This is the title of my thesis

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Abstract

This is an abstract

Aknowledgments

I would like to thank some of you . . .

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Introduction

Over the past decades, humanity is progressively becoming aware of the finiteness of earth's resources and its impact on the current global warming. On the one hand, Houghton and Change (1996) anticipated in their first report an average global warming between +1° and +3.5° C until 2100 relative to the temperature of 1990. They also warned that an increase of temperatures superior to +2° C could have some harsh climatic repercussions. On the other hand the Kyoto Protocol had been written in 1997, enforced in 2005 and led to the first Global Agreement on global warming during the Paris Conference in 2015. Those different solutions implemented over the past decades did not have any significant impacts on the fight against global warming. Greenhouse Gas Emissions (GGE) have still increased considerably across years. Although the environmental consciousness-raising had already gained ground, according to Jean Jouzel (2017) human being have to act now if he we want to have a chance to reduce effects of climate change.

For the last several decades, companies have been more and more considered as entities responsible for stewardship of the natural environment (Majumdar and Marcus 2001; Przychodzen and Przychodzen 2015). Ecosystem degradation and resources depletion engender a threat to firm's longevity (Dowell, Hart, and Yeung 2000), and as a reaction, firms have to pro-actively adopt an environmental strategy (Hart 1995). In his speech at Lloyds of London 2015, Mark Carney, Governor of the Bank of England and Chair of the Financial Stability Board (FSB), identified climate change as one of the most material threats to financial stability (Elliott 2015). To this end, companies facing higher risks associated to climate change are ones subject to greater incentives to develop green strategies (Hoffman 2005). However, both economic benefits and strategic opportunities deriving from sustainable development are usually underestimated by managers and still too many companies do not feel concerned about global warming (Berchicci and King 2007; Hart 1995). Moreover, according to Scarpellini, Valero-Gil, and Portillo-Tarragona (2016), green projects are not common in companies of many countries because of significant barriers and a negligible culture of excluding sustainable development from an organization's strategy. If we consider that people's actions reflect a variable mix of altruistic motivation, material self-interest, and social or self-image concerns (Bénabou and Tirole 2006), demonstrating that green development is a significant interest for firms could be a serious step forward in the fight against global warming.

To be continued...

1 Literature Review

According to…

- The link between CEP and CFP. Literrature have shown that it pays to be green. However answering the question "When an how does it pay to be green?" remains unclear.
- Citation from (Endrikat, Guenther, and Hoppe 2014)

  > Over the last four decades, myriad studies have sought to identify the relationship between these performance constructs. In this context, one of the most fundamental issues shaping research on the focal relationship refers to the direction of causality (i.e., whether CEP influences CFP, whether CFP influences CEP, or whether there is a bidirectional relationship) ## Subsection 1

-

1.1 Subsection 2

2 Hypotheses

Here are my three hypotheses based on Li, Ngniatedema, and Chen (2017) and Chen, Ngniatedema, and Li (2018) :

- **H1:** The higher the level of green initiatives (Pay Link, Sustainability Themed Committee and Audit), the higher the level of green performance (Energy Productivity, Carbon Productivity, Water Productivity, Waste Production and Green Revenue).
- **H2:** The higher the level of green performance (Energy Productivity, Carbon Productivity, Water Productivity, Waste Production and Green Revenue), the higher the level of financial performance (ROA and Tobin's Q).
- **H3:** The higher the level of green initiatives (Pay Link, Sustainability Themed Committee and Audit), the higher the level of financial performance (ROA and Tobin's Q).

3 Data

DataBase_010418 ## Sample Selection

My database is a long panel data containing n companies, each of which includes T observations measured at 1 through t time period. As the same companies are observed for each period, I can describe my panel data as a fixed panel (Greene 2007).

Balanced or unbalanced panel data?

3.1 Dependent Variables

3.2 Independent Variables

3.3 Control Variables

4 Methodology

Here is my methodology...

4.1 Panel Data

4.1.1 Definition of panel data

Panel data, also called longitudinal data or cross-sectional time-series data include observations on N cross section units (i.e., firms) over T time-periods.

