712 -24.641  < 2e-16 ***
## factor(naics)333994 -0.681173   0.035153 -19.377  < 2e-16 ***
## factor(naics)333995 -0.963426   0.034665 -27.792  < 2e-16 ***
## factor(naics)333996 -0.983033   0.034651 -28.369  < 2e-16 ***
## factor(naics)333997 -0.690791   0.035866 -19.260  < 2e-16 ***
## factor(naics)333999 -0.981332   0.034663 -28.310  < 2e-16 ***
## factor(naics)334111  0.186684   0.034644   5.389 7.17e-08 ***
## factor(naics)334112 -0.372597   0.034556 -10.782  < 2e-16 ***
## factor(naics)334113 -0.448443   0.035147 -12.759  < 2e-16 ***
## factor(naics)334119 -0.317523   0.034638  -9.167  < 2e-16 ***
## factor(naics)334210 -0.525165   0.034756 -15.110  < 2e-16 ***
## factor(naics)334220 -0.485370   0.034774 -13.958  < 2e-16 ***
## factor(naics)334290 -0.461833   0.035371 -13.057  < 2e-16 ***
## factor(naics)334310 -0.511162   0.034650 -14.752  < 2e-16 ***
## factor(naics)334411 -1.304174   0.034555 -37.742  < 2e-16 ***
## factor(naics)334412 -1.466004   0.034817 -42.106  < 2e-16 ***
## factor(naics)334413 -0.934863   0.035082 -26.648  < 2e-16 ***
## factor(naics)334414 -1.381733   0.034817 -39.685  < 2e-16 ***
## factor(naics)334415 -1.372659   0.034952 -39.273  < 2e-16 ***
## factor(naics)334416 -1.358942   0.035306 -38.491  < 2e-16 ***
## factor(naics)334417 -1.100295   0.034810 -31.609  < 2e-16 ***
## factor(naics)334418 -0.739961   0.034723 -21.310  < 2e-16 ***
## factor(naics)334419 -1.210568   0.035042 -34.546  < 2e-16 ***
## factor(naics)334510 -0.420598   0.034896 -12.053  < 2e-16 ***
## factor(naics)334511 -0.588428   0.035011 -16.807  < 2e-16 ***
## factor(naics)334512 -0.978540   0.035031 -27.933  < 2e-16 ***
## factor(naics)334513 -0.687282   0.034808 -19.745  < 2e-16 ***
## factor(naics)334514 -0.610523   0.035218 -17.335  < 2e-16 ***
## factor(naics)334515 -0.781835   0.034658 -22.559  < 2e-16 ***
## factor(naics)334516 -0.452189   0.034716 -13.025  < 2e-16 ***
## factor(naics)334517 -0.003067   0.035778  -0.086 0.931692
## factor(naics)334518 -0.845327   0.035073 -24.102  < 2e-16 ***
## factor(naics)334519 -0.714117   0.034861 -20.485  < 2e-16 ***
## factor(naics)334611 -1.344801   0.052574 -25.579  < 2e-16 ***
## factor(naics)334612 -1.240475   0.034556 -35.897  < 2e-16 ***
## factor(naics)334613 -0.968703   0.034567 -28.024  < 2e-16 ***
## factor(naics)335110 -0.994197   0.034690 -28.659  < 2e-16 ***
## factor(naics)335121 -0.979898   0.035217 -27.825  < 2e-16 ***
## factor(naics)335122 -0.729940   0.035066 -20.816  < 2e-16 ***
## factor(naics)335129 -0.703151   0.035166 -19.995  < 2e-16 ***
## factor(naics)335211 -0.874278   0.034761 -25.151  < 2e-16 ***
## factor(naics)335212 -0.632945   0.035001 -18.084  < 2e-16 ***
## factor(naics)335221 -0.739892   0.034843 -21.235  < 2e-16 ***
## factor(naics)335222 -0.768315   0.034709 -22.136  < 2e-16 ***
## factor(naics)335224 -0.538771   0.034701 -15.526  < 2e-16 ***
## factor(naics)335228 -0.606660   0.034861 -17.402  < 2e-16 ***
## factor(naics)335311 -0.893185   0.034788 -25.675  < 2e-16 ***
```

