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THE “SCHEFFE TEST” AND THE “EFFECT SIZE”

For further analysis of variability in Regional Ecological Aptitude within the European Union

LE « TEST DE SCHEFFE » ET LA « TAILLE DE L’EFFET »

Pour un complément d’analyse de la variabilité de l’aptitude écologique régionale au sein de l’U.E

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Abstract

In climate change economics, several solutions could be applied to limit the harmful climate change effects: application of eco-taxation, increase in energy prices, rationing of fuel use. Are these solutions all equally effective regardless of the region or origin country? This essay focuses on a variability analysis of the efforts deployed for a “fair fight” against global warming within European Union. Among 5 countries, belonging to 5 different regions, we were able to detect a difference concerning the ecological suitability between 4 countries. These differences are due to the unbalanced proportions of two differences, one relative to the country and the other relative to the region. Since all the regions are normally endowed with the same means (financial and non-financial resources) to combat the effects of climate change, it was possible to detect the presence of a difference in the effectiveness of the action due to a difference between regions, within a country (between regions) and also to the existence of a difference due to the gap between countries. To do this, in addition to the use of the univariate statistical tool "ANOVA" (analysis of variance), we used two other concepts to complete this analysis, namely: the “Scheffe test” for making multiple comparisons and the concept of "effect size" also called "correlation ratio".

Key Words: ANOVA, Scheffe Test, Effect Size, Correlation Ratio, Ecological Aptitude, Fair Fight, European Union

INTRODUCTION

ANOVA or ***ANalysis Of VAriance***, as its name suggests, allows the analysis of differences between two or more groups of any size is a generalization of the "t test" while being one of the most widely used statistical tests today and whose understanding is necessary for the interpretation of most scientific texts or for reading the results of evaluative studies. It uses the F statistic (R. Fisher), which compares the difference between groups relative to the difference between observations that come from the same groups. The Interpretation of the F statistic is done by comparing its value to the critical value found in the table of critical values. When it turns out that the difference between the groups is statistically significant, we use multiple comparison tests, to more accurately determine how many populations are represented by the groups. Finally, the «°the size effect°» gives us a numerical indication, and in percentage, of the size of the difference between the groups. This last statistic is essential for estimating the "practical significance" of a difference detected by the analysis of variance.

The European Union[1] is faced with a dilemma concerning the aids granting within the framework of the CAP (the Common Agricultural Policy). It is in force to grant aid to agriculture according to the maple areas cultivated. However, faced with the problem of global warming due to greenhouse gas emissions (GGE), agriculture is incriminated. In addition, it is topical to opt for solutions that emerge following the consultations of the all-European Union group members. These solutions must demonstrate effectiveness, efficiency and universal, distributive «°sharing the burden°» justice at the EU entirely level even if their objective remains local and concerns regions belonging to various union countries. The question that arises is of a practical nature and its application and above all its effectiveness is of a political nature. Is it more effective to opt for regional policies for an effective fight against the climate change effects? or is it enough to apply the same policies to all the union countries without differentiation? Our analysis could be applied to a European-style economic union with 242 regions belonging to 27 member states (at least until December 2022). The motivation of this work is to detect the differences in ecological suitability between these territories which initially present great differences in economic and social development. Through cohesion policies, the European Union is counting on a regional policy to limit these disparities. The main question

[1] Shaped by history, each country of the European Union has its own administrative division. Each can be marked by a strong centralization, or on the contrary by an important federalism, passing through a multitude of intermediate systems. Local authorities thus implement a certain number of public policies. And some of them, such as the Regions in France, manage the funds of the European cohesion policy. Coming from the European budget, it makes it possible to finance a variety of projects throughout Europe.

to be answered is: Is it more effective to act at the regional level or at the national level? To do this, we will have to answer the subsidiary questions: Are there differences in terms of Ecological Aptitude between European Union countries caused by the heterogeneity of the regions that make up this Union? If so, how to detect and explain them? Are these differences due to a simple difference between countries or to a mix of national and regional differences and in what proportions? We are going to present a theoretical approach to the concepts that we will subsequently mobilize in the practical part which concerns 25 regions belonging to 5 countries drawn at random from the 242 regions of the European Union.