4.1.2 Advantages of panel data :

As panel data analysis uses variation in both these dimensions, it is considered to be one of the most efficient analytical methods for data (Dimitrios Asteriou 2006). It usually contains more degrees of freedom, less collinearity among the variables, more efficiency and more sample variability than one-dimensional method (i.e.cross-sectional data and time series data) giving a more accurate inference of the parameters estimated in the model (Hsiao 2007, Hsiao (2014)).

4.1.3 Fixed or random effect model

Panel data may have individual (group) effect, time effect, or both, which are analyzed by fixed effect and/or random effect models. *A fixed effect model* examines if intercepts vary across group or time period, whereas a *random effect model* explores differences in error variance components across individual or time period. (Park 2011).

!! I need to test the fixed-random effect model of my database before moving forward !!

- Ng and Rezaee (2015) used the two-stage-least-square regressions to estimate its models.

** In case of presence of endogeneyity in an econometric model, OLS is not capable of delivering consistent parameter estimates (Wooldridge 2008).**

Citation from (Wooldridge 2008) :

> The general concept is that of the instrumental variables estimator; a popular form of that estimator, often employed in the context of endogeneity, is known as two-stage least squares (2SLS)

4.1.4 Endogeneity test

Even if panel data have a lot of advantages. . .

Two issues involved in utilizing panel data, namely heterogeneity bias and selectivity bias (Hsiao 2014).

Citation from Hsiao (2014):

> It is only by taking proper account of selectivity and heterogeneity biases in the panel data that one can have confidence in the results obtained.

Dang, Kim, and Shin (2015) examine which methods are appropriate for estimating dynamic panel data models in empirical corporate finance,especially in short panels of company data, in the likely presence of (1) unobserved heterogeneity and endogeneity, (2) residual serial correlation, or (3) fractional dependent variables. The bias-corrected fixed-effects estimators, based on an analytical, bootstrap, or indirect inference approach, are found to be the most appropriate and robust methods.

But Miroshnychenko, Barontini, and Testa (2017) used the OLS regressions in micro panel using the Huber-White sand wich estimator, to account for the heteroscedasticity problem. . . **Which method should I use?**

Hausmann test to test the random effects model for both dependant variables?

4.2 Econometric Model

The first hypothesis will be tested with T-tests on the impact of each green initiative on green performance.

Both Hypotheses two and three will be tested by regression analysis. Econometric models are based on Delmas, Nairn-Birch, and Lim (2015) and Miroshnychenko, Barontini, and Testa (2017) and started from the general form:

$$Y_{t+1} = \beta_0 + \beta_1(X_{it}) + +\beta_2(C_{it}) + \varepsilon_{it} \tag{1}$$

where Y_{t+1} is the financial performance of firm i in year $t+1$, β is the vector of estimated regression coefficients for each of the explanatory variables X_{it}, C_{it} is a vector of control variables that include financial leverage, firm size and industry sector, $\varepsilon_{it}$is the error term.

More precisely I will test six models :

Model 1 : Green Initiatives on Tobin's Q

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

Model 2 : Green Initiatives on ROA

$$ROA_{it+1} = \beta_0 + \beta_1(SP_{it}) + \beta_2(ST_{it}) + \beta_3(AS_{it}) + \beta_9(C_{it}) + \varepsilon_{it} \tag{3}$$

Model 3 : Green Performance on Tobin's Q

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

Model 4 : Green Performance on ROA

$$ROA_{it+1} = \beta_0+\beta_1(EP_{it})+\beta_2(CP_{it})+\beta_3(WatP_{it})+\beta_4(WasP_{it})+\beta_5(GP_{it})+\beta_9(C_{it})+\varepsilon_{it} \tag{5}$$

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

$$TobinsQ_{it+1} = \beta_0+\beta_1(EP_{it})+\beta_2(CP_{it})+\beta_3(WatP_{it})+\beta_4(WasP_{it})+\beta_5(GP_{it})+\beta_6(SP_{it})+\beta_7(ST_{it})+\beta_8(AS \tag{6}$$

Model 6 : Both Green Performance and Green Initiative on ROA

$$ROA_{it+1} = \beta_0+\beta_1(EP_{it})+\beta_2(CP_{it})+\beta_3(WatP_{it})+\beta_4(WasP_{it})+\beta_5(GP_{it})+\beta_6(SP_{it})+\beta_7(ST_{it})+\beta_8(AS_{it})+ \quad (7)$$

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

Dans l'Equation 8, blabla ou dans l'équation 8

4.3 Sensitivity Analysis

Table 5.1: Test Summary

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model**
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

5 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.

