Table 1: Test Summary

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Poolability	NA	NA	NA	NA	NA	NA
Hausmann	Fixed	Fixed	Fixed	Fixed	Fixed	Fixed
Time Fixed Effect	No	Yes	No	Yes	No	Yes
Cross Sectional Dependence	?	Yes	?	?	?	Yes
Serial Correlation	Yes	Yes	Yes	Yes	Yes	Yes
Stationarity	None	None	None	None	None	None
Heteroskedasticity	Yes	Yes	Yes	Yes	Yes	Yes

Tests

This section will not be in the final document. It is only to report the result of the bunch of tests I carried out in order to define which panel data methotolody I will use for each one of my 6 models.

@Croissant2008a and @Torres-Reyna2010 really helped me.

Here are the tests :

1. Test of poolability
2. Hausmann Test to determine the fixed or random effect
3. Test for time fixed effect
4. Test for cross-sectional dependence
5. Test for serial correlation
6. Test for stationarity
7. Test for heteroskedasticity

The table 1 summaries the result of each test for each model. You can find details below.

Regarding the poolability test I have an issue with my code that I still need to solve. This is why it writtent *NA* in the table 1. I have also an issue with the test for cross-sectionnal dependence. Indeed depending the method I used with the test syntax (i.e. Pesaran's CD test (test="cd"), Breusch and Pagan's LM test (test="lm"), I got divergent results. **Do you know why?**

Some specifications :

1. The data base of model 1,3 and 5 (i.e. model with DV = ROA) is not the same than the one of model 2,4 and 6 (i.e. model with DV = Tobins Q). Indeed I have 350 companies whose I have the tobin's Q value as I have 399 companies whose I have the ROA's value. **What do you think? Can I do that? Maybe should I do a test to test if both sample are the same? What kind of test?**
2. As in my data base I have some negatieve DebtRatio (i.e. leverage) I used the sq(DebtRatio) as a control variable. **Is it ok?**

3.I did not remove outliers from my databases. **I still need to have your opinion about the outliers treatment in panel data.** However I have identified them in measuring the cooks distance. Basically I have about 15 outliers in each database.

4. I have unbalanced panel data

```r
if (!require("plm")) install.packages("plm")
```

```
## Loading required package: plm
```

```
## Loading required package: Formula
```

```r
library(plm)

# I dowload my DataBase with read.csv2
DB_Tobin<-data.frame(read.csv2("DataBase/DB_Tobin.csv", sep = ";",stringsAsFactors=FALSE, header = TRUE
```

Model 1

Test

Analyse and test of my first model. These tests help select the panel model to be estimated. Here is my first model :

Model 1 : Green Initiatives on Tobin's Q

$$TobinsQ_{it+1} = \beta_0 + \beta_1(SP_{it}) + \beta_2(ST_{it}) + \beta_3(AS_{it}) + \beta_9(C_{it}) + \varepsilon_{it} \quad (1)$$

Tests of poolability

Citation from [@Croissant2008] :

> *pooltest tests the hypothesis that the same coeffcients apply to each individual. It is a standard F test, based on the comparison of a model obtained for the full sample and a model based on the estimation of an equation for each individual. The first argument of pooltest is a plm object. The second argument is a pvcm object obtained with model=within. If the first argument is a pooling model, the test applies to all the coefficients (including the intercepts), if it is a within model, different intercepts are assumed.*

```r
# Test of poolability --> error that I cannot understand

# M1_pvcm <- pvcm(TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRati

# M1_plm<-plm(TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2

# pooltest(M1_pvcm,M1_plm)

# pooltest(TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2 + N
```

Fixed or Random : Hausman Test

Citation from @Torres-Reyna2010 :

> *To decide between fixed or random effects you can run a Hausman test where the null hypothesis is that the preferred model is random effects vs. the alternative the fixed effects (see Green, 2008, chapter 9). It basically tests whether the unique errors (ui) are correlated with the regressors, the null hypothesis is they are not.*

```r
fixed <- plm(TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2 +

random <- plm(TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2
```

```r
phtest(fixed,random)
```

```
##
##  Hausman Test
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +  ...
## chisq = 73.256, df = 6, p-value = 8.769e-14
## alternative hypothesis: one model is inconsistent
```

Interpretation : P-Value < 0.05 then Ho is rejected and I have to use the fixed-effect.

Testing for time fixed effects

```r
fixed <- plm(TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2 +

fixed_time <- plm(TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRati


# Testing the time-fixed effects. The null is that no time-fixed effects needed
pFtest(fixed_time, fixed)
```

```
##
##  F test for individual effects
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +  ...
## F = 1.2064, df1 = 2, df2 = 692, p-value = 0.2999
## alternative hypothesis: significant effects
```

Interpretation Fixed_time effect : P-Value is > 0.05 meaning that null hypothesis is verified and that there is not a significant time-fixed effect. **So I do not need to use time fixed effect in my model1!!**

Testing for cross-sectional dependence/contemporaneous correlation

Citation from @Torres-Reyna2010 :

> According to Baltagi, cross-sectional dependence is a problem in macro panels with long time series. This is not much of a problem in micro panels (few years and large number of cases). The null hypothesis in the B -P/LM and Pasaran CD tests of independence is that residuals across entities are not correlated. B- P/LM and Pasaran CD (cross-sectional dependence) tests are used to test whether the residuals are correlated across entities*. Cross-sectional dependence can lead to bias in tests results (also called contemporaneous correlation).

```r
pcdtest(fixed_time, test = c("lm"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditScore + DebtRatio^2 +
## chisq = 102140, df = 61773, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```r
pcdtest(fixed_time, test = c("cd"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditScore + DebtRatio^2 +
## z = 1.5264, p-value = 0.1269
## alternative hypothesis: cross-sectional dependence
```

```r
pcdtest(fixed, test = c("lm"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditScore + DebtRatio^2 +
## chisq = 101960, df = 61773, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```r
pcdtest(fixed, test = c("cd"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditScore + DebtRatio^2 +
## z = 3.8613, p-value = 0.0001128
## alternative hypothesis: cross-sectional dependence
```

Depending the method used, HO is verified (Pesaran), namely the model do not have cross-sectional dependence or rejected (Breusch-Pagan)... **Which one is the most suitable for my model?**

Testing for serial correlation

```r
pbgtest(fixed_time)
```

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
##  models
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditScore + DebtRatio^2 +
## chisq = 25.464, df = 1, p-value = 4.507e-07
## alternative hypothesis: serial correlation in idiosyncratic errors
```

```r
pbgtest(fixed)
```

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
```

```
##  models
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditScore + DebtRatio^2 +
## chisq = 25.495, df = 1, p-value = 4.435e-07
## alternative hypothesis: serial correlation in idiosyncratic errors
```

Interpretation: HO is rejected as p-value < 0.05 then I have serial correlation. . . .

Testing for stationarity

```
if (!require("tseries")) install.packages("tseries")
```

```
## Loading required package: tseries
```

```
library(tseries)
PanelSet <- plm.data(DB_Tobin, index = c("Companies", "YearFinancialIndicator"))
```

```
## Warning: use of 'plm.data' is discouraged, better use 'pdata.frame' instead
```

```
adf.test(PanelSet$TobinsQ, k=2)
```

```
## Warning in adf.test(PanelSet$TobinsQ, k = 2): p-value smaller than printed
## p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  PanelSet$TobinsQ
## Dickey-Fuller = -16.843, Lag order = 2, p-value = 0.01
## alternative hypothesis: stationary
```

Ho : Series has stationarity **Interpretation :** p-value < 0.05 then ho is rejected and my panel data do not have stationarity

Testing for heteroskedasticity

```
if (!require("lmtest")) install.packages("lmtest")
```

```
## Loading required package: lmtest
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

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

```
library(lmtest)

bptest(TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2 + NetMa
```

```
##
##  Breusch-Pagan test
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditScore + DebtRatio^2 +
## BP = 9390.5, df = 365, p-value < 2.2e-16
```

Interpretation: p-value < 0.05 then the null hypothesis of homoskedasticity is rejected and heteroskedasticity assumed...

Use the **sandwich estimator** to account for the heteroskedasticity issue? See @MiroshnychenkoGreenpracticesfinancial2017 and @Stock2008

"If hetersokedaticity is detected you can use the sandwich estimaror" [@Torres-Reyna2010]

vcovHC is a function for estimating a robust covariance matrix of parameters for a fixed effects or random effects panel model according to the White method (White 1980, 1984; Arellano 1987). The –vcovHC– function estimates three heteroskedasticity-consistent covariance estimators:

- "white1" - for general heteroskedasticity but no serial correlation. Recommended for random effects.
- "white2" - is "white1" restricted to a common variance within groups. Recommended for random effects.
- "arellano" - both heteroskedasticity and serial correlation. Recommended for fixed effects.

The following options apply*:

- HC0 - heteroskedasticity consistent. The default.
- HC1,HC2, HC3 – Recommended for small samples. HC3 gives less weight to influential observations.
- HC4 - small samples with influential observations
- HAC - heteroskedasticity and autocorrelation consistent (type ?vcovHAC for more details)

```
coeftest(fixed) # Original coefficients
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value Pr(>|t|)
## SustainabilityPayLink        7.8140e-01  6.2396e-01  1.2523  0.21088
## SustainableThemedCommitment  3.4699e+00  2.0681e+00  1.6778  0.09383 .
## AuditScore                   4.4975e-01  1.9719e+00  0.2281  0.81965
## DebtRatio                    8.5462e-05  5.5560e-04  0.1538  0.87780
## NetMargin                    1.7293e-02  1.2575e-01  0.1375  0.89066
## log(Asset)                  -1.3909e-01  5.4198e-02 -2.5663  0.01049 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed, vcovHC) # Heteroskedasticity consistent coefficients
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value Pr(>|t|)
## SustainabilityPayLink        7.8140e-01  4.5439e-01  1.7197  0.08594 .
## SustainableThemedCommitment  3.4699e+00  2.4628e+00  1.4089  0.15930
## AuditScore                   4.4975e-01  9.0368e-01  0.4977  0.61886
## DebtRatio                    8.5462e-05  1.1681e-04  0.7316  0.46463
## NetMargin                    1.7293e-02  1.7574e-01  0.0984  0.92164
## log(Asset)                  -1.3909e-01  1.6191e-01 -0.8591  0.39061
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed, vcovHC(fixed, method = "arellano")) # Heteroskedasticity consistent
```