I. THEORETICAL APPROACH TO ANALYSE OF VARIANCE "ANOVA"

Analysis of variance ANOVA "Analysis of variance" is one of the most frequently used statistical analyses: using Fisher's statistics. A, it generalizes the "t test" by making it possible to determine whether several groups belong to one or more populations. Once calculated, the F statistic standardizes the difference between the means of several groups. We look for the "F observed" value in a distribution table of the F statistic to determine the probability of obtaining the "F observed" when the groups come from the same population. If this probability is low ($p < 0.05$), we conclude that the groups do not come from a single population, that is to say that at least one of the groups comes from a different population. As with the "t test", the conclusions drawn with the F statistic include a risk of error, defined by the threshold (α).

1.1. A MULTIPLE "T-TEST" OR AN ANOVA?

1.1.1. REMINDER OF THE "STUDENT" TEST, "THE T STATISTIC"

The "t test" specially designed to infer whether or not two "small size" samples come from the same population, makes it possible to compare two experimental conditions, before and after (paired samples) or two groups with different characteristics. To do this, we calculate the t-statistic which standardizes the difference between the means of the two groups. We check, from a distribution of values T, the probability of obtaining such a value T when two samples come from the same population: when this probability is low, often $p < 5\%$, we deduce that the two samples come from two different populations, with a risk of error close to 5%. When we want to minimize the probability of committing such an inference error, as for the Fisher statistic, we opt for a statistical significance level (α) which is smaller, more conservative ($p < 0.01$ or even $p < 0.001$).

We have three groups, group A, group B and group C, and we want to decide if the groups differ (come from different populations). At first glance, we could compare them two by two

using the "t test" for two independent samples. A first "T test" would compare group A to group B, another, groups B and C and a last, the difference between groups A and C. If we have five groups, we could compare each pair of groups with the "T test" (A versus B, A versus C, A versus D, A versus E, B versus C, B versus D, B versus E, C versus D, C versus E and D versus E). This approach is suboptimal and should not be used. The use of a multitude of T-tests, in addition to its impracticality, "almost certainly" causes an inference error, due to a problem of *cumulative risk of «The First Kind of Error » (α).*

1.1.2. MULTIPLE "T-TESTS": AN INCONVENIENT STRATEGY

Using repeated t-tests increases the number of calculations required. When there are two groups, only one comparison (and therefore only one T test) is required (A versus B). When there are three groups, three comparisons are required (A versus B, B versus C and A versus C). The practical problem shouldn't seem so huge. However, with 5 groups, you need to do 10 comparisons and therefore run 10 t-tests. With 10 groups, you need to do 45, which starts to be absurd. With this approach, the number of tests to be performed quickly becomes excessive. From the number of groups Y, it is possible to calculate the number of pairs of comparisons X, and consequently the number of tests T that should be carried out. "Formula 1" teaches us how to do it.

$$\mathbf{X = Y\ (Y - 1)/2} \qquad \textbf{Formula 1}$$

Applying this Formula to 9 groups, the number of "t-tests" required is X = (8 × 9)/2 = 36. For 12 groups, 66 "T-tests" must be performed. We are on the verge of absurdity

1.1.3. ACCUMULATION OF "Α" ERROR RISKS (MULTIPLICATION OF "T TESTS")

The use of ANOVA rather than the "t-test" is advised when one wants to compare more than two groups and avoid a bias in the inference, induced by the accumulation of «The First Kind of Error ». this will most likely lead to a false conclusion. Following a t-test, comparing three groups, the probability *that at least one* of these conclusions to be false is no longer α%; the risk of committing at least one «The First Kind of Error » (α) is higher. It is possible to calculate the probability of an "inference error" with "Formula 2":

$$\mathbf{P_{err.}\ inf = 1 - (1 - \alpha)^{x}} \qquad \textbf{Formula 2}$$

where "$\mathbf{P_{err}}$.inf" is the probability of making at least "The First Kind of Error", α is the significance level chosen for the individual t-tests, and X is the number of comparisons to be made. Suppose we want to compare five groups (Y= 5). To establish the cumulated risk of "*The First Kind of Error* ", we first calculate the number of comparisons required with "Formula 1".

$$X = Y\,(Y - 1)/2 = 5(2)/2 = 5$$

Then we calculate the cumulated «The First Kind of Error » risks (α) with Formula 2 for the threshold α = 0.05.

$$P_{\cdot err\cdot}\ inf = 1 - (1 - \alpha)^{X} = 1 - (1 - 0.05)\ 5 = 1 - (0.95)5 = 1 - 0.77 = 0.22$$

While we thought we would infer that there would be a 5% risk of error, "Formula 2" indicates that the true risk *of at least one* «The First Kind of Error » *(α)* is 22%, almost five times that!