Croissant and Millo (2008a) and Torres-Reyna (2010) 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 5.1 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 5.1. 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

5.1 Model 1

5.1.1 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

$$TobinsQ_{it+1} = \beta_0 + \beta_1(SP_{it}) + \beta_2(ST_{it}) + \beta_3(AS_{it}) + \beta_9(C_{it}) + \varepsilon_{it} \tag{8}$$

5.1.1.1 Tests of poolability

Citation from (Croissant and Millo 2008b) :

> *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.*

5.1.1.2 Fixed or Random : Hausman Test

Citation from Torres-Reyna (2010) :

> *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.*

```
##
##  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.

5.1.1.3 Testing for time fixed effects

```
##
##  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!!**

5.1.1.4 Testing for cross-sectional dependence/contemporaneous correlation

Citation from Torres-Reyna (2010) :

> 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).

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

```
## alternative hypothesis: cross-sectional dependence

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

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

##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditSco
## 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?**

5.1.1.5 Testing for serial correlation

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

##
```

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

5.1.1.6 Testing for stationarity

```
##
##  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

5.1.1.7 Testing for heteroskedasticity

```
##
##  Breusch-Pagan test
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditSco
## 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 Miroshnychenko, Barontini, and Testa (2017) and Stock and Watson (2008)

"If hetersokedaticity is detected you can use the sandwich estimaror" (Torres-Reyna 2010) 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)

```
##
## 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
```

```
##
## 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
```

```
##
## 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
```

```
##
## 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
```

```
##     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?

5.2 Model 2

5.2.1 Test

Model 2 : Green Initiatives on ROA

$$ROA_{it+1} = \beta_0 + \beta_1(SP_{it}) + \beta_2(ST_{it}) + \beta_3(AS_{it}) + \beta_9(C_{it}) + \varepsilon_{it} \tag{9}$$

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

5.2.1.1 Tests of poolability

Citation from (Croissant and Millo 2008b) :

> *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.*

5.2.1.2 Fixed or Random : Hausman Test

Citation from Torres-Reyna (2010) :

> *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.*

```
##
##  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.

5.2.1.3 Testing for time fixed effects

```
##
##  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!!**

5.2.1.4 Testing for cross-sectional dependence/contemporaneous correlation

Citation from Torres-Reyna (2010) :

> 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).

```
##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +
## chisq = 123910, df = 78606, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence

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

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

##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +
## 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

5.2.1.5 Testing for serial correlation

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

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

5.2.1.6 Testing for stationarity

```
##
##  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

5.2.1.7 Testing for heteroskedasticity

```
##
##  Breusch-Pagan test
##
```

```
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +
## 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 Miroshnychenko, Barontini, and Testa (2017) and Stock and Watson (2008)

"If hetersokedaticity is detected you can use the sandwich estimaror" (Torres-Reyna 2010)

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)

```
##
## 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

##
## 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
```


```
##
## 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
```


```
##
## 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
```

```
##     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?

5.3 Model 3

Model 3 : Green Performance on Tobin's Q

$$TobinsQ_{it+1} = \beta_0+\beta_1(EP_{it})+\beta_2(CP_{it})+\beta_3(WatP_{it})+\beta_4(WasP_{it})+\beta_5(GP_{it})+\beta_9(C_{it})+\varepsilon_{it} \tag{10}$$

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

5.3.1 Test

5.3.1.1 Tests of poolability

Citation from (Croissant and Millo 2008b) :

> *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.*

5.3.1.2 Fixed or Random : Hausman Test

Citation from Torres-Reyna (2010) :

> *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.*

```
##
##  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.

5.3.1.3 Testing for time fixed effects

```
##
##  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!!**

5.3.1.4 Testing for cross-sectional dependence/contemporaneous correlation

Citation from Torres-Reyna (2010) :

> 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).

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

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

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

```
##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity +
## 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?