```
##
## t test of coefficients:
```

```
##
##                                Estimate  Std. Error t value Pr(>|t|)
## SustainabilityPayLink        7.8140e-01  4.5439e-01  1.7197  0.08594 .
## SustainableThemedCommitment  3.4699e+00  2.4628e+00  1.4089  0.15930
## AuditScore                   4.4975e-01  9.0368e-01  0.4977  0.61886
## DebtRatio                    8.5462e-05  1.1681e-04  0.7316  0.46463
## NetMargin                    1.7293e-02  1.7574e-01  0.0984  0.92164
## log(Asset)                  -1.3909e-01  1.6191e-01 -0.8591  0.39061
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed, vcovHC(fixed, type = "HC3")) # Heteroskedasticity consistent coefficients, type 3coeffi
```

```
##
## t test of coefficients:
##
##                                Estimate  Std. Error t value Pr(>|t|)
## SustainabilityPayLink        7.8140e-01  4.6315e-01  1.6871  0.09203 .
## SustainableThemedCommitment  3.4699e+00  2.5156e+00  1.3793  0.16824
## AuditScore                   4.4975e-01  9.3231e-01  0.4824  0.62967
## DebtRatio                    8.5462e-05  1.3739e-04  0.6220  0.53413
## NetMargin                    1.7293e-02  1.8436e-01  0.0938  0.92530
## log(Asset)                  -1.3909e-01  1.9042e-01 -0.7304  0.46538
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# The following shows the HC standard errors of the coefficients
t(sapply(c("HC0", "HC1", "HC2", "HC3", "HC4"), function(x) sqrt(diag(vcovHC(fixed, type = x)))))
```

```
##     SustainabilityPayLink SustainableThemedCommitment AuditScore
## HC0             0.4543894                    2.462755  0.9036830
## HC1             0.4556809                    2.469755  0.9062515
## HC2             0.4587034                    2.488924  0.9172043
## HC3             0.4631538                    2.515635  0.9323054
## HC4             0.4699198                    2.563063  0.9648546
##        DebtRatio NetMargin log(Asset)
## HC0 0.0001168086 0.1757424  0.1619082
## HC1 0.0001171406 0.1762419  0.1623683
## HC2 0.0001256778 0.1798083  0.1751514
## HC3 0.0001373932 0.1843639  0.1904211
## HC4 0.0001754764 0.1944598  0.2280699
```

What should I do with those estimates?

```r
if (!require("plm")) install.packages("plm")
library(plm)

# I dowload my DataBase with read.csv2
DB_ROA<-data.frame(read.csv2("DataBase/DataBase_010418.csv", sep = ";",stringsAsFactors=FALSE, header =
```

Model 2

Test

Model 2 : Green Initiatives on ROA

$$ROA_{it+1} = \beta_0 + \beta_1(SP_{it}) + \beta_2(ST_{it}) + \beta_3(AS_{it}) + \beta_9(C_{it}) + \varepsilon_{it} \quad (2)$$

where :

- $TobinsQ_{it+1}$ = a proxy for a firm's financial performance
- ROA_{it+1} = a proxy for a firm's financial performance
- EP_{it} = a proxy for a firm's energy productivity
- CP_{it} = a proxy for a firm's carbon productivity
- $WatP_{it}$ = a proxy for a firm's water productivity
- $WasP_{it}$ = a proxy for a firm's waste productivity
- GP_{it} = a proxy for a firm's green reputation
- SP_{it} = a proxy for a firm's sustainability pay link
- ST_{it} = a proxy for a firm's sustainability themed commitment
- EP_{it} = a proxy for a firm's audit score
- C_{it} = a vector of control variables that include financial leverage, firm size and industry sector
- ε_{it} = the error term

Tests of poolability

Citation from [@Croissant2008] :

> *pooltest tests the hypothesis that the same coeffcients apply to each individual. It is a standard F test, based on the comparison of a model obtained for the full sample and a model based on the estimation of an equation for each individual. The first argument of pooltest is a plm object. The second argument is a pvcm object obtained with model=within. If the first argument is a pooling model, the test applies to all the coefficients (including the intercepts), if it is a within model, different intercepts are assumed.*

```r
# Test of poolability --> error that I cannot understand

# M2_pvcm <- pvcm(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2 +

# M2_plm<-plm(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2 + Ne

# pooltest(M2_pvcm,M2_plm)

#pooltest(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2 + NetMar
```

Fixed or Random : Hausman Test

Citation from @Torres-Reyna2010 :

To decide between fixed or random effects you can run a Hausman test where the null hypothesis is that the preferred model is random effects vs. the alternative the fixed effects (see Green, 2008, chapter 9). It basically tests whether the unique errors (ui) are correlated with the regressors, the null hypothesis is they are not.

```
fixed2 <- plm(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2 + Ne

random2 <- plm(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2 + N

phtest(fixed2,random2)
```

```
##
##  Hausman Test
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +  ...
## chisq = 21.344, df = 6, p-value = 0.001591
## alternative hypothesis: one model is inconsistent
```

Interpretation : P-Value < 0.05 then Ho is rejected and I have to use the fixed-effect.

Testing for time fixed effects

```
fixed_time2 <- plm(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2


# Testing the time-fixed effects. The null is that no time-fixed effects needed
pFtest(fixed_time2, fixed2)
```

```
##
##  F test for individual effects
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +  ...
## F = 8.2374, df1 = 2, df2 = 785, p-value = 0.0002881
## alternative hypothesis: significant effects
```

Interpretation Fixed_time effect : P-Value is < 0.05 meaning that null hypothesis is rejected and that there is a significant time-fixed effect. **So I do need to use time fixed effect in my model1!!**

Testing for cross-sectional dependence/contemporaneous correlation

Citation from @Torres-Reyna2010 :

> According to Baltagi, cross-sectional dependence is a problem in macro panels with long time series. This is not much of a problem in micro panels (few years and large number of cases). The null hypothesis in the B -P/LM and Pasaran CD tests of independence is that residuals across entities are not correlated. B- P/LM and Pasaran CD (cross-sectional dependence) tests are used to test whether the residuals are correlated across entities*. Cross-sectional dependence can lead to bias in tests results (also called contemporaneous correlation).

```
pcdtest(fixed_time2, test = c("lm"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (2 percent) do not have any or just
## one time period in common and have been omitted from calculation

##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
```

```
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     DebtRatio^2 + Ne
## chisq = 123910, df = 78606, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed_time2, test = c("cd"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (2 percent) do not have any or just
## one time period in common and have been omitted from calculation
```

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     DebtRatio^2 + Ne
## z = 21.892, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed2, test = c("lm"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (2 percent) do not have any or just
## one time period in common and have been omitted from calculation
```

```
##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     DebtRatio^2 + Ne
## chisq = 122210, df = 78606, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed2, test = c("cd"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (2 percent) do not have any or just
## one time period in common and have been omitted from calculation
```

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     DebtRatio^2 + Ne
## z = 5.6983, p-value = 1.21e-08
## alternative hypothesis: cross-sectional dependence
```

HO is rejected meaning I have cross-sectionnal dependence in this model

Testing for serial correlation

```
pbgtest(fixed_time2)
```

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
##  models
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     DebtRatio^2 + Ne
## chisq = 36.715, df = 1, p-value = 1.367e-09
## alternative hypothesis: serial correlation in idiosyncratic errors
```

```
pbgtest(fixed2)
```

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
##  models
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     DebtRatio^2 + Ne
## chisq = 39.042, df = 1, p-value = 4.149e-10
## alternative hypothesis: serial correlation in idiosyncratic errors
```

Interpretation: HO is rejected as p-value < 0.05 then I have serial correlation. . . .

Testing for stationarity

```
if (!require("tseries")) install.packages("tseries")
library(tseries)
PanelSet <- plm.data(DB_ROA, index = c("Companies", "YearFinancialIndicator"))
```

```
## Warning: use of 'plm.data' is discouraged, better use 'pdata.frame' instead
```

```
adf.test(PanelSet$ROA, k=2)
```

```
## Warning in adf.test(PanelSet$ROA, k = 2): p-value smaller than printed p-
## value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  PanelSet$ROA
## Dickey-Fuller = -18.238, Lag order = 2, p-value = 0.01
## alternative hypothesis: stationary
```

Ho : Series has stationarity **Interpretation :** p-value < 0.05 then ho is rejected and my panel data do not have stationarity

Testing for heteroskedasticity

```
if (!require("lmtest")) install.packages("lmtest")
library(lmtest)

bptest(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2 + NetMargin
```

```
##
##  Breusch-Pagan test
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     DebtRatio^2 + Ne
## BP = 13815, df = 404, p-value < 2.2e-16
```

Interpretation: p-value < 0.05 then the null hypothesis of homoskedasticity is rejected and heteroskedasticity assumed. . .

Use the **sandwich estimator** to account for the heteroskedasticity issue? See @MiroshnychenkoGreenpracticesfinancial2017 and @Stock2008

"If hetersokedaticity is detected you can use the sandwich estimaror" [@Torres-Reyna2010]

vcovHC is a function for estimating a robust covariance matrix of parameters for a fixed effects or random effects panel model according to the White method (White 1980, 1984; Arellano 1987). The –vcovHC– function estimates three heteroskedasticity-consistent covariance estimators:

- "white1" - for general heteroskedasticity but no serial correlation. Recommended for random effects.
- "white2" - is "white1" restricted to a common variance within groups. Recommended for random effects.
- "arellano" - both heteroskedasticity and serial correlation. Recommended for fixed effects.

The following options apply*:

- HC0 - heteroskedasticity consistent. The default.
- HC1,HC2, HC3 – Recommended for small samples. HC3 gives less weight to influential observations.
- HC4 - small samples with influential observations
- HAC - heteroskedasticity and autocorrelation consistent (type ?vcovHAC for more details)