```
## factor(naics)335312 -1.085124   0.034860 -31.128  < 2e-16 ***
## factor(naics)335313 -0.771269   0.034863 -22.123  < 2e-16 ***
## factor(naics)335314 -0.811640   0.034810 -23.317  < 2e-16 ***
## factor(naics)335911 -0.861298   0.034683 -24.834  < 2e-16 ***
## factor(naics)335912 -0.632931   0.034992 -18.088  < 2e-16 ***
## factor(naics)335921 -0.461335   0.034723 -13.286  < 2e-16 ***
## factor(naics)335929 -0.600710   0.034640 -17.341  < 2e-16 ***
## factor(naics)335931 -1.080364   0.034831 -31.018  < 2e-16 ***
## factor(naics)335932 -0.791637   0.034718 -22.802  < 2e-16 ***
## factor(naics)335991 -0.996607   0.034639 -28.771  < 2e-16 ***
## factor(naics)335999 -0.885068   0.034771 -25.454  < 2e-16 ***
## factor(naics)336111 -0.223355   0.035357  -6.317 2.71e-10 ***
## factor(naics)336112  0.025511   0.035421   0.720 0.471402
## factor(naics)336120 -0.407353   0.034626 -11.764  < 2e-16 ***
## factor(naics)336211 -0.866260   0.034978 -24.766  < 2e-16 ***
## factor(naics)336212 -0.833218   0.034836 -23.918  < 2e-16 ***
## factor(naics)336213 -0.452468   0.035590 -12.713  < 2e-16 ***
## factor(naics)336214 -0.802646   0.035317 -22.727  < 2e-16 ***
## factor(naics)336311 -1.307652   0.034629 -37.761  < 2e-16 ***
## factor(naics)336312 -0.642410   0.034870 -18.423  < 2e-16 ***
## factor(naics)336321 -0.848332   0.034907 -24.302  < 2e-16 ***
## factor(naics)336322 -0.942606   0.034821 -27.070  < 2e-16 ***
## factor(naics)336330 -0.894231   0.034627 -25.824  < 2e-16 ***
## factor(naics)336340 -0.791633   0.034599 -22.880  < 2e-16 ***
## factor(naics)336350 -0.736660   0.035016 -21.038  < 2e-16 ***
## factor(naics)336360 -0.567438   0.034940 -16.240  < 2e-16 ***
## factor(naics)336370 -1.150738   0.035030 -32.850  < 2e-16 ***
## factor(naics)336391 -0.563113   0.034645 -16.254  < 2e-16 ***
## factor(naics)336399 -1.013133   0.035140 -28.832  < 2e-16 ***
## factor(naics)336411 -0.453517   0.035182 -12.891  < 2e-16 ***
## factor(naics)336412 -0.639090   0.034841 -18.343  < 2e-16 ***
## factor(naics)336413 -0.990945   0.034942 -28.360  < 2e-16 ***
## factor(naics)336414 -0.260075   0.034669  -7.502 6.51e-14 ***
## factor(naics)336415 -0.500080   0.034602 -14.452  < 2e-16 ***
## factor(naics)336419 -0.876070   0.034673 -25.267  < 2e-16 ***
## factor(naics)336510 -0.634612   0.034684 -18.297  < 2e-16 ***
## factor(naics)336611 -1.321141   0.035024 -37.721  < 2e-16 ***
## factor(naics)336612 -1.154329   0.034888 -33.087  < 2e-16 ***
## factor(naics)336991 -0.721044   0.034904 -20.658  < 2e-16 ***
## factor(naics)336992 -0.276771   0.034706  -7.975 1.59e-15 ***
## factor(naics)336999 -0.390463   0.035276 -11.069  < 2e-16 ***
## factor(naics)337110 -1.288757   0.035281 -36.529  < 2e-16 ***
## factor(naics)337121 -1.274946   0.035366 -36.050  < 2e-16 ***
## factor(naics)337122 -1.556170   0.035198 -44.212  < 2e-16 ***
## factor(naics)337124 -1.136689   0.035159 -32.330  < 2e-16 ***
## factor(naics)337125 -1.051959   0.035983 -29.235  < 2e-16 ***
## factor(naics)337127 -1.197074   0.035569 -33.655  < 2e-16 ***
## factor(naics)337129 -1.410816   0.035693 -39.526  < 2e-16 ***
## factor(naics)337211 -1.198166   0.035521 -33.731  < 2e-16 ***
## factor(naics)337212 -1.026126   0.035923 -28.565  < 2e-16 ***
## factor(naics)337214 -0.974499   0.034710 -28.075  < 2e-16 ***
## factor(naics)337215 -1.173947   0.035071 -33.473  < 2e-16 ***
## factor(naics)337910 -0.751799   0.035144 -21.392  < 2e-16 ***
## factor(naics)337920 -0.901563   0.035406 -25.464  < 2e-16 ***
```