Table (1): Cumulative «The First Kind of Error » (α) for different numbers of groups with α = 0.05 and α = 0.01			
Number of groups	*VS*	$P_{\cdot err\cdot}$ lower*(α = 0.05)*	$P_{\cdot err\cdot}$ lower*(α = 0.01)*
2	1	0.05	0.01
3	3	0.14	0.03
4	6	0.26	0.06
5	10	0.40	0.10
7	21	0.66	0.19
10	45	0.90	0.36
15	105	0.99	0.65
20	190	0.99	0.85

The risk of incorrectly inferring that at least one of the differences is statistically significant increases when the number of comparisons increases. When a more conservative threshold α is used (0.01 rather than 0.05), the risk of arriving, at least, at one false conclusion is reduced, although it often remains very high (for example p = 0.65 for 15 groups) and, in any case, it greatly exceeds the conventional threshold of statistical significance ($p < 0.05$), which is generally defined as being minimal to justify rejecting the null hypothesis. Nevertheless, this opens the door to a potential solution to the cumulative inference error problem. By reducing the threshold (α) for each, when the comparisons number increases, we can reduce the risk of cumulative error if we opt for α = 0.0001: the cumulative risk of incorrectly inferring that a pair of groups differs is $p < 0.04$. By seeking to control the level of risk (α), it is likely increasing «The Second Kind of Error » risk (β)[2]. The analysis of variance is the most suitable alternative technique to avoid the problem of the accumulation of the risks of «The First Kind of Error », without increasing «The Second Kind of Error » risk (β), if more than two groups are compared.

[2]The risk of a «second kind of Error» (β) corresponds to the fact of deducing that there is no difference, when in reality there is one.

1.2. ANOVA: ITS PRINCIPLES, USES, HYPOTHESIS TEST AND IMPERFECTIONS

1.2.1. THE USES AND PRINCIPLES OF ANOVA

The ANOVA is the statistical technique answered and specifically designed to make several comparisons simultaneously. In the economics of climate change, several solutions can be applied to limit the harmful effects of climate change: application of taxation, increase in energy prices, rationing of fuel use, are these solutions all equally effective? Do the actions of the regions have the same results? To answer this last question, a random sample of 25 regions with the same financial and non-financial means to fight against climate change is randomly drawn from 242 regions in the European Union in five groups and the results of their ecological skills are collected following the application of each provision. After the experiment, the average level of GHG (Greenhouse Gas) emissions is measured for each group. If following the application of the devices, the average level of GHG emissions for each group is the same, it cannot be inferred that the various provisions are *unevenly* effective (or ineffective). Where applicable, it is concluded that the provisions are not equally effective: the same devices produce different "degree of GHG rejection" effects.

the ANOVA is a series of statistical procedures that compare the mean of the dependent variable for each "level" of the independent variable. There *independent variable* represents the characteristic that distinguishes the groups, while the *levels* define each of the groups that will be compared. We need the value obtained by the dependent variable, measured for each observation of each group. Here are some illustrations in different contexts: the independent variable (carbon taxation, energy price increase, material compensation depending on the effort provided) is divided into levels. There is no limit to the number of levels of an independent variable that can be compared by ANOVA.

1.2.2. BETWEEN-GROUP AND WITHIN-GROUP DIFFERENCES

We use an ANOVA to check whether the differences inter-groups are well-founded or not. The assumptions are: H_0: $\mu_1 = \mu_2 = \mu_3$ **(there is no difference between the groups):** the difference between the groups is not significant (the groups all come from the same population).

H_1: $\mu_i \neq \mu_j$ **for at least one pair of means:** the difference between the groups is significant (the groups do not all come from the same population).