```
coeftest(fixed2) # Original coefficients
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value  Pr(>|t|)
## SustainabilityPayLink       -6.5040e-02  3.8739e-02 -1.6789  0.093563 .
## SustainableThemedCommitment  3.5058e-01  1.3211e-01  2.6537  0.008121 **
## AuditScore                   1.6298e-02  1.2660e-01  0.1287  0.897598
## DebtRatio                   -3.1410e-05  3.6249e-05 -0.8665  0.386480
## NetMargin                    2.0178e-01  7.8861e-03 25.5870 < 2.2e-16 ***
## log(Asset)                  -1.0426e-02  3.4383e-03 -3.0324  0.002506 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed2, vcovHC) # Heteroskedasticity consistent coefficients
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value  Pr(>|t|)
## SustainabilityPayLink       -6.5040e-02  4.6297e-02 -1.4048   0.16046
## SustainableThemedCommitment  3.5058e-01  1.3811e-01  2.5384   0.01133 *
## AuditScore                   1.6298e-02  6.5588e-02  0.2485   0.80382
## DebtRatio                   -3.1410e-05  1.8741e-05 -1.6760   0.09413 .
## NetMargin                    2.0178e-01  3.6606e-02  5.5123 4.802e-08 ***
## log(Asset)                  -1.0426e-02  5.1920e-03 -2.0081   0.04497 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed2, vcovHC(fixed2, method = "arellano")) # Heteroskedasticity consistent
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value  Pr(>|t|)
## SustainabilityPayLink       -6.5040e-02  4.6297e-02 -1.4048   0.16046
## SustainableThemedCommitment  3.5058e-01  1.3811e-01  2.5384   0.01133 *
## AuditScore                   1.6298e-02  6.5588e-02  0.2485   0.80382
## DebtRatio                   -3.1410e-05  1.8741e-05 -1.6760   0.09413 .
## NetMargin                    2.0178e-01  3.6606e-02  5.5123 4.802e-08 ***
```

```
## log(Asset)                  -1.0426e-02  5.1920e-03 -2.0081   0.04497 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed2, vcovHC(fixed2, type = "HC3")) # Heteroskedasticity consistent coefficients, type 3coef
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value Pr(>|t|)
## SustainabilityPayLink       -6.5040e-02  4.7924e-02 -1.3572  0.17512
## SustainableThemedCommitment  3.5058e-01  1.4081e-01  2.4898  0.01299 *
## AuditScore                   1.6298e-02  6.6887e-02  0.2437  0.80755
## DebtRatio                   -3.1410e-05  3.0003e-05 -1.0469  0.29547
## NetMargin                    2.0178e-01  4.0434e-02  4.9904 7.42e-07 ***
## log(Asset)                  -1.0426e-02  5.4247e-03 -1.9220  0.05497 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# The following shows the HC standard errors of the coefficients
t(sapply(c("HC0", "HC1", "HC2", "HC3", "HC4"), function(x) sqrt(diag(vcovHC(fixed2, type = x)))))
```

```
##     SustainabilityPayLink SustainableThemedCommitment AuditScore
## HC0            0.04629727                   0.1381124 0.06558800
## HC1            0.04641424                   0.1384613 0.06575370
## HC2            0.04707799                   0.1394481 0.06622851
## HC3            0.04792355                   0.1408087 0.06688689
## HC4            0.04961082                   0.1432209 0.06803650
##        DebtRatio  NetMargin  log(Asset)
## HC0 1.874051e-05 0.03660554 0.005191980
## HC1 1.878785e-05 0.03669802 0.005205097
## HC2 2.341063e-05 0.03843347 0.005303009
## HC3 3.000301e-05 0.04043376 0.005424673
## HC4 5.249125e-05 0.04500967 0.005692590
```

What should I do with those estimates?

```r
if (!require("plm")) install.packages("plm")
library(plm)

# I dowload my DataBase with read.csv2
DB_Tobin<-data.frame(read.csv2("DataBase/DB_Tobin.csv", sep = ";",stringsAsFactors=FALSE, header = TRUE
```

Model 3

Model 3 : Green Performance on Tobin's Q

$$TobinsQ_{it+1} = \beta_0 + \beta_1(EP_{it}) + \beta_2(CP_{it}) + \beta_3(WatP_{it}) + \beta_4(WasP_{it}) + \beta_5(GP_{it}) + \beta_9(C_{it}) + \varepsilon_{it} \quad (3)$$

where :

- $TobinsQ_{it+1}$ = a proxy for a firm's financial performance
- ROA_{it+1} = a proxy for a firm's financial performance
- EP_{it} = a proxy for a firm's energy productivity
- CP_{it} = a proxy for a firm's carbon productivity
- $WatP_{it}$ = a proxy for a firm's water productivity
- $WasP_{it}$ = a proxy for a firm's waste productivity
- GP_{it} = a proxy for a firm's green reputation
- SP_{it} = a proxy for a firm's sustainability pay link
- ST_{it} = a proxy for a firm's sustainability themed commitment
- EP_{it} = a proxy for a firm's audit score
- C_{it} = a vector of control variables that include financial leverage, firm size and industry sector
- ε_{it} = the error term

Test

Tests of poolability

Citation from [@Croissant2008] :

> *pooltest tests the hypothesis that the same coeffcients apply to each individual. It is a standard F test, based on the comparison of a model obtained for the full sample and a model based on the estimation of an equation for each individual. The first argument of pooltest is a plm object. The second argument is a pvcm object obtained with model=within. If the first argument is a pooling model, the test applies to all the coefficients (including the intercepts), if it is a within model, different intercepts are assumed.*

```r
# Test of poolability --> Error that I do not understand

# M3_pvcm <- pvcm(TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProducti

# M3_plm<-plm(TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProductivity

# pooltest(M3_pvcm,M3_plm)

# pooltest(TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProductivity +
```

Fixed or Random : Hausman Test

Citation from @Torres-Reyna2010 :

> *To decide between fixed or random effects you can run a Hausman test where the null hypothesis is that the preferred model is random effects vs. the alternative the fixed effects (see Green, 2008, chapter 9). It basically tests whether the unique errors (ui) are correlated with the regressors, the null hypothesis is they are not.*

```
fixed3 <- plm(TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProductivity

random3 <- plm(TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProductivit

phtest(fixed3,random3)
```

```
##
##  Hausman Test
##
## data:  TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity +  ...
## chisq = 53.106, df = 8, p-value = 1.029e-08
## alternative hypothesis: one model is inconsistent
```

Interpretation : P-Value < 0.05 then Ho is rejected and I have to use the fixed-effect.

Testing for time fixed effects

```
fixed_time3 <- plm(TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProducti


# Testing the time-fixed effects. The null is that no time-fixed effects needed
pFtest(fixed_time3, fixed3)
```

```
##
##  F test for individual effects
##
## data:  TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity +  ...
## F = 0.59388, df1 = 2, df2 = 690, p-value = 0.5525
## alternative hypothesis: significant effects
```

Interpretation Fixed_time effect : P-Value is > 0.05 meaning that null hypothesis is verified and that there is a non significant time-fixed effect. **So I do not need to use time fixed effect in this model!!**

Testing for cross-sectional dependence/contemporaneous correlation

Citation from @Torres-Reyna2010 :

> According to Baltagi, cross-sectional dependence is a problem in macro panels with long time series. This is not much of a problem in micro panels (few years and large number of cases). The null hypothesis in the B -P/LM and Pasaran CD tests of independence is that residuals across entities are not correlated. B- P/LM and Pasaran CD (cross-sectional dependence) tests are used to test whether the residuals are correlated across entities*. Cross-sectional dependence can lead to bias in tests results (also called contemporaneous correlation).

```
pcdtest(fixed_time3, test = c("lm"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity
## chisq = 100090, df = 61773, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed_time3, test = c("cd"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity
## z = 1.1273, p-value = 0.2596
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed3, test = c("lm"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity
## chisq = 101290, df = 61773, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed3, test = c("cd"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity
## z = -0.14497, p-value = 0.8847
## alternative hypothesis: cross-sectional dependence
```

Depending the method used, HO is verified (Pesaran), namely the model do not have cross-sectional dependence or rejected (Breusch-Pagan)... **Which one is the most suitable for my model?**

Testing for serial correlation

```
pbgtest(fixed_time3)
```

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
##  models
##
## data:  TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity
```

```
## chisq = 27.688, df = 1, p-value = 1.425e-07
## alternative hypothesis: serial correlation in idiosyncratic errors
```

```
pbgtest(fixed3)
```

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
##  models
##
## data:  TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity
## chisq = 28.331, df = 1, p-value = 1.023e-07
## alternative hypothesis: serial correlation in idiosyncratic errors
```

Interpretation: HO is rejected as p-value < 0.05 then I have serial correlation. . . .

Testing for stationarity

```
if (!require("tseries")) install.packages("tseries")
library(tseries)
PanelSet <- plm.data(DB_Tobin, index = c("Companies", "YearFinancialIndicator"))
```

```
## Warning: use of 'plm.data' is discouraged, better use 'pdata.frame' instead
```

```
adf.test(PanelSet$TobinsQ, k=2)
```

```
## Warning in adf.test(PanelSet$TobinsQ, k = 2): p-value smaller than printed
## p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  PanelSet$TobinsQ
## Dickey-Fuller = -16.843, Lag order = 2, p-value = 0.01
## alternative hypothesis: stationary
```

Ho : Series has stationarity **Interpretation :** p-value < 0.05 then ho is rejected and my panel data do not have stationarity

Testing for heteroskedasticity

```
if (!require("lmtest")) install.packages("lmtest")
library(lmtest)

bptest(TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProductivity + Gree
```

```
##
##  Breusch-Pagan test
##
## data:  TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity
## BP = 9393.2, df = 367, p-value < 2.2e-16
```

Interpretation: p-value < 0.05 then the null hypothesis of homoskedasticity is rejected and heteroskedasticity assumed. . .

Use the **sandwich estimator** to account for the heteroskedasticity issue? See @MiroshnychenkoGreenpracticesfinancial2017 and @Stock2008

"If hetersokedaticity is detected you can use the sandwich estimaror" [@Torres-Reyna2010]

vcovHC is a function for estimating a robust covariance matrix of parameters for a fixed effects or random effects panel model according to the White method (White 1980, 1984; Arellano 1987). The –vcovHC– function estimates three heteroskedasticity-consistent covariance estimators:

- "white1" - for general heteroskedasticity but no serial correlation. Recommended for random effects.
- "white2" - is "white1" restricted to a common variance within groups. Recommended for random effects.
- "arellano" - both heteroskedasticity and serial correlation. Recommended for fixed effects.

The following options apply*:

- HC0 - heteroskedasticity consistent. The default.
- HC1,HC2, HC3 – Recommended for small samples. HC3 gives less weight to influential observations.
- HC4 - small samples with influential observations
- HAC - heteroskedasticity and autocorrelation consistent (type ?vcovHAC for more details)

```
coeftest(fixed3) # Original coefficients
```

```
##
## t test of coefficients:
##
##                       Estimate  Std. Error t value Pr(>|t|)
## EnergyProductivity  1.0116e-01  1.9341e-01  0.5230  0.60112
## CarbonProductivity -4.4318e-02  2.3003e-01 -0.1927  0.84728
## WaterProductivity  -9.9272e-02  1.6284e-01 -0.6096  0.54231
## WasteProductivity  -2.0713e-01  1.5855e-01 -1.3064  0.19186
## GreenReputation    -6.0121e-02  8.0942e-02 -0.7428  0.45788
## DebtRatio           6.6345e-05  5.5629e-04  0.1193  0.90510
## NetMargin           2.6000e-02  1.2660e-01  0.2054  0.83735
## log(Asset)         -1.3753e-01  5.4161e-02 -2.5394  0.01132 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed3, vcovHC) # Heteroskedasticity consistent coefficients
```