```
## factor(naics)339111 -0.650868   0.035124 -18.531  < 2e-16 ***
## factor(naics)339112 -0.844347   0.034824 -24.246  < 2e-16 ***
## factor(naics)339113 -0.739332   0.034787 -21.253  < 2e-16 ***
## factor(naics)339114 -0.649751   0.035335 -18.388  < 2e-16 ***
## factor(naics)339115 -1.177833   0.034842 -33.805  < 2e-16 ***
## factor(naics)339116 -1.987094   0.052547 -37.815  < 2e-16 ***
## factor(naics)339911 -0.591198   0.035418 -16.692  < 2e-16 ***
## factor(naics)339912 -1.050122   0.035193 -29.839  < 2e-16 ***
## factor(naics)339913 -0.479928   0.035943 -13.353  < 2e-16 ***
## factor(naics)339914 -1.172510   0.035502 -33.026  < 2e-16 ***
## factor(naics)339920 -0.967956   0.034913 -27.725  < 2e-16 ***
## factor(naics)339931 -1.173011   0.035581 -32.967  < 2e-16 ***
## factor(naics)339932 -0.998133   0.034722 -28.746  < 2e-16 ***
## factor(naics)339941 -0.956899   0.035099 -27.263  < 2e-16 ***
## factor(naics)339942 -0.730586   0.035326 -20.681  < 2e-16 ***
## factor(naics)339943 -1.070438   0.035978 -29.752  < 2e-16 ***
## factor(naics)339944 -0.661865   0.035501 -18.644  < 2e-16 ***
## factor(naics)339950 -1.116549   0.035177 -31.741  < 2e-16 ***
## factor(naics)339991 -1.156341   0.034843 -33.187  < 2e-16 ***
## factor(naics)339992 -1.197645   0.035361 -33.869  < 2e-16 ***
## factor(naics)339993 -1.282522   0.034948 -36.698  < 2e-16 ***
## factor(naics)339994 -0.999465   0.035325 -28.293  < 2e-16 ***
## factor(naics)339995 -1.054577   0.035206 -29.954  < 2e-16 ***
## factor(naics)339999 -1.100663   0.035130 -31.331  < 2e-16 ***
## factor(year)1959     0.058403   0.011718   4.984 6.26e-07 ***
## factor(year)1960     0.054302   0.011720   4.633 3.61e-06 ***
## factor(year)1961     0.067677   0.011725   5.772 7.93e-09 ***
## factor(year)1962     0.098458   0.011730   8.394  < 2e-16 ***
## factor(year)1963     0.136170   0.011738  11.601  < 2e-16 ***
## factor(year)1964     0.169833   0.011747  14.457  < 2e-16 ***
## factor(year)1965     0.207093   0.011762  17.607  < 2e-16 ***
## factor(year)1966     0.242749   0.011784  20.600  < 2e-16 ***
## factor(year)1967     0.271702   0.011815  22.996  < 2e-16 ***
## factor(year)1968     0.321152   0.011845  27.114  < 2e-16 ***
## factor(year)1969     0.358982   0.011873  30.236  < 2e-16 ***
## factor(year)1970     0.386104   0.011917  32.399  < 2e-16 ***
## factor(year)1971     0.464643   0.011963  38.840  < 2e-16 ***
## factor(year)1972     0.533986   0.011978  44.579  < 2e-16 ***
## factor(year)1973     0.615560   0.012001  51.293  < 2e-16 ***
## factor(year)1974     0.758911   0.012048  62.989  < 2e-16 ***
## factor(year)1975     0.858320   0.012133  70.740  < 2e-16 ***
## factor(year)1976     0.932057   0.012141  76.769  < 2e-16 ***
## factor(year)1977     1.014496   0.012151  83.494  < 2e-16 ***
## factor(year)1978     1.090408   0.012175  89.558  < 2e-16 ***
## factor(year)1979     1.167707   0.012206  95.664  < 2e-16 ***
## factor(year)1980     1.267025   0.012273 103.239  < 2e-16 ***
## factor(year)1981     1.349149   0.012316 109.540  < 2e-16 ***
## factor(year)1982     1.406985   0.012404 113.431  < 2e-16 ***
## factor(year)1983     1.458895   0.012412 117.541  < 2e-16 ***
## factor(year)1984     1.517332   0.012411 122.262  < 2e-16 ***
## factor(year)1985     1.550256   0.012470 124.321  < 2e-16 ***
## factor(year)1986     1.579729   0.012507 126.305  < 2e-16 ***
## factor(year)1987     1.631222   0.012491 130.595  < 2e-16 ***
## factor(year)1988     1.691260   0.012492 135.388  < 2e-16 ***
```