But does the presence of differences between the groups necessarily indicate that there is more than one population (rejection of H_0)? We must compare the difference between the groups to

a standard (calibration value): the average difference that exists between the observations of the *even*-group or the *within-group difference*. The difference that exists between each group and the mean of the groups or the between-group difference. By summing the within-group differences, we get the total within-group difference. The ratio of the between-group difference to the within-group difference yields the F-like Fisher[3]. (Ronald Aylmer) statistic.. When the between-group difference is much larger than the within-group difference, we reject H_0 and conclude that the difference is statistically significant. We therefore need to establish the relationship between the between-group difference and the within-group difference, which produces a new statistic, the F statistic. "Formula 3" gives the calculation of the F statistic.

$$F = \frac{\text{Between-group difference}}{\text{Within-group difference}}$$

$$F = \frac{\sum nj\,(Mj - M.)2}{k-1} \Big/ \frac{\sum_{j=1}^{k} \sum_{i=1}^{n} (Xij - Mj)2}{N-K} \qquad \text{Formula 3}$$

When this ratio F is close to 1.0, this implies that there is as much difference between the groups as there is within the groups. When this ratio is significantly greater than 1, it implies that the between-group difference is greater than the within-group difference. Since we are particularly Interested in the difference between the groups, when the ratio F is "large enough", we conclude that it is unlikely that all the groups come from the same population.

1.2.2.1. FROM BETWEEN-GROUP SUM OF SQUARES ($SS_{BETWEEN}$) TO BETWEEN-GROUP MEAN SQUARE ($MS_{BETWEEN}$)

$$SCBetween = \sum_{j=1}^{k} nj\,(Mj - M.)2 \qquad \text{Formula 4}$$

The squared difference between the means $SS_{Between}$ mixes two quantities: the difference between each mean and the large mean, on the one hand, and the number of groups, on the other hand: the greater the number of groups, the greater the sum of the between-group squares is large. To separate these two influences, we will not use it directly but separated by the between-group Degree of Freedom which allows us to calculate an average difference between the groups. The

[3]The F statistic is named after Ronald Fisher, the famous statistician who discovered the F distribution.

number of groups (the means of the groups) minus the mean of the means. By dividing the $SS_{Between}$ by the Degree of Freedom, we are sure of the independence of the observations and we obtain the $MS_{Between}$ (see formula 5 in part I of this work). By dividing the $SS_{Between}$ by the number of degrees of freedom between the groups (which we explain later): ($df_{Between}=k-1$) when k is the number of groups. This statistic, the *between-group mean of squares*, or more simply *Mean Square* (*MS*), is calculated with the following formula: "formula 5"

$$CMinter = {SCinter}/{ddlinter} = \frac{\sum_{j=1}^{k} nj\ (Mj - M.)2}{ddl\ inter} \quad \text{Formula 5}$$

1.2.2.2. FROM WITHIN-GROUP SUM OF SQUARES (SS_{WITHIN}) TO WITHIN-GROUP MEAN SQUARE MS_{WITHIN}

$$SC_{intra} = \sum_{j=1}^{k}\sum_{i=1}^{n}(Xij - Mj)^2 \quad \text{Formula 6}$$

Or *Xij* is the score of subject *i* in group *j* and *Mj* is the mean for this group. The double summation (∑∑) indicates that we first sum the squared differences between each observation (*Xij*) and its own group mean (*Mj*), and then we sum all these quantities. The following formulation is the expansion of Formula 6. It clarifies the nature of the calculations which must be made.

$$SC_{intra} = \sum_{i=1}^{n1}(Xi1 - M1)2 + \sum_{j=1}^{k}(Xi1 - M2)2 + \cdots \sum_{j=1}^{k}(Xik - Mk)2 + \quad \text{Formula 7}$$

We therefore lose one Degree of Freedom per group since inevitably one observation in each group is not free. In total, the degrees of freedom become N–K, where N is the total number of observations and K is the number of clusters. Which brings us to the final Formula 8, the formula required for the calculation of the within-group Mean Square, **MS_{Within}**. "Formula 8"

$$CM_{intra} = {SC_{intra}}/{dl_{intra}} = \frac{\sum_{j=1}^{k}\sum_{i=1}^{n}(Xij - Mj)2}{N - K} \quad \text{Formula 8}$$