```
##
## t test of coefficients:
##
##                       Estimate  Std. Error t value Pr(>|t|)
## EnergyProductivity  1.0116e-01  1.4739e-01  0.6864  0.49271
## CarbonProductivity -4.4318e-02  1.8866e-01 -0.2349  0.81435
## WaterProductivity  -9.9272e-02  1.2879e-01 -0.7708  0.44108
## WasteProductivity  -2.0713e-01  1.0682e-01 -1.9391  0.05289 .
## GreenReputation    -6.0121e-02  1.1413e-01 -0.5268  0.59852
## DebtRatio           6.6345e-05  1.1802e-04  0.5622  0.57418
## NetMargin           2.6000e-02  1.7401e-01  0.1494  0.88127
## log(Asset)         -1.3753e-01  1.6235e-01 -0.8471  0.39721
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed3, vcovHC(fixed3, method = "arellano")) # Heteroskedasticity consistent
```

```
##
## t test of coefficients:
##
##                       Estimate  Std. Error t value Pr(>|t|)
## EnergyProductivity  1.0116e-01  1.4739e-01  0.6864  0.49271
```

```
## CarbonProductivity -4.4318e-02  1.8866e-01 -0.2349  0.81435
## WaterProductivity  -9.9272e-02  1.2879e-01 -0.7708  0.44108
## WasteProductivity  -2.0713e-01  1.0682e-01 -1.9391  0.05289 .
## GreenReputation    -6.0121e-02  1.1413e-01 -0.5268  0.59852
## DebtRatio           6.6345e-05  1.1802e-04  0.5622  0.57418
## NetMargin           2.6000e-02  1.7401e-01  0.1494  0.88127
## log(Asset)         -1.3753e-01  1.6235e-01 -0.8471  0.39721
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed3, vcovHC(fixed3, type = "HC3")) # Heteroskedasticity consistent coefficients, type 3coef
```

```
##
## t test of coefficients:
##
##                       Estimate  Std. Error t value Pr(>|t|)
## EnergyProductivity  1.0116e-01  1.5108e-01  0.6696  0.50334
## CarbonProductivity -4.4318e-02  1.9146e-01 -0.2315  0.81701
## WaterProductivity  -9.9272e-02  1.3082e-01 -0.7589  0.44819
## WasteProductivity  -2.0713e-01  1.0859e-01 -1.9074  0.05688 .
## GreenReputation    -6.0121e-02  1.1624e-01 -0.5172  0.60518
## DebtRatio           6.6345e-05  1.4681e-04  0.4519  0.65147
## NetMargin           2.6000e-02  1.8388e-01  0.1414  0.88760
## log(Asset)         -1.3753e-01  1.9180e-01 -0.7171  0.47357
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# The following shows the HC standard errors of the coefficients
t(sapply(c("HC0", "HC1", "HC2", "HC3", "HC4"), function(x) sqrt(diag(vcovHC(fixed3, type = x)))))
```

```
##     EnergyProductivity CarbonProductivity WaterProductivity
## HC0          0.1473855          0.1886630         0.1287875
## HC1          0.1479449          0.1893790         0.1292763
## HC2          0.1491405          0.1900286         0.1297913
## HC3          0.1510779          0.1914581         0.1308166
## HC4          0.1542843          0.1927383         0.1317370
##     WasteProductivity GreenReputation    DebtRatio NetMargin log(Asset)
## HC0         0.1068157       0.1141293 0.0001180154 0.1740107  0.1623513
## HC1         0.1072210       0.1145625 0.0001184633 0.1746711  0.1629675
## HC2         0.1076986       0.1151248 0.0001303660 0.1786648  0.1760086
## HC3         0.1085941       0.1162414 0.0001468068 0.1838835  0.1917965
## HC4         0.1093978       0.1177057 0.0002006872 0.1948994  0.2308212
```

What should I do with those estimates?

```r
if (!require("plm")) install.packages("plm")
library(plm)

# I dowload my DataBase with read.csv2
DB_ROA<-data.frame(read.csv2("DataBase/DataBase_010418.csv", sep = ";",stringsAsFactors=FALSE, header =
```

Model 4

Model 4 : Green Performance on ROA

$$ROA_{it+1} = \beta_0 + \beta_1(EP_{it}) + \beta_2(CP_{it}) + \beta_3(WatP_{it}) + \beta_4(WasP_{it}) + \beta_5(GP_{it}) + \beta_9(C_{it}) + \varepsilon_{it} \qquad (4)$$

where :

- $TobinsQ_{it+1}$ = a proxy for a firm's financial performance
- ROA_{it+1} = a proxy for a firm's financial performance
- EP_{it} = a proxy for a firm's energy productivity
- CP_{it} = a proxy for a firm's carbon productivity
- $WatP_{it}$ = a proxy for a firm's water productivity
- $WasP_{it}$ = a proxy for a firm's waste productivity
- GP_{it} = a proxy for a firm's green reputation
- SP_{it} = a proxy for a firm's sustainability pay link
- ST_{it} = a proxy for a firm's sustainability themed commitment
- EP_{it} = a proxy for a firm's audit score
- C_{it} = a vector of control variables that include financial leverage, firm size and industry sector
- ε_{it} = the error term

Test

Tests of poolability

Citation from [@Croissant2008] :

> *pooltest tests the hypothesis that the same coeffcients apply to each individual. It is a standard F test, based on the comparison of a model obtained for the full sample and a model based on the estimation of an equation for each individual. The first argument of pooltest is a plm object. The second argument is a pvcm object obtained with model=within. If the first argument is a pooling model, the test applies to all the coefficients (including the intercepts), if it is a within model, different intercepts are assumed.*

```r
# Test of poolability --> Error that I do not understand

# M4_pvcm <- pvcm(ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProductivity

# M4_plm<-plm(ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProductivity + G

# pooltest(M4_pvcm,M4_plm)

# pooltest(ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProductivity + Gree
```

Fixed or Random : Hausman Test

Citation from @Torres-Reyna2010 :

To decide between fixed or random effects you can run a Hausman test where the null hypothesis is that the preferred model is random effects vs. the alternative the fixed effects (see Green, 2008, chapter 9). It basically tests whether the unique errors (ui) are correlated with the regressors, the null hypothesis is they are not.

```
fixed4 <- plm(ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProductivity + G

random4 <- plm(ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProductivity + 

phtest(fixed4,random4)
```

```
##
##  Hausman Test
##
## data:  ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity +  ...
## chisq = 24.506, df = 8, p-value = 0.001884
## alternative hypothesis: one model is inconsistent
```

Interpretation : P-Value < 0.05 then Ho is rejected and I have to use the fixed-effect.

Testing for time fixed effects

```
fixed_time4 <- plm(ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProductivit


# Testing the time-fixed effects. The null is that no time-fixed effects needed
pFtest(fixed_time4, fixed4)
```

```
##
##  F test for individual effects
##
## data:  ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity +  ...
## F = 7.1282, df1 = 2, df2 = 783, p-value = 0.0008553
## alternative hypothesis: significant effects
```

Interpretation Fixed_time effect : P-Value is < 0.05 meaning that null hypothesis is rejected and that there is a significant time-fixed effect. **So I do need to use time fixed effect in this model!!**

Testing for cross-sectional dependence/contemporaneous correlation

Citation from @Torres-Reyna2010 :

> According to Baltagi, cross-sectional dependence is a problem in macro panels with long time series. This is not much of a problem in micro panels (few years and large number of cases). The null hypothesis in the B -P/LM and Pasaran CD tests of independence is that residuals across entities are not correlated. B- P/LM and Pasaran CD (cross-sectional dependence) tests are used to test whether the residuals are correlated across entities*. Cross-sectional dependence can lead to bias in tests results (also called contemporaneous correlation).

```
pcdtest(fixed_time4, test = c("lm"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (2 percent) do not have any or just
## one time period in common and have been omitted from calculation
```

```
##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
```

```
##
## data:  ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity + G
## chisq = 124250, df = 78606, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed_time4, test = c("cd"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (2 percent) do not have any or just
## one time period in common and have been omitted from calculation
```

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity + G
## z = 20.376, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed4, test = c("lm"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (2 percent) do not have any or just
## one time period in common and have been omitted from calculation
```

```
##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
##
## data:  ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity + G
## chisq = 123340, df = 78606, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed4, test = c("cd"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (2 percent) do not have any or just
## one time period in common and have been omitted from calculation
```

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity + G
## z = 1.2776, p-value = 0.2014
## alternative hypothesis: cross-sectional dependence
```

Depending the method used, HO is verified (Pesaran), namely the model do not have cross-sectional dependence or rejected (Breusch-Pagan)... **Which one is the most suitable for my model?**

Testing for serial correlation

```
pbgtest(fixed_time4)
```

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
##  models
##
## data:  ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity + G
## chisq = 37.949, df = 1, p-value = 7.264e-10
## alternative hypothesis: serial correlation in idiosyncratic errors
```

```r
pbgtest(fixed4)
```

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
##  models
##
## data:  ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity + Gr
## chisq = 40.051, df = 1, p-value = 2.474e-10
## alternative hypothesis: serial correlation in idiosyncratic errors
```

Interpretation: HO is rejected as p-value < 0.05 then I have serial correlation. . . .

Testing for stationarity

```r
if (!require("tseries")) install.packages("tseries")
library(tseries)
PanelSet <- plm.data(DB_ROA, index = c("Companies", "YearFinancialIndicator"))
```

```
## Warning: use of 'plm.data' is discouraged, better use 'pdata.frame' instead
```

```r
adf.test(PanelSet$ROA, k=2)
```

```
## Warning in adf.test(PanelSet$ROA, k = 2): p-value smaller than printed p-
## value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  PanelSet$ROA
## Dickey-Fuller = -18.238, Lag order = 2, p-value = 0.01
## alternative hypothesis: stationary
```

Ho : Series has stationarity **Interpretation :** p-value < 0.05 then ho is rejected and my panel data do not have stationarity

Testing for heteroskedasticity

```r
if (!require("lmtest")) install.packages("lmtest")
library(lmtest)

bptest(ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity + WasteProductivity + GreenRepu
```