```
## factor(year)1989     1.731325   0.012511 138.380  < 2e-16 ***
## factor(year)1990     1.752909   0.012551 139.662  < 2e-16 ***
## factor(year)1991     1.768468   0.012610 140.241  < 2e-16 ***
## factor(year)1992     1.813947   0.012604 143.917  < 2e-16 ***
## factor(year)1993     1.852915   0.012615 146.883  < 2e-16 ***
## factor(year)1994     1.900036   0.012620 150.560  < 2e-16 ***
## factor(year)1995     1.941684   0.012629 153.752  < 2e-16 ***
## factor(year)1996     1.970954   0.012664 155.636  < 2e-16 ***
## factor(year)1997     2.033221   0.012704 160.049  < 2e-16 ***
## factor(year)1998     2.039690   0.012757 159.889  < 2e-16 ***
## factor(year)1999     2.048485   0.012849 159.425  < 2e-16 ***
## factor(year)2000     2.077995   0.012931 160.703  < 2e-16 ***
## factor(year)2001     2.067797   0.013062 158.302  < 2e-16 ***
## factor(year)2002     2.118975   0.013203 160.491  < 2e-16 ***
## factor(year)2003     2.144576   0.013251 161.841  < 2e-16 ***
## factor(year)2004     2.223414   0.013300 167.174  < 2e-16 ***
## factor(year)2005     2.306513   0.013311 173.275  < 2e-16 ***
## factor(year)2006     2.363675   0.013348 177.080  < 2e-16 ***
## factor(year)2007     2.390965   0.013354 179.039  < 2e-16 ***
## factor(year)2008     2.423815   0.013437 180.379  < 2e-16 ***
## factor(year)2009     2.374015   0.013705 173.221  < 2e-16 ***
## factor(year)2010     2.463002   0.013720 179.518  < 2e-16 ***
## factor(year)2011     2.524589   0.013678 184.573  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1794 on 24858 degrees of freedom
##   (156 observations deleted due to missingness)
## Multiple R-squared:  0.9832, Adjusted R-squared:  0.9828
## F-statistic:  2756 on 527 and 24858 DF,  p-value: < 2.2e-16
```

Estimates of beta1 and beta2 for different estimation approaches. OLS: beta1 0.12, beta2 0.883 IV: beta1 -0.81, beta2 1.36 fixed: 0.787, beta2 0.284

We probably would never be able to say that any model is capable of completely resolving the endogeneity problem, but the fixed effect model seems a rather effective way to reduce the effect of a endogenous variable.

Compare the three pairs of beta estimates above, I would say that since we have chosen a not so appropriate instrument for the IV model, we could not give a fair judgment of the effectiveness of it in resolving the endogeneity issue. Therefore, the fixed effect modle is perhaps the most credible one.

Olley and Pakes model