5.3.1.5 Testing for serial correlation

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
##  models
##
## data:  TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity +
## chisq = 27.688, df = 1, p-value = 1.425e-07
## alternative hypothesis: serial correlation in idiosyncratic errors
```

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

5.3.1.6 Testing for stationarity

```
##
##  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

5.3.1.7 Testing for heteroskedasticity

```
##
```

```
##  Breusch-Pagan test
##
## data:  TobinsQ ~ EnergyProductivity + CarbonProductivity + WaterProductivity +
## 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 Miroshnychenko, Barontini, and Testa (2017) and Stock and Watson (2008)

"If hetersokedaticity is detected you can use the sandwich estimaror" (Torres-Reyna 2010)

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)

```
##
## 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

##
## 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

##
## 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
```

```
##
## 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
```

```
##     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?

5.4 Model 4

Model 4 : Green Performance on ROA

$$ROA_{it+1} = \beta_0 + \beta_1(EP_{it}) + \beta_2(CP_{it}) + \beta_3(WatP_{it}) + \beta_4(WasP_{it}) + \beta_5(GP_{it}) + \beta_9(C_{it}) + \varepsilon_{it} \quad (11)$$

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

5.4.1 Test

5.4.1.1 Tests of poolability

Citation from (Croissant and Millo 2008b) :

> *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.*

5.4.1.2 Fixed or Random : Hausman Test

Citation from Torres-Reyna (2010) :

> *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.*

```
##
##  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.

5.4.1.3 Testing for time fixed effects

```
##
##  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!!**

5.4.1.4 Testing for cross-sectional dependence/contemporaneous correlation

Citation from Torres-Reyna (2010) :

> 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).

```
##
##  Breusch-Pagan LM test for cross-sectional dependence in panels
##
## data:  ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     Wast
## chisq = 124250, df = 78606, p-value < 2.2e-16
## alternative hypothesis: cross-sectional dependence

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

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

##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     Wast
## 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?

5.4.1.5 Testing for serial correlation

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

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

5.4.1.6 Testing for stationarity

```
##
##  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

5.4.1.7 Testing for heteroskedasticity

```
##
```

```
##  Breusch-Pagan test
##
## data:  ROA ~ EnergyProductivity + CarbonProductivity + WaterProductivity +     Wast
## 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 Miroshnychenko, Barontini, and Testa (2017) and Stock and Watson (2008)

"If hetersokedaticity is detected you can use the sandwich estimaror" (Torres-Reyna 2010)

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)

```
##
## 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
```

```
##
## 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
```

```
##
## 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
```

```
##
## 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
```

```
##     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?

5.5 Model 5

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

$$TobinsQ_{it+1} = \beta_0+\beta_1(EP_{it})+\beta_2(CP_{it})+\beta_3(WatP_{it})+\beta_4(WasP_{it})+\beta_5(GP_{it})+\beta_6(SP_{it})+\beta_7(ST_{it})+\beta_8(AS \tag{12}$$

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

5.5.1 Test

5.5.1.1 Tests of poolability

Citation from (Croissant and Millo 2008b) :

> *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.*

5.5.1.2 Fixed or Random : Hausman Test

Citation from Torres-Reyna (2010) :

> *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.*

```
##
##  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.

5.5.1.3 Testing for time fixed effects

```
##
##  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!!**

5.5.1.4 Testing for cross-sectional dependence/contemporaneous correlation

Citation from Torres-Reyna (2010) :

> 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).

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

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

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

```
## 
##  Pesaran CD test for cross-sectional dependence in panels
## 
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditSco
## 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?

5.5.1.5 Testing for serial correlation

```
##
##  Breusch-Godfrey/Wooldridge test for serial correlation in panel
##  models
##
## data:  TobinsQ ~ SustainabilityPayLink + SustainableThemedCommitment +     AuditSco
## chisq = 26.535, df = 1, p-value = 2.588e-07
## alternative hypothesis: serial correlation in idiosyncratic errors
```

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

5.5.1.6 Testing for stationarity

```
##
##  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

5.5.1.7 Testing for heteroskedasticity

```
##
```

```
##  Breusch-Pagan test
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +
## 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 Miroshnychenko, Barontini, and Testa (2017) and Stock and Watson (2008)

"If hetersokedaticity is detected you can use the sandwich estimaror" (Torres-Reyna 2010)

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)