```
##
##  Breusch-Pagan test
##
## data:  ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     WasteProductivity + Gr
## BP = 13519, df = 406, p-value < 2.2e-16
```

Interpretation: p-value < 0.05 then the null hypothesis of homoskedasticity is rejected and heteroskedasticity assumed. . .

Use the **sandwich estimator** to account for the heteroskedasticity issue? See @MiroshnychenkoGreenpracticesfinancial2017 and @Stock2008

"If hetersokedaticity is detected you can use the sandwich estimaror" [@Torres-Reyna2010]

vcovHC is a function for estimating a robust covariance matrix of parameters for a fixed effects or random effects panel model according to the White method (White 1980, 1984; Arellano 1987). The –vcovHC– function estimates three heteroskedasticity-consistent covariance estimators:

- "white1" - for general heteroskedasticity but no serial correlation. Recommended for random effects.
- "white2" - is "white1" restricted to a common variance within groups. Recommended for random effects.
- "arellano" - both heteroskedasticity and serial correlation. Recommended for fixed effects.

The following options apply*:

- HC0 - heteroskedasticity consistent. The default.
- HC1,HC2, HC3 – Recommended for small samples. HC3 gives less weight to influential observations.
- HC4 - small samples with influential observations
- HAC - heteroskedasticity and autocorrelation consistent (type ?vcovHAC for more details)

```
coeftest(fixed4) # Original coefficients
```

```
##
## t test of coefficients:
##
##                       Estimate  Std. Error t value  Pr(>|t|)
## EnergyProductivity  1.0965e-02  1.2044e-02  0.9104  0.362899
## CarbonProductivity -2.8359e-02  1.4331e-02 -1.9788  0.048183 *
## WaterProductivity   2.4759e-02  1.0100e-02  2.4514  0.014448 *
## WasteProductivity   2.0609e-03  9.9310e-03  0.2075  0.835659
## GreenReputation     1.9821e-03  4.9654e-03  0.3992  0.689871
## DebtRatio          -3.1374e-05  3.6290e-05 -0.8645  0.387557
## NetMargin           1.9923e-01  7.9306e-03 25.1210 < 2.2e-16 ***
## log(Asset)         -9.9536e-03  3.4374e-03 -2.8956  0.003889 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed4, vcovHC) # Heteroskedasticity consistent coefficients
```

```
##
## t test of coefficients:
##
##                       Estimate  Std. Error t value  Pr(>|t|)
## EnergyProductivity  1.0965e-02  1.3617e-02  0.8052   0.42093
## CarbonProductivity -2.8359e-02  1.7033e-02 -1.6649   0.09633 .
## WaterProductivity   2.4759e-02  1.1511e-02  2.1510   0.03178 *
## WasteProductivity   2.0609e-03  8.2970e-03  0.2484   0.80390
## GreenReputation     1.9821e-03  5.6934e-03  0.3481   0.72783
## DebtRatio          -3.1374e-05  1.8582e-05 -1.6884   0.09172 .
## NetMargin           1.9923e-01  3.7313e-02  5.3394 1.222e-07 ***
## log(Asset)         -9.9536e-03  5.2092e-03 -1.9108   0.05640 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed4, vcovHC(fixed4, method = "arellano")) # Heteroskedasticity consistent
```

```
##
## t test of coefficients:
##
##                       Estimate  Std. Error t value  Pr(>|t|)
## EnergyProductivity  1.0965e-02  1.3617e-02  0.8052   0.42093
```

```
## CarbonProductivity -2.8359e-02  1.7033e-02 -1.6649   0.09633 .
## WaterProductivity   2.4759e-02  1.1511e-02  2.1510   0.03178 *
## WasteProductivity   2.0609e-03  8.2970e-03  0.2484   0.80390
## GreenReputation     1.9821e-03  5.6934e-03  0.3481   0.72783
## DebtRatio          -3.1374e-05  1.8582e-05 -1.6884   0.09172 .
## NetMargin           1.9923e-01  3.7313e-02  5.3394 1.222e-07 ***
## log(Asset)         -9.9536e-03  5.2092e-03 -1.9108   0.05640 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed4, vcovHC(fixed4, type = "HC3")) # Heteroskedasticity consistent coefficients, type 3coef
```

```
##
## t test of coefficients:
##
##                       Estimate  Std. Error t value  Pr(>|t|)
## EnergyProductivity  1.0965e-02  1.4007e-02  0.7828   0.43395
## CarbonProductivity -2.8359e-02  1.7330e-02 -1.6364   0.10216
## WaterProductivity   2.4759e-02  1.1794e-02  2.0993   0.03611 *
## WasteProductivity   2.0609e-03  8.4309e-03  0.2444   0.80695
## GreenReputation     1.9821e-03  5.8858e-03  0.3368   0.73639
## DebtRatio          -3.1374e-05  2.9834e-05 -1.0516   0.29330
## NetMargin           1.9923e-01  4.1328e-02  4.8206 1.719e-06 ***
## log(Asset)         -9.9536e-03  5.4816e-03 -1.8158   0.06978 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# The following shows the HC standard errors of the coefficients
t(sapply(c("HC0", "HC1", "HC2", "HC3", "HC4"), function(x) sqrt(diag(vcovHC(fixed4, type = x)))))
```

```
##     EnergyProductivity CarbonProductivity WaterProductivity
## HC0         0.01361705         0.01703327        0.01151051
## HC1         0.01366298         0.01709072        0.01154933
## HC2         0.01380467         0.01718006        0.01164810
## HC3         0.01400654         0.01732978        0.01179400
## HC4         0.01433867         0.01747283        0.01202959
##     WasteProductivity GreenReputation    DebtRatio  NetMargin  log(Asset)
## HC0       0.008297019     0.005693390 1.858180e-05 0.03731273 0.005209237
## HC1       0.008325003     0.005712592 1.864447e-05 0.03743857 0.005226806
## HC2       0.008363576     0.005786931 2.324575e-05 0.03922956 0.005338444
## HC3       0.008430950     0.005885837 2.983430e-05 0.04132810 0.005481637
## HC4       0.008504634     0.006074296 5.232972e-05 0.04610729 0.005796206
```

What should I do with those estimates?

```r
if (!require("plm")) install.packages("plm")
library(plm)

# I dowload my DataBase with read.csv2
DB_Tobin<-data.frame(read.csv2("DataBase/DB_Tobin.csv", sep = ";",stringsAsFactors=FALSE, header = TRUE
```

Model 5

Model 5 : Both Green Performance and Green Initiative on Tobin's Q

$$TobinsQ_{it+1} = \beta_0+\beta_1(EP_{it})+\beta_2(CP_{it})+\beta_3(WatP_{it})+\beta_4(WasP_{it})+\beta_5(GP_{it})+\beta_6(SP_{it})+\beta_7(ST_{it})+\beta_8(AS_{it})+\beta_9(C_{it})+\varepsilon_{it} \quad (5)$$

where :

- $TobinsQ_{it+1}$ = a proxy for a firm's financial performance
- ROA_{it+1} = a proxy for a firm's financial performance
- EP_{it} = a proxy for a firm's energy productivity
- CP_{it} = a proxy for a firm's carbon productivity
- $WatP_{it}$ = a proxy for a firm's water productivity
- $WasP_{it}$ = a proxy for a firm's waste productivity
- GP_{it} = a proxy for a firm's green reputation
- SP_{it} = a proxy for a firm's sustainability pay link
- ST_{it} = a proxy for a firm's sustainability themed commitment
- EP_{it} = a proxy for a firm's audit score
- C_{it} = a vector of control variables that include financial leverage, firm size and industry sector
- ε_{it} = the error term

Test

Tests of poolability

Citation from [@Croissant2008] :

> *pooltest tests the hypothesis that the same coeffcients apply to each individual. It is a standard F test, based on the comparison of a model obtained for the full sample and a model based on the estimation of an equation for each individual. The first argument of pooltest is a plm object. The second argument is a pvcm object obtained with model=within. If the first argument is a pooling model, the test applies to all the coefficients (including the intercepts), if it is a within model, different intercepts are assumed.*

```r
# Test of poolability --> Error that I do not understand

# M5_pvcm <- pvcm(TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + EnergyPr

# M5_plm<-plm(TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + EnergyProduc

# pooltest(M5_pvcm,M5_plm)

# pooltest(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + DebtRatio^2 + NetMa
```

Fixed or Random : Hausman Test

Citation from @Torres-Reyna2010 :

> *To decide between fixed or random effects you can run a Hausman test where the null hypothesis is that the preferred model is random effects vs. the alternative the fixed effects (see Green, 2008, chapter 9). It basically tests whether the unique errors (ui) are correlated with the regressors, the null hypothesis is they are not.*

```
fixed5 <- plm(TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + EnergyProduc

random5 <- plm(TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + EnergyProdu

phtest(fixed5,random5)
```

```
##
##  Hausman Test
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +  ...
## chisq = 63.602, df = 11, p-value = 1.972e-09
## alternative hypothesis: one model is inconsistent
```

Interpretation : P-Value < 0.05 then Ho is rejected and I have to use the fixed-effect.

Testing for time fixed effects

```
fixed_time5 <- plm(TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + EnergyPr


# Testing the time-fixed effects. The null is that no time-fixed effects needed
pFtest(fixed_time5, fixed5)
```

```
##
##  F test for individual effects
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +  ...
## F = 0.45697, df1 = 2, df2 = 687, p-value = 0.6334
## alternative hypothesis: significant effects
```

Interpretation Fixed_time effect : P-Value is > 0.05 meaning that null hypothesis is verified and that there is a non significant time-fixed effect. **So I do notneed to use time fixed effect in this model!!**

Testing for cross-sectional dependence/contemporaneous correlation

Citation from @Torres-Reyna2010 :

> According to Baltagi, cross-sectional dependence is a problem in macro panels with long time series. This is not much of a problem in micro panels (few years and large number of cases). The null hypothesis in the B -P/LM and Pasaran CD tests of independence is that residuals across entities are not correlated. B- P/LM and Pasaran CD (cross-sectional dependence) tests are used to test whether the residuals are correlated across entities*. Cross-sectional dependence can lead to bias in tests results (also called contemporaneous correlation).