1.2.3. THE CALCULATION OF THE F STATISTIC

The F statistic is the ratio of the mean between-group difference to the mean within-group difference. "Formula 10" takes up "Formula 3", but with its now formalized components:

$$F = {}^{SC_{inter}}\!/_{dl_{inter}} \Big/ {}^{SC_{intra}}\!/_{dl_{intra}}$$ Formula 9

By replacing the Sums of Squares SS($_{Between}$, Within) by the Mean Squares MS($_{Between}$, Within), we obtain values that take into consideration the degrees of freedom.

$$F = {}^{CM_{inter}}\!/_{CM_{intra}}$$ Formula 10

Where $MS_{Between}$ is the between-group Mean Square and MS_{Within} is the within group Mean Square. If the $F_{Statistic}$ is 1, we conclude that there is as much difference between the groups as there is within the groups. If $F_{Statistic} = \rho$, this means that the average difference between groups is "ρ times" greater than the average difference within groups.

1.2.3.1. Statistical inference: table of critical values of F

Using the table and starting from the values $MS_{Between}$ and $\mathbf{MS_{Within}}$, we can calculate the statistic $F_{Statistic}$ (N-k; k-1; α) for the degrees of freedom and the level (α) chosen, the cell which corresponds to it. Finally, we compare the F calculated from the data to that found in the Flu table. If the calculated F is less than F_{table}, it cannot be said that there is a difference between the groups. The difference between the groups is not statistically significant (at least one group differs from the others). But if the $F_{calculated}$ from the data is equal to or greater than the $F_{critical}$, we conclude that the difference between the groups is statistically significant, at the level (α) chosen.

1.2.4. ANOVA hypothesis tests for *K* groups

How does the ANOVA test work? The steps to be applied are summarized below.

1.2.4.1. Make assumptions

The null hypothesis always assumes that all K groups are equal, i.e., they all come from a single population. The assumption is that there is at least one group that differs from the others:

H_0: $\mu_1 = \mu_2 = ... = \mu_k$ the groups come from the same population

H_1:$\mu_i \neq \mu_j$ (at least one group is not from the same population).

1.2.4.2. Choose the significance level α

We must choose the threshold α before looking at the data, so that this choice is objective. Often, we take α = 5%, but depending on the problem and, above all, the importance of minimizing inference errors (types I and II), we could choose a larger threshold (α = 0.10) or smaller (α = 0.01 or even α = 0.001).

1.2.4.3. Specify the decision rule to choose between H_1 and H_0

The ANOVA test is of the form: Rejection of H_0 if $F_{observed} \geq F_{critical}$: we reject the null hypothesis if the $F_{observed}$ is greater than or equal to $F_{critical}$. The $F_{critical}$ value is obtained from the table of critical values and it depends on the significance level chosen (α) and the degrees of freedom $\nu_{1 = N\text{-}k}$ and $\nu_{2 = k\text{-}1}$ which correspond and which were used for the calculation of the $F_{observed}$.

1.2.4.4. Calculate and infer

Check the size of $F_{observed}$ against the size of $F_{critical}$ and apply the decision rule identified in the previous step.

1.2.5. Imperfect ANOVA!

The ANOVA test is used to infer whether or not the groups belong to the same population. The null hypothesis H_0 states that all the groups are identical, that they all come from the same population. When we reject the null hypothesis H_0, we conclude that the groups do not come from the same population. As with the t-test case, the concept of statistical significance is central to ANOVA, and involves a table of critical values. In the case of ANOVA, it is the table of "critical values" of the $F_{statistic}$. When the difference between the groups is statistically significant, it is known that at least one of the groups comes from a different population of the others; that all groups do not come from the same population. However, the results that an ANOVA produces allow us to determine whether or not the groups come from the same population without being able to tell us:

a. Whether the difference is large or small, even if the difference is statistically significant. Thus, it will be necessary to complete the tests by using a particular statistical technique based on the calculation of the correlation ratio giving rise to the "size of the effect" concept.
b. Where do these differences lie? Thus, if we compare several groups and the ANOVA confirms that they don't come from the same population, we will still not know if this difference comes from a single group or from several groups. Hence the interest of multiple comparison tests.