```
##
## 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
```

```
##
## 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
```

```
##
## 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

##
## 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

##     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?

5.6 Model 6

Model 6 : Both Green Performance and Green Initiative on ROA

$$ROA_{it+1} = \beta_0+\beta_1(EP_{it})+\beta_2(CP_{it})+\beta_3(WatP_{it})+\beta_4(WasP_{it})+\beta_5(GP_{it})+\beta_6(SP_{it})+\beta_7(ST_{it})+\beta_8(AS_{it})+ \tag{13}$$

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

5.6.1 Test

5.6.1.1 Tests of poolability

Citation from (Croissant and Millo 2008b) :

> *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.*

5.6.1.2 Fixed or Random : Hausman Test

Citation from Torres-Reyna (2010) :

> *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.*

```
##
##  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.

5.6.1.3 Testing for time fixed effects

```
##
##  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!!**

5.6.1.4 Testing for cross-sectional dependence/contemporaneous correlation

Citation from Torres-Reyna (2010) :

> 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).

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

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

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

##
##  Pesaran CD test for cross-sectional dependence in panels
##
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +
## 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. . .

5.6.1.5 Testing for serial correlation

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

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

5.6.1.6 Testing for stationarity

```
##
##  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

5.6.1.7 Testing for heteroskedasticity

```
##
##  Breusch-Pagan test
##
```

```
## data:  ROA ~ SustainabilityPayLink + SustainableThemedCommitment + AuditScore +
## 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 Miroshnychenko, Barontini, and Testa (2017) and Stock and Watson (2008)

"If hetersokedaticity is detected you can use the sandwich estimaror" (Torres-Reyna 2010)