```
pcdtest(fixed_time5, test = c("lm"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditScore + EnergyProduc
## chisq = 101660, df = 61773, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed_time5, test = c("cd"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditScore + EnergyProduc
## z = 1.3264, p-value = 0.1847
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed5, test = c("lm"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditScore + EnergyProduc
## chisq = 103390, df = 61773, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed5, test = c("cd"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditScore + EnergyProduc
## z = 0.0088253, p-value = 0.993
## alternative hypothesis: cross-sectional dependence
```

Depending the method used, HO is verified (Pesaran), namely the model do not have cross-sectional dependence or rejected (Breusch-Pagan)... **Which one is the most suitable for my model?**

Testing for serial correlation

```
pbgtest(fixed_time5)
```

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
##  models
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditScore + EnergyProduc
```

```
## chisq = 26.535, df = 1, p-value = 2.588e-07
## alternative hypothesis: serial correlation in idiosyncratic errors
```

```
pbgtest(fixed5)
```

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
##  models
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditScore + EnergyProduc
## chisq = 26.867, df = 1, p-value = 2.179e-07
## alternative hypothesis: serial correlation in idiosyncratic errors
```

Interpretation: HO is rejected as p-value < 0.05 then I have serial correlation. . . .

Testing for stationarity

```
if (!require("tseries")) install.packages("tseries")
library(tseries)
PanelSet <- plm.data(DB_ROA, index = c("Companies", "YearFinancialIndicator"))
```

```
## Warning: use of 'plm.data' is discouraged, better use 'pdata.frame' instead
```

```
adf.test(PanelSet$ROA, k=2)
```

```
## Warning in adf.test(PanelSet$ROA, k = 2): p-value smaller than printed p-
## value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  PanelSet$ROA
## Dickey-Fuller = -18.238, Lag order = 2, p-value = 0.01
## alternative hypothesis: stationary
```

Ho : Series has stationarity **Interpretation :** p-value < 0.05 then ho is rejected and my panel data do not have stationarity

Testing for heteroskedasticity

```
if (!require("lmtest")) install.packages("lmtest")
library(lmtest)

bptest(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + EnergyProductivity + Ca
```

```
##
##  Breusch-Pagan test
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     EnergyProductivi
## BP = 13464, df = 409, p-value < 2.2e-16
```

Interpretation: p-value < 0.05 then the null hypothesis of homoskedasticity is rejected and heteroskedasticity assumed. . .

Use the **sandwich estimator** to account for the heteroskedasticity issue? See @MiroshnychenkoGreenpracticesfinancial2017 and @Stock2008

"If hetersokedaticity is detected you can use the sandwich estimaror" [@Torres-Reyna2010]

vcovHC is a function for estimating a robust covariance matrix of parameters for a fixed effects or random effects panel model according to the White method (White 1980, 1984; Arellano 1987). The –vcovHC– function estimates three heteroskedasticity-consistent covariance estimators:

- "white1" - for general heteroskedasticity but no serial correlation. Recommended for random effects.
- "white2" - is "white1" restricted to a common variance within groups. Recommended for random effects.
- "arellano" - both heteroskedasticity and serial correlation. Recommended for fixed effects.

The following options apply*:

- HC0 - heteroskedasticity consistent. The default.
- HC1,HC2, HC3 – Recommended for small samples. HC3 gives less weight to influential observations.
- HC4 - small samples with influential observations
- HAC - heteroskedasticity and autocorrelation consistent (type ?vcovHAC for more details)

```
coeftest(fixed5) # Original coefficients
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value Pr(>|t|)
## SustainabilityPayLink        5.0582e-01  6.8547e-01  0.7379  0.46081
## SustainableThemedCommitment  2.8097e+00  2.0921e+00  1.3430  0.17971
## AuditScore                  -3.4719e-02  2.0061e+00 -0.0173  0.98620
## EnergyProductivity           1.0955e-01  1.9408e-01  0.5645  0.57262
## CarbonProductivity          -2.6327e-02  2.3130e-01 -0.1138  0.90941
## WaterProductivity           -9.8320e-02  1.6297e-01 -0.6033  0.54651
## WasteProductivity           -1.8388e-01  1.5958e-01 -1.1523  0.24958
## GreenReputation             -4.4298e-02  8.2166e-02 -0.5391  0.58997
## DebtRatio                    6.8966e-05  5.5641e-04  0.1239  0.90139
## NetMargin                    2.6797e-02  1.2665e-01  0.2116  0.83249
## log(Asset)                  -1.4008e-01  5.4244e-02 -2.5824  0.01002 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed5, vcovHC) # Heteroskedasticity consistent coefficients
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value Pr(>|t|)
## SustainabilityPayLink        5.0582e-01  5.6977e-01  0.8878  0.37498
## SustainableThemedCommitment  2.8097e+00  2.5805e+00  1.0888  0.27661
## AuditScore                  -3.4719e-02  9.4075e-01 -0.0369  0.97057
## EnergyProductivity           1.0955e-01  1.4729e-01  0.7438  0.45728
## CarbonProductivity          -2.6327e-02  1.9214e-01 -0.1370  0.89105
## WaterProductivity           -9.8320e-02  1.2917e-01 -0.7612  0.44683
## WasteProductivity           -1.8388e-01  1.0863e-01 -1.6928  0.09094 .
## GreenReputation             -4.4298e-02  1.1792e-01 -0.3757  0.70727
## DebtRatio                    6.8966e-05  1.1613e-04  0.5939  0.55280
## NetMargin                    2.6797e-02  1.7437e-01  0.1537  0.87791
## log(Asset)                  -1.4008e-01  1.6302e-01 -0.8593  0.39048
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
coeftest(fixed5, vcovHC(fixed5, method = "arellano")) # Heteroskedasticity consistent
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value Pr(>|t|)
## SustainabilityPayLink        5.0582e-01  5.6977e-01  0.8878  0.37498
## SustainableThemedCommitment  2.8097e+00  2.5805e+00  1.0888  0.27661
## AuditScore                  -3.4719e-02  9.4075e-01 -0.0369  0.97057
## EnergyProductivity           1.0955e-01  1.4729e-01  0.7438  0.45728
## CarbonProductivity          -2.6327e-02  1.9214e-01 -0.1370  0.89105
## WaterProductivity           -9.8320e-02  1.2917e-01 -0.7612  0.44683
## WasteProductivity           -1.8388e-01  1.0863e-01 -1.6928  0.09094 .
## GreenReputation             -4.4298e-02  1.1792e-01 -0.3757  0.70727
## DebtRatio                    6.8966e-05  1.1613e-04  0.5939  0.55280
## NetMargin                    2.6797e-02  1.7437e-01  0.1537  0.87791
## log(Asset)                  -1.4008e-01  1.6302e-01 -0.8593  0.39048
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
coeftest(fixed5, vcovHC(fixed5, type = "HC3")) # Heteroskedasticity consistent coefficients, type 3coef
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value Pr(>|t|)
## SustainabilityPayLink        5.0582e-01  5.8475e-01  0.8650   0.3873
## SustainableThemedCommitment  2.8097e+00  2.6426e+00  1.0632   0.2881
## AuditScore                  -3.4719e-02  9.6463e-01 -0.0360   0.9713
## EnergyProductivity           1.0955e-01  1.5129e-01  0.7241   0.4693
## CarbonProductivity          -2.6327e-02  1.9537e-01 -0.1348   0.8928
## WaterProductivity           -9.8320e-02  1.3157e-01 -0.7473   0.4552
## WasteProductivity           -1.8388e-01  1.1085e-01 -1.6589   0.0976 .
## GreenReputation             -4.4298e-02  1.2007e-01 -0.3689   0.7123
## DebtRatio                    6.8966e-05  1.4388e-04  0.4793   0.6319
## NetMargin                    2.6797e-02  1.8432e-01  0.1454   0.8844
## log(Asset)                  -1.4008e-01  1.9265e-01 -0.7271   0.4674
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# The following shows the HC standard errors of the coefficients
t(sapply(c("HC0", "HC1", "HC2", "HC3", "HC4"), function(x) sqrt(diag(vcovHC(fixed5, type = x)))))
```

```
##     SustainabilityPayLink SustainableThemedCommitment AuditScore
## HC0             0.5697722                    2.580510  0.9407454
## HC1             0.5727517                    2.594005  0.9456650
## HC2             0.5771804                    2.611254  0.9523021
## HC3             0.5847548                    2.642621  0.9646266
## HC4             0.5930259                    2.668655  0.9782099
##     EnergyProductivity CarbonProductivity WaterProductivity
## HC0          0.1472909          0.1921390         0.1291730
## HC1          0.1480611          0.1931438         0.1298485
## HC2          0.1491981          0.1937205         0.1303599
## HC3          0.1512921          0.1953691         0.1315723
## HC4          0.1542671          0.1964206         0.1321311
```

```
##     WasteProductivity GreenReputation    DebtRatio NetMargin log(Asset)
## HC0         0.1086250       0.1179158 0.0001161319 0.1743706  0.1630199
## HC1         0.1091930       0.1185324 0.0001167392 0.1752825  0.1638724
## HC2         0.1097272       0.1189373 0.0001280659 0.1790677  0.1767647
## HC3         0.1108502       0.1200725 0.0001438826 0.1843173  0.1926549
## HC4         0.1115271       0.1211420 0.0001953052 0.1945782  0.2318702
```

What should I do with those estimates?

```r
if (!require("plm")) install.packages("plm")
library(plm)

# I dowload my DataBase with read.csv2
DB_ROA<-data.frame(read.csv2("DataBase/DataBase_010418.csv", sep = ";",stringsAsFactors=FALSE, header =
```

Model 6

Model 6 : Both Green Performance and Green Initiative on ROA

$$ROA_{it+1} = \beta_0+\beta_1(EP_{it})+\beta_2(CP_{it})+\beta_3(WatP_{it})+\beta_4(WasP_{it})+\beta_5(GP_{it})+\beta_6(SP_{it})+\beta_7(ST_{it})+\beta_8(AS_{it})+(C_{it})+\varepsilon_{it} \quad (6)$$

where :

- $TobinsQ_{it+1}$ = a proxy for a firm's financial performance
- ROA_{it+1} = a proxy for a firm's financial performance
- EP_{it} = a proxy for a firm's energy productivity
- CP_{it} = a proxy for a firm's carbon productivity
- $WatP_{it}$ = a proxy for a firm's water productivity
- $WasP_{it}$ = a proxy for a firm's waste productivity
- GP_{it} = a proxy for a firm's green reputation
- SP_{it} = a proxy for a firm's sustainability pay link
- ST_{it} = a proxy for a firm's sustainability themed commitment
- EP_{it} = a proxy for a firm's audit score
- C_{it} = a vector of control variables that include financial leverage, firm size and industry sector
- ε_{it} = the error term

Test

Tests of poolability

Citation from [@Croissant2008] :

> *pooltest tests the hypothesis that the same coeffcients apply to each individual. It is a standard F test, based on the comparison of a model obtained for the full sample and a model based on the estimation of an equation for each individual. The first argument of pooltest is a plm object. The second argument is a pvcm object obtained with model=within. If the first argument is a pooling model, the test applies to all the coefficients (including the intercepts), if it is a within model, different intercepts are assumed.*