```
data <- data %>% mutate(cap_sq = (cap)^2, invest_sq = (invest)^2)

fit4 <- lm(log(vship) ~ log(prodh) + cap + invest + cap_sq + invest_sq + invest*cap,data)
summary(fit4)
```

```
##
## Call:
## lm(formula = log(vship) ~ log(prodh) + cap + invest + cap_sq +
##     invest_sq + invest * cap, data = data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
```

```
## -6.2188 -0.6792  0.1169  0.6815 10.8175
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)  5.580e+00  2.080e-02 268.261   <2e-16 ***
## log(prodh)   4.419e-01  6.441e-03  68.612   <2e-16 ***
## cap          1.226e-04  3.522e-06  34.794   <2e-16 ***
## invest       1.302e-03  4.352e-05  29.912   <2e-16 ***
## cap_sq      -1.522e-09  5.343e-11 -28.489   <2e-16 ***
## invest_sq   -5.491e-08  5.416e-09 -10.139   <2e-16 ***
## cap:invest  -1.166e-09  1.059e-09  -1.101    0.271
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9127 on 25379 degrees of freedom
##   (156 observations deleted due to missingness)
## Multiple R-squared:  0.5553, Adjusted R-squared:  0.5552
## F-statistic:  5282 on 6 and 25379 DF,  p-value: < 2.2e-16
```

```
beta2_MOM <- function(beta2){
  data <- data %>% mutate(h_it = 1.226e-04*cap + 1.302e-03*invest + -1.522e-09*cap_sq + -5.491e-08*inves

  # create an empty data frame with all variable names of the orginal dataset
  final <- data
  final = final[FALSE,]

  for (i in unique(data$naics)){
  naics_set <- filter(data, naics == i)
  naics_set <- naics_set %>% mutate(ome_it_lag = lag(ome_it))
  final <- rbind(final, naics_set)
  }

  fit <- lm(ome_it ~ ome_it_lag, final)
  rho0 <- fit$coefficients[1]
  rho1 <- fit$coefficients[2]

  final <- final %>% mutate(rho0 = rho0, rho1 = rho1) %>% mutate(
  xi = ome_it - rho0 - rho1*ome_it_lag)

  v <- mean(final$xi*final$cap, na.rm = TRUE)
  return(v)
}
```

```
library(nleqslv)
beta2 <- 1
nleqslv(beta2, beta2_MOM)
```

```
## $x
## [1] 0.6300946
##
## $fvec
## [1] 1.210632e-10
##
## $termcd
## [1] 1
```

```
##
## $message
## [1] "Function criterion near zero"
##
## $scalex
## [1] 1
##
## $nfcnt
## [1] 7
##
## $njcnt
## [1] 1
##
## $iter
## [1] 7
```

```
# beta1 is 0.442, and beta2 is 0.63.
```

Since beta1 + beta2 > 1, there is increasing returns to scale.