1.3. MULTIPLE COMPARISON: *A POSTERIORI TESTS* OF SCHEFFE AND THE "EFFECT SIZE"

Since the ANOVA is constructed by comparing the between-group difference with the within-group difference, it is not able to help us solve the problem. By Consequently, additional statistical procedures, multiple comparison tests (sometimes called comparison tests a posteriori, comparison tests post-hoc, or even more simply testing a posteriori), were designed to help us determine which of the groups differs from the others. Technically, when we have obtained a significant difference following an ANOVA, the tests of multiple comparisons precisely identify the difference source. Therefore, the Multiple comparison tests are only interpretable (and therefore should only be performed) if the ANOVA indicates a statistically significant difference.

1.3.1. SCHEFFE'S TEST

In the following we examine the five steps of calculating the scheffe test and its formulation for the multiple comparison.

1.3.1.1. THE FIVE STEPS OF CALCULATING THE SCHEFFE TEST.

i. An ANOVA is performed that compares all the groups. The «Scheffe test» will only be applied if a statistically significant F is obtained: it is now a question of determining where the existing differences are.
ii. The desired comparison is identified (e.g., group A *versus* group B).
iii. For these comparisons, the $C_{observed}$ statistic is calculated with Formula 11.
iv. We calculate the critical value $C_{critical}$ with Formula 12
v. The $C_{observed}$ statistic is compared to the $C_{critical}$ value. When the $C_{observed}$ statistic is equal to or greater than the $C_{critical}$ value, it is concluded that the groups examined in the comparison are statistically different from each other.

1.3.1.2. THE FORMULATION OF THE SCHEFFE TEST FOR MULTIPLE COMPARISON

We begin with a presentation of the formulas for calculating the statistics $C_{observed}$ and $C_{critical}$. The construction of the «Scheffé test» first requires the calculation of the statistic $C_{observed}$, which is given with Formula 11

$$C_{obsérvé} = \frac{M1 - M2}{\sqrt{CM_{intra}(\frac{1}{n1} + \frac{1}{n2})}} \quad \text{Formula 11}$$

where M1 and M2 are the means of the groups to be compared, $\mathbf{MS_{Within}}$ is the within-group Mean Square, taken directly from the ANOVA sources of variance table, and n_1 And n_2 are the number of observations associated with each compared group. Note the simplicity of Scheffé's "Formula 11" design. It answers the following question: is the difference between the two groups in question greater or less than the average difference between people, all groups combined? We must then calculate the statistic $C_{critical}$:

$$\boldsymbol{C_{critical} = \sqrt{(k-1)F_{critical}}} \quad \textbf{Formula 12}$$

Where the $F_{critical}$ is the one found in the table of the distribution of the values of $F_{statistic}$ for the number of degrees of freedom coming from the initial analysis of variance.

1.3.2. THE "EFFECT SIZE" AND THE CORRELATION RATIO (THE STATISTIC ETA SQUARED (H2))

The "effect size" is used to indicate whether the difference between the groups is large or small. This is the ratio of the difference between the groups ($SS_{Between}$) and the total difference (SS_{total}), as described by Formula 13:

$$SS_{total} = SS_{Between} + SS_{Within} \quad \textbf{Formula 13}$$

The logic of the "effect size" is simple: of all the differences that exist in our data (SS_{total} to Formula 13), what percentage of these differences comes from the difference between the groups ($SS_{Between}$ the Formula 13)? The eta-squared statistic (η^2) is the name we give to this ratio raised to the power of 2:

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$$\eta 2 = SC_{inter} / SC_{total} \quad \textbf{Formula 14}$$

In Formula 14, we see that the statistic η^2 defines the ratio of between-group differences to the total difference, which is nothing more than the sum of between-group differences and within-group differences (Formula 13). The squared eta statistic can take on varying values between 0 and 1. But we often choose to express it as a percentage. Thus, if we get[4] = 0.25, we conclude that 25% of the total difference observed on the dependent variable is explained by the independent variable. The larger the squared eta statistic, the larger the difference between the groups. When the "effect size" is 1 (or 100%), it should be understood that any differences that exist are attributable to (or "explained" by) the difference between the groups.

1.2.5.1. The Interpretation of "effect size"

Ceteribus paribus, the smaller the within-group difference, the larger the "effect size", the larger the between-group difference, the larger the "effect size". When the statistical significance indicates whether the groups come from different populations, the "Effect size", however, indicates whether the difference between the groups is of sufficient size to have a practical impact: it helps to distinguish between a statistically significant difference and a practical difference. When the "the effect size" is an extreme value (0 or 1), its interpretation is very easy: the difference between the performances on the dependent variable is completely ($\eta^2 = 1$) or not at all ($\eta^2 = 0$) explained by the independent variable. Cohen[5] (1988) proposes that the "size of the effect" be considered "small" when it is around 1% ($\eta^2 = 0.01$), "medium" when it is around 6% ($\eta^2 = 0.06$) and "large" when it is around 14% ($\eta^2 = 0.14$). Although practical, these criteria for defining "effect size" are completely arbitrary. The statistical significance level, (α) = 0.05, for example, is also arbitrary. Rather than sticking to Cohen's criteria, most researchers and practitioners assess practical significance in terms of the problem. In what follows, we are interested in the case of 25 regions belonging to the 242 regions making up the European Union to detect the possible difference in terms of Ecological Aptitude, to then identify the location of said differences as well as the size of the effect.

[4] The eta squared statistic is also known as the "correlation ratio". Eta is a non-linear correlation, as it measures the degree of change on the dependent variable as a function of the independent variable. When the relationship between the independent variable and the dependent variable is linear, eta is exactly equal to r_{xy}, the (linear) Pearson correlation. Eta squared is interpreted exactly as the coefficient of determination (see chapter 6)

[5] Cohen, J. (1988), *Statistical Power Analysis for the Behavioral Sciences*, New York, Academic Press.

II. THE "SCHEFFE TEST" AND THE "EFFECT SIZE": THE REGIONAL ECOLOGICAL APTITUDE ANOVA'S COMPLEMENT

2.1. THE ANOVA OF REGIONAL ECOLOGICAL APTITUDE

The European Union is made up of 27 Member States (until December 2022), themselves divided into 242 regions. Territories that present great differences in terms of economic and social development. To limit these disparities, the European Union has a regional policy, also called "cohesion policy", which accounts for one third of the total European budget. The big question that arises: is it more effective to act at the regional level or at the national level? this makes it possible to justify the funds devoted to the adaptation of European regions to climate change. The most well-known fund is the cohesion fund, which grants countries financial means in the form of credit according to their needs. In this work, countries are considered to have the same means to combat the harmful effects of global warming. Our objective is to detect the possible difference existing between the regions and to try to explain it: is it due to a difference between the countries or to a difference between the regions in the same country: in other words, even if the regions belong to the same country, this does not prevent their difference which goes so far as to consider them to belong to two different populations. The possibility of generalizing the statistical "t-test" allows us to use Fisher's F but does not allow us to detect pairs of regions that differ from each other. We will need to practice multiple comparison tests. Neither, we cannot measure the weight of the impact of this difference, which is due to an Within-group difference. the measurement of the size of the effect passes by the calculation of the ratio of correlation which puts in relation in the form of report the relation between the Between-regional variability and the total variability which is composed of this last in addition to that which relates to the area of inside.

We draw, at random, five countries of the European Union, each one is represented by 5 regions. Each country is made up of five regions randomly chosen from regions with equivalent resources for the fight against climate change (financial resources, information on climate change affecting their regions). We pass the same aptitude test environment to representatives of the five countries (25 regions). The independent variable is Country of origin; this variable has five levels (Country 1, Country 2, Country 3, Country 4, Country 5). The dependent variable is the Ecological Aptitude for the test scored out of 100 for each region. Is there a difference in

Ecological Aptitude between the 5 countries due to regional heterogeneity? In other words, does the regional average deviate from the national average? ANOVA through the value of the "Fischer statistic" tells us if there is a difference but does not tell us at what level or its size (size of the effect) hence the following questions: Can we make multiple comparisons to detect where the differences lie? hence the Scheffe test. Of all the differences in Ecological Aptitude that exist between regions, what percentage of those can be explained by the Country of origin of the region? In other words, if we know the Country of origin of a region by how much is the uncertainty reduced in relation to its Ecological Aptitude? We want to determine whether the five regions of the five countries have different Ecological Aptitude or not.

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Table (2): Best Ecological Aptitude results of 25 regions

		INDEPENDENT VARIABLE (Xi)				
		COUNTRY 1	COUNTRY 2	COUNTRY 3	COUNTRY 4	COUNTRY 5
Regions	Region 1	30	40	50	31	49
	Region 2	35	45	55	36	52
	Region 3	40	50	60	41	59
	Region 4	45	55	65	46	63
	Region 5	50	60	70	49	69
	M	40	50	60	40.6	58.4

The calculation of the MS Between

		INDEPENDENT VARIABLE (Xi)				
		COUNTRY 1	COUNTRY 2	COUNTRY 3	COUNTRY 4	COUNTRY 5
Regions	Region 1	30	40	50	31	49
	Region 2	35	45	55	36	52
	Region 3	40	50	60	41	59
	Region 4	45	55	65	46	63
	Region 5	50	60	70	49	69
	M=49.8	40	50	60	40.6	58.4
	Nij	5	5	5	5	5
	MM.	-9.8	0.2	10.2	-9.2	8.6
	(MM.)2	96.04	0.04	104.04	84.64	73.96
	nj(MM.)2	480.2	0.2	520.2	423.2	369.8

1793.6	$SS_{Between}$	DF Between
448.4	MS Between	4

The calculation of the Within MS

	INDEPENDENT VARIABLE (Xi)				
	COUNTRY 1	COUNTRY 2	COUNTRY 3	COUNTRY 4	COUNTRY 5
(X1-M)^2	100	100	100	92.16	88.36
(X1-M)^2	25	25	25	21.16	40.96
(X1-M)^2	0	0	0	0.16	0.36
(X1-M)^2	25	25	25	29.16	21.16
(X1-M)^2	100	100	100	70.56	112.36
Sum	**250**	**250**	**250**	**213.2**	**263.2**

The independent variable: Country
The dependent variable: the results of the Ecological Aptitude test:

SS_{Within}	1226.4	Within DF
MS_{Within}	61.32	20

CS Within	MS_{Within}	Within DF
1226.4	61.32	20

F calculated	7.3125	FISHER table (critical)	(4.20.0.5%)

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2.2. THE ECOLOGICAL APTITUDE HYPOTHESIS TEST

We can now formalize everything to show how the ANOVA test works. As with the t-test, there are four steps.

2.2.1. MAKE ASSUMPTIONS

The assumptions are:

3. H_0: The Ecological Aptitude is not different for the five regions of the five countries (the regions of the five countries all come from the same Ecological Aptitude population). $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5$ **(there is no difference between the groups).**
4. H_1: The Ecological Aptitude is different for the regions of the five countries (the regions of the five countries do not all come from the same Ecological Aptitude population). $\mu_1 \neq \mu_1$ **for at least one pair of means**.

2.2.2. CHOOSE THE SIGNIFICANCE LEVEL A

We take α = 5% since it is the level of alpha which makes it possible to minimize the risk of type 2 error.

2.2.3. SPECIFY THE DECISION RULE TO CHOOSE BETWEEN H$_1$ AND

The ANOVA test is of the form: rejection of H_0 if $F_{observed} \geq F_{critical}$: we reject the null hypothesis if the $F_{observed}$ is equal or greater at $F_{critique}$. The $F_{critical}$ value is obtained from the table of critical values and it depends on the significance level chosen (α) and the degrees of freedom ν1 and ν2 which correspond and which were used for the calculation of the $F_{observed}$

2.2.4. CALCULATION OF F-STATISTIC AND CONCLUSIONS

Table 1 shows the results obtained by five[6]regions in each of the 5 countries. The best estimate we have of the aptitude of the regions is the average obtained in each region: $M_1 = 40$; $M_2=50$ and $M_3=60$, $M_4=40.6$, $M_5=58.4$. The five averages are not numerically identical. There is variability between the groups, which we will need to quantify. We give the name of *Between country difference* to this quantity.

2.2.4.1. THE SUM OF SQUARES AND THE BETWEEN-GROUP – WITHIN-GROUP MEAN SQUARES

Does the presence of differences between groups necessarily indicate that there is more than one population of Ecological Aptitude (rejection of H_0)? Looking at this cross-regional difference in isolation, we cannot answer the question. After all, several regions from different

6 The choice of five regions in each country is arbitrary. In an actual study, the sample size is determined by the size of the population, the standard deviation of the mean, and other statistical elements.

Countries get the same score (region 2 from countries 3, 4 and 5) and, among