```r
# Test of poolability --> Error that I do not understand

# M6_pvcm <- pvcm(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + EnergyProduc

# M6_plm<-plm(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + EnergyProductivi

# pooltest(M6_pvcm,M6_plm)

# pooltest(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + EnergyProductivity
```

Fixed or Random : Hausman Test

Citation from @Torres-Reyna2010 :

> *To decide between fixed or random effects you can run a Hausman test where the null hypothesis is that the preferred model is random effects vs. the alternative the fixed effects (see Green, 2008, chapter 9). It basically tests whether the unique errors (ui) are correlated with the regressors, the null hypothesis is they are not.*

```
fixed6 <- plm(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + EnergyProductivi

random6 <- plm(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + EnergyProductivi

phtest(fixed6,random6)
```

```
##
##  Hausman Test
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +  ...
## chisq = 119.49, df = 11, p-value < 2.2e-16
## alternative hypothesis: one model is inconsistent
```

Interpretation : P-Value < 0.05 then Ho is rejected and I have to use the fixed-effect.

Testing for time fixed effects

```
fixed_time6 <- plm(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + EnergyProduc


# Testing the time-fixed effects. The null is that no time-fixed effects needed
pFtest(fixed_time6, fixed6)
```

```
##
##  F test for individual effects
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +  ...
## F = 4.3047, df1 = 2, df2 = 687, p-value = 0.01387
## alternative hypothesis: significant effects
```

Interpretation Fixed_time effect : P-Value is < 0.05 meaning that null hypothesis is rejected and that there is a significant time-fixed effect. **So I do need to use time fixed effect in this model!!**

Testing for cross-sectional dependence/contemporaneous correlation

Citation from @Torres-Reyna2010 :

> According to Baltagi, cross-sectional dependence is a problem in macro panels with long time series. This is not much of a problem in micro panels (few years and large number of cases). The null hypothesis in the B -P/LM and Pasaran CD tests of independence is that residuals across entities are not correlated. B- P/LM and Pasaran CD (cross-sectional dependence) tests are used to test whether the residuals are correlated across entities*. Cross-sectional dependence can lead to bias in tests results (also called contemporaneous correlation).

```
pcdtest(fixed_time6, test = c("lm"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     EnergyProductivi
## chisq = 96592, df = 61773, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed_time6, test = c("cd"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     EnergyProductivi
## z = 10.626, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed6, test = c("lm"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     EnergyProductivi
## chisq = 96195, df = 61773, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence
```

```
pcdtest(fixed6, test = c("cd"))
```

```
## Warning in pcdres(tres = tres, n = n, w = w, form = paste(deparse(x
## $formula)), : Some pairs of individuals (8.8 percent) do not have any or
## just one time period in common and have been omitted from calculation
```

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     EnergyProductivi
## z = 1.971, p-value = 0.04872
## alternative hypothesis: cross-sectional dependence
```

HO is rejected as p-value < 0.05, namely the model do have cross-sectional dependence...

Testing for serial correlation

```
pbgtest(fixed_time6)
```

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
##  models
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     EnergyProductivi
## chisq = 52.903, df = 1, p-value = 3.505e-13
```

```
## alternative hypothesis: serial correlation in idiosyncratic errors
```

```
pbgtest(fixed6)
```

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
##  models
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     EnergyProductivi
## chisq = 54.232, df = 1, p-value = 1.781e-13
## alternative hypothesis: serial correlation in idiosyncratic errors
```

Interpretation: HO is rejected as p-value < 0.05 then I have serial correlation. . . .

Testing for stationarity

```
if (!require("tseries")) install.packages("tseries")
library(tseries)
PanelSet <- plm.data(DB_Tobin, index = c("Companies", "YearFinancialIndicator"))
```

```
## Warning: use of 'plm.data' is discouraged, better use 'pdata.frame' instead
```

```
adf.test(PanelSet$TobinsQ, k=2)
```

```
## Warning in adf.test(PanelSet$TobinsQ, k = 2): p-value smaller than printed
## p-value
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  PanelSet$TobinsQ
## Dickey-Fuller = -16.843, Lag order = 2, p-value = 0.01
## alternative hypothesis: stationary
```

Ho : Series has stationarity **Interpretation :** p-value < 0.05 then ho is rejected and my panel data do not have stationarity

Testing for heteroskedasticity

```
if (!require("lmtest")) install.packages("lmtest")
library(lmtest)

bptest(ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore + EnergyProductivity + Ca
```

```
##
##  Breusch-Pagan test
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +     EnergyProductivi
## BP = 13746, df = 370, p-value < 2.2e-16
```

Interpretation: p-value < 0.05 then the null hypothesis of homoskedasticity is rejected and heteroskedasticity assumed. . .

Use the **sandwich estimator** to account for the heteroskedasticity issue? See @MiroshnychenkoGreenpracticesfinancial2017 and @Stock2008

"If hetersokedaticity is detected you can use the sandwich estimaror" [@Torres-Reyna2010]

vcovHC is a function for estimating a robust covariance matrix of parameters for a fixed effects or random effects panel model according to the White method (White 1980, 1984; Arellano 1987). The –vcovHC– function estimates three heteroskedasticity-consistent covariance estimators:

- "white1" - for general heteroskedasticity but no serial correlation. Recommended for random effects.
- "white2" - is "white1" restricted to a common variance within groups. Recommended for random effects.
- "arellano" - both heteroskedasticity and serial correlation. Recommended for fixed effects.

The following options apply*:

- HC0 - heteroskedasticity consistent. The default.
- HC1,HC2, HC3 – Recommended for small samples. HC3 gives less weight to influential observations.
- HC4 - small samples with influential observations
- HAC - heteroskedasticity and autocorrelation consistent (type ?vcovHAC for more details)

```
coeftest(fixed_time6) # Original coefficients
```

```
##
## t test of coefficients:
##
##                                      Estimate  Std. Error t value
## SustainabilityPayLink              -2.8600e-02  4.2197e-02 -0.6778
## SustainableThemedCommitment         3.9284e-01  1.2741e-01  3.0832
## AuditScore                          3.0198e-02  1.2297e-01  0.2456
## EnergyProductivity                  1.0692e-02  1.1892e-02  0.8991
## CarbonProductivity                 -2.3715e-02  1.4099e-02 -1.6820
## WaterProductivity                   1.6937e-02  9.9335e-03  1.7051
## WasteProductivity                   2.2452e-03  9.7797e-03  0.2296
## GreenReputation                    -5.4184e-03  5.8923e-03 -0.9196
## DebtRatio                          -3.5511e-05  3.3804e-05 -1.0505
## NetMargin                           2.0726e-01  7.7380e-03 26.7851
## log(Asset)                         -5.5829e-03  3.3087e-03 -1.6873
## factor(YearFinancialIndicator)2014 -8.5186e-04  3.4622e-03 -0.2460
## factor(YearFinancialIndicator)2015 -6.7287e-03  3.4769e-03 -1.9352
##                                    Pr(>|t|)
## SustainabilityPayLink               0.49815
## SustainableThemedCommitment         0.00213 **
## AuditScore                          0.80608
## EnergyProductivity                  0.36890
## CarbonProductivity                  0.09302 .
## WaterProductivity                   0.08863 .
## WasteProductivity                   0.81848
## GreenReputation                     0.35812
## DebtRatio                           0.29387
## NetMargin                           < 2e-16 ***
## log(Asset)                          0.09200 .
## factor(YearFinancialIndicator)2014  0.80572
## factor(YearFinancialIndicator)2015  0.05337 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed_time6, vcovHC) # Heteroskedasticity consistent coefficients
```

```
##
## t test of coefficients:
```

```
##
##                                    Estimate  Std. Error t value
## SustainabilityPayLink             -2.8600e-02  4.3366e-02 -0.6595
## SustainableThemedCommitment        3.9284e-01  1.3780e-01  2.8509
## AuditScore                         3.0198e-02  7.3821e-02  0.4091
## EnergyProductivity                 1.0692e-02  1.3445e-02  0.7953
## CarbonProductivity                -2.3715e-02  1.8013e-02 -1.3165
## WaterProductivity                  1.6937e-02  1.1711e-02  1.4463
## WasteProductivity                  2.2452e-03  8.7718e-03  0.2560
## GreenReputation                   -5.4184e-03  5.1713e-03 -1.0478
## DebtRatio                         -3.5511e-05  1.8490e-05 -1.9205
## NetMargin                          2.0726e-01  3.5649e-02  5.8139
## log(Asset)                        -5.5829e-03  6.2134e-03 -0.8985
## factor(YearFinancialIndicator)2014 -8.5186e-04  1.9330e-03 -0.4407
## factor(YearFinancialIndicator)2015 -6.7287e-03  2.6054e-03 -2.5826
##                                    Pr(>|t|)
## SustainabilityPayLink              0.509801
## SustainableThemedCommitment        0.004491 **
## AuditScore                         0.682620
## EnergyProductivity                 0.426732
## CarbonProductivity                 0.188431
## WaterProductivity                  0.148562
## WasteProductivity                  0.798056
## GreenReputation                    0.295101
## DebtRatio                          0.055206 .
## NetMargin                         9.347e-09 ***
## log(Asset)                         0.369224
## factor(YearFinancialIndicator)2014  0.659579
## factor(YearFinancialIndicator)2015  0.010013 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed_time6, vcovHC(fixed_time6, method = "arellano")) # Heteroskedasticity consistent
```

```
##
## t test of coefficients:
##
##                                    Estimate  Std. Error t value
## SustainabilityPayLink             -2.8600e-02  4.3366e-02 -0.6595
## SustainableThemedCommitment        3.9284e-01  1.3780e-01  2.8509
## AuditScore                         3.0198e-02  7.3821e-02  0.4091
## EnergyProductivity                 1.0692e-02  1.3445e-02  0.7953
## CarbonProductivity                -2.3715e-02  1.8013e-02 -1.3165
## WaterProductivity                  1.6937e-02  1.1711e-02  1.4463
## WasteProductivity                  2.2452e-03  8.7718e-03  0.2560
## GreenReputation                   -5.4184e-03  5.1713e-03 -1.0478
## DebtRatio                         -3.5511e-05  1.8490e-05 -1.9205
## NetMargin                          2.0726e-01  3.5649e-02  5.8139
## log(Asset)                        -5.5829e-03  6.2134e-03 -0.8985
## factor(YearFinancialIndicator)2014 -8.5186e-04  1.9330e-03 -0.4407
## factor(YearFinancialIndicator)2015 -6.7287e-03  2.6054e-03 -2.5826
##                                    Pr(>|t|)
## SustainabilityPayLink              0.509801
## SustainableThemedCommitment        0.004491 **
## AuditScore                         0.682620
```

```
## EnergyProductivity                   0.426732
## CarbonProductivity                   0.188431
## WaterProductivity                    0.148562
## WasteProductivity                    0.798056
## GreenReputation                      0.295101
## DebtRatio                            0.055206 .
## NetMargin                           9.347e-09 ***
## log(Asset)                           0.369224
## factor(YearFinancialIndicator)2014   0.659579
## factor(YearFinancialIndicator)2015   0.010013 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed_time6, vcovHC(fixed_time6, type = "HC3")) # Heteroskedasticity consistent coefficients,
```

```
##
## t test of coefficients:
##
##                                      Estimate  Std. Error t value
## SustainabilityPayLink              -2.8600e-02  4.4843e-02 -0.6378
## SustainableThemedCommitment         3.9284e-01  1.4146e-01  2.7769
## AuditScore                          3.0198e-02  7.5943e-02  0.3976
## EnergyProductivity                  1.0692e-02  1.3913e-02  0.7685
## CarbonProductivity                 -2.3715e-02  1.8449e-02 -1.2854
## WaterProductivity                   1.6937e-02  1.2072e-02  1.4030
## WasteProductivity                   2.2452e-03  8.9860e-03  0.2499
## GreenReputation                    -5.4184e-03  5.3876e-03 -1.0057
## DebtRatio                          -3.5511e-05  2.9604e-05 -1.1995
## NetMargin                           2.0726e-01  3.9914e-02  5.1927
## log(Asset)                         -5.5829e-03  7.0670e-03 -0.7900
## factor(YearFinancialIndicator)2014 -8.5186e-04  1.9874e-03 -0.4286
## factor(YearFinancialIndicator)2015 -6.7287e-03  2.6584e-03 -2.5311
##                                     Pr(>|t|)
## SustainabilityPayLink               0.523833
## SustainableThemedCommitment         0.005637 **
## AuditScore                          0.691022
## EnergyProductivity                  0.442458
## CarbonProductivity                  0.199074
## WaterProductivity                   0.161067
## WasteProductivity                   0.802771
## GreenReputation                     0.314902
## DebtRatio                           0.230733
## NetMargin                          2.733e-07 ***
## log(Asset)                          0.429806
## factor(YearFinancialIndicator)2014  0.668335
## factor(YearFinancialIndicator)2015  0.011592 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# The following shows the HC standard errors of the coefficients
t(sapply(c("HC0", "HC1", "HC2", "HC3", "HC4"), function(x) sqrt(diag(vcovHC(fixed_time6, type = x)))))
```

```
##     SustainabilityPayLink SustainableThemedCommitment AuditScore
## HC0            0.04336616                  0.1377961 0.07382128
## HC1            0.04363456                  0.1386489 0.07427817
```

```
## HC2            0.04407811                   0.1396144 0.07486993
## HC3            0.04484293                   0.1414643 0.07594285
## HC4            0.04576222                   0.1425230 0.07697275
##     EnergyProductivity CarbonProductivity WaterProductivity
## HC0         0.01344481         0.01801320        0.01171115
## HC1         0.01352802         0.01812468        0.01178363
## HC2         0.01367093         0.01822875        0.01188688
## HC3         0.01391325         0.01844914        0.01207213
## HC4         0.01419487         0.01852085        0.01224806
##     WasteProductivity GreenReputation    DebtRatio  NetMargin  log(Asset)
## HC0       0.008771776     0.005171251 1.849029e-05 0.03564927 0.006213450
## HC1       0.008826065     0.005203257 1.860473e-05 0.03586991 0.006251905
## HC2       0.008877850     0.005274518 2.309810e-05 0.03767820 0.006602796
## HC3       0.008986043     0.005387573 2.960394e-05 0.03991387 0.007067045
## HC4       0.009041856     0.005579867 5.181145e-05 0.04492458 0.008247656
##     factor(YearFinancialIndicator)2014 factor(YearFinancialIndicator)2015
## HC0                         0.001933025                         0.002605442
## HC1                         0.001944988                         0.002621568
## HC2                         0.001958575                         0.002630374
## HC3                         0.001987447                         0.002658375
## HC4                         0.002033324                         0.002690145
```

```
coeftest(fixed6) # Original coefficients
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value Pr(>|t|)
## SustainabilityPayLink       -3.3613e-02  4.1798e-02 -0.8042  0.42158
## SustainableThemedCommitment  3.7652e-01  1.2757e-01  2.9514  0.00327 **
## AuditScore                  -3.0092e-03  1.2233e-01 -0.0246  0.98038
## EnergyProductivity           1.4422e-02  1.1834e-02  1.2186  0.22341
## CarbonProductivity          -2.5799e-02  1.4104e-02 -1.8292  0.06780 .
## WaterProductivity            1.7874e-02  9.9376e-03  1.7986  0.07252 .
## WasteProductivity            4.4850e-03  9.7306e-03  0.4609  0.64500
## GreenReputation             -1.7713e-03  5.0103e-03 -0.3535  0.72380
## DebtRatio                   -3.0944e-05  3.3929e-05 -0.9120  0.36208
## NetMargin                    2.0989e-01  7.7229e-03 27.1772  < 2e-16 ***
## log(Asset)                  -6.5081e-03  3.3077e-03 -1.9676  0.04952 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed6, vcovHC) # Heteroskedasticity consistent coefficients
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value  Pr(>|t|)
## SustainabilityPayLink       -3.3613e-02  4.2850e-02 -0.7844   0.43305
## SustainableThemedCommitment  3.7652e-01  1.3816e-01  2.7252   0.00659 **
## AuditScore                  -3.0092e-03  6.9786e-02 -0.0431   0.96562
## EnergyProductivity           1.4422e-02  1.3888e-02  1.0385   0.29942
## CarbonProductivity          -2.5799e-02  1.8596e-02 -1.3874   0.16578
## WaterProductivity            1.7874e-02  1.1800e-02  1.5147   0.13030
## WasteProductivity            4.4850e-03  8.8279e-03  0.5080   0.61158
```

```
## GreenReputation             -1.7713e-03  5.0393e-03 -0.3515   0.72532
## DebtRatio                   -3.0944e-05  2.0253e-05 -1.5278   0.12701
## NetMargin                    2.0989e-01  3.5471e-02  5.9171 5.164e-09 ***
## log(Asset)                  -6.5081e-03  5.9128e-03 -1.1007   0.27142
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed6, vcovHC(fixed6, method = "arellano")) # Heteroskedasticity consistent
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value  Pr(>|t|)
## SustainabilityPayLink       -3.3613e-02  4.2850e-02 -0.7844   0.43305
## SustainableThemedCommitment  3.7652e-01  1.3816e-01  2.7252   0.00659 **
## AuditScore                  -3.0092e-03  6.9786e-02 -0.0431   0.96562
## EnergyProductivity           1.4422e-02  1.3888e-02  1.0385   0.29942
## CarbonProductivity          -2.5799e-02  1.8596e-02 -1.3874   0.16578
## WaterProductivity            1.7874e-02  1.1800e-02  1.5147   0.13030
## WasteProductivity            4.4850e-03  8.8279e-03  0.5080   0.61158
## GreenReputation             -1.7713e-03  5.0393e-03 -0.3515   0.72532
## DebtRatio                   -3.0944e-05  2.0253e-05 -1.5278   0.12701
## NetMargin                    2.0989e-01  3.5471e-02  5.9171 5.164e-09 ***
## log(Asset)                  -6.5081e-03  5.9128e-03 -1.1007   0.27142
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
coeftest(fixed6, vcovHC(fixed6, type = "HC3")) # Heteroskedasticity consistent coefficients, type 3coef
```

```
##
## t test of coefficients:
##
##                               Estimate  Std. Error t value  Pr(>|t|)
## SustainabilityPayLink       -3.3613e-02  4.4258e-02 -0.7595  0.447825
## SustainableThemedCommitment  3.7652e-01  1.4171e-01  2.6569  0.008069 **
## AuditScore                  -3.0092e-03  7.1761e-02 -0.0419  0.966564
## EnergyProductivity           1.4422e-02  1.4337e-02  1.0059  0.314809
## CarbonProductivity          -2.5799e-02  1.9019e-02 -1.3565  0.175373
## WaterProductivity            1.7874e-02  1.2148e-02  1.4713  0.141665
## WasteProductivity            4.4850e-03  9.0285e-03  0.4968  0.619512
## GreenReputation             -1.7713e-03  5.2652e-03 -0.3364  0.736655
## DebtRatio                   -3.0944e-05  3.2373e-05 -0.9559  0.339479
## NetMargin                    2.0989e-01  3.9678e-02  5.2898 1.647e-07 ***
## log(Asset)                  -6.5081e-03  6.6242e-03 -0.9825  0.326215
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# The following shows the HC standard errors of the coefficients
t(sapply(c("HC0", "HC1", "HC2", "HC3", "HC4"), function(x) sqrt(diag(vcovHC(fixed6, type = x)))))
```

```
##     SustainabilityPayLink SustainableThemedCommitment AuditScore
## HC0            0.04285004                   0.1381649 0.06978621
## HC1            0.04307412                   0.1388874 0.07015115
## HC2            0.04352959                   0.1399239 0.07076091
## HC3            0.04425798                   0.1417137 0.07176134
## HC4            0.04529470                   0.1434776 0.07302858
```

```
##     EnergyProductivity CarbonProductivity WaterProductivity
## HC0         0.01388758         0.01859610        0.01180022
## HC1         0.01396020         0.01869335        0.01186193
## HC2         0.01410490         0.01880518        0.01196966
## HC3         0.01433674         0.01901861        0.01214845
## HC4         0.01463927         0.01914805        0.01236877
##     WasteProductivity GreenReputation    DebtRatio  NetMargin  log(Asset)
## HC0       0.008827938     0.005039290 2.025313e-05 0.03547135 0.005912826
## HC1       0.008874103     0.005065642 2.035904e-05 0.03565684 0.005943746
## HC2       0.008927327     0.005145955 2.527851e-05 0.03747295 0.006237912
## HC3       0.009028450     0.005265185 3.237270e-05 0.03967784 0.006624225
## HC4       0.009115643     0.005512491 5.659911e-05 0.04469506 0.007605714
```

What should I do with those estimates?