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)

```
##
## 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

##
## 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

##
## 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

##
## 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
```

```
##     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
```

```
##
## 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
```

```
##
## 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

##
## 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

##
## 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

##     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?

6 Results

Some incredible results…

7 Discussion

Let's speak...

Conclusion

This is my conclusion...

Appendix

Appendix A : This is an appendix a

Appendix B : This is an appendix b

References

Berchicci, Luca, and Andrew King. 2007. "11 Postcards from the Edge." *The Academy of Management Annals* 1 (1): 513–47. doi:10.1080/078559816.

Bénabou, Roland, and Jean Tirole. 2006. "Incentives and Prosocial Behavior." *The American Economic Review* 96 (5): 1652–78. doi:10.1257/000282806779396283.

Chen, Fang, Thomas Ngniatedema, and Suhong Li. 2018. "A Cross-Country Comparison of Green Initiatives, Green Performance and Financial Performance." *Management Decision*, February. doi:10.1108/MD-08-2017-0761.

Croissant, Yves, and Giovanni Millo. 2008a. "Panel Data Econometrics in R: The Plm Package." *Journal of Statistical Software* 27 (2): 1–43.

———. 2008b. "Panel Data Econometrics in R: The Plm Package." *Journal of Statistical Software* 27 (2): 1–43. https://cran.r-project.org/web/packages/plm/vignettes/plm.pdf.

Dang, Viet Anh, Minjoo Kim, and Yongcheol Shin. 2015. "In Search of Robust Methods for Dynamic Panel Data Models in Empirical Corporate Finance." *Journal of Banking & Finance* 53 (April): 84–98. doi:10.1016/j.jbankfin.2014.12.009.

Delmas, Magali A., Nicholas Nairn-Birch, and Jinghui Lim. 2015. "Dynamics of Environmental and Financial Performance: The Case of Greenhouse Gas Emissions." *Organization & Environment* 28 (4): 374–93. https://pdfs.semanticscholar.org/cbe5/48cbdb9e569de3c79bad22f1f02442374ac8.pdf.

Dimitrios Asteriou. 2006. *Applied Econometrics*. http://www.macmillanihe.com/page/detail/Applied-Econometrics/?K=9781137415462.

Dowell, Glen, Stuart Hart, and Bernard Yeung. 2000. "Do Corporate Global Environmental Standards Create or Destroy Market Value?" *Management Science* 46 (8): 1059–74.

Elliott, Larry. 2015. "Carney Warns of Risks from Climate Change 'Tragedy of the Horizon'." *The Guardian*. September 29. http://www.theguardian.com/environment/2015/sep/29/carney-warns-of-risks-from-climate-change-tragedy-of-the-horizon.

Endrikat, Jan, Edeltraud Guenther, and Holger Hoppe. 2014. "Making Sense of

Conflicting Empirical Findings: A Meta-Analytic Review of the Relationship Between Corporate Environmental and Financial Performance." *European Management Journal* 32 (5): 735–51. doi:10.1016/j.emj.2013.12.004.

Greene, William H. 2007. "Fixed and Random Effects Models for Count Data." SSRN Scholarly Paper ID 1281928. Rochester, NY: Social Science Research Network. https://papers.ssrn.com/abstract=1281928.

Hart, Stuart L. 1995. "A Natural-Resource-Based View of the Firm." *Academy of Management Review* 20 (4): 986–1014. doi:10.5465/AMR.1995.9512280033.

Hoffman, Andrew J. 2005. "Climate Change Strategy: The Business Logic Behind Voluntary Greenhouse Gas Reductions." *California Management Review* 47 (3): 21–46. doi:10.2307/41166305.

Houghton, John T., and Intergovernmental Panel on Climate Change. 1996. *Climate Change 1995: The Science of Climate Change: Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Hsiao, Cheng. 2007. "Panel Data Analysisadvantages and Challenges." *TEST* 16 (1): 1–22. doi:10.1007/s11749-007-0046-x.

———. 2014. "Chapitre 5 : Panel Data Models." In *Analysis of Panel Data*. 54. Cambridge university press.

Jean Jouzel. 2017. "Luxembourg Sustainability Forum 2017 - Jean Jouzel, Les Enjeux Du Réchauffement Climatique."

Li, Suhong, Thomas Ngniatedema, and Fang Chen. 2017. "Understanding the Impact of Green Initiatives and Green Performance on Financial Performance in the US." *Business Strategy and the Environment*, January, n/a–n/a. doi:10.1002/bse.1948.

Majumdar, Sumit K., and Alfred A. Marcus. 2001. "Rules Versus Discretion: The Productivity Consequences of Flexible Regulation." *Academy of Management Journal* 44 (1): 170–79. doi:10.2307/3069344.

Miroshnychenko, Ivan, Roberto Barontini, and Francesco Testa. 2017. "Green Practices and Financial Performance: A Global Outlook." *Journal of Cleaner Production* 147

(Supplement C): 340–51. doi:10.1016/j.jclepro.2017.01.058.

Ng, Anthony C., and Zabihollah Rezaee. 2015. "Business Sustainability Performance and Cost of Equity Capital." *Journal of Corporate Finance* 34 (October): 128–49. doi:10.1016/j.jcorpfin.2015.08.003.

Park, Hun Myoung. 2011. "Practical Guides to Panel Data Modeling: A Step by Step Analysis Using Stata." *Public Management and Policy Analysis Program, Graduate School of International Relations, International University of Japan.*

Przychodzen, Justyna, and Wojciech Przychodzen. 2015. "Relationships Between Eco-Innovation and Financial Performance Evidence from Publicly Traded Companies in Poland and Hungary." *Journal of Cleaner Production* 90 (March): 253–63. doi:10.1016/j.jclepro.2014.11.034.

Scarpellini, Sabina, Jesús Valero-Gil, and Pilar Portillo-Tarragona. 2016. "The 'Economicfinance Interface' for Eco-Innovation Projects." *International Journal of Project Management* 34 (6): 1012–25. doi:10.1016/j.ijproman.2016.04.005.

Stock, James H., and Mark W. Watson. 2008. "Heteroskedasticity-Robust Standard Errors for Fixed Effects Panel Data Regression." *Econometrica* 76 (1): 155–74. doi:doi:10.1111/j.0012-9682.2008.00821.x.

Torres-Reyna, Oscar. 2010. "Getting Started in Fixed/Random Effects Models Using R." *Data & Statistical Services. Princeton University.*

Wooldridge, J. M. 2008. "Chapter 15: Instrumental Variables and Two Stage Least Squares." *Introductory Econometrics: A Modern Approach* 4: 506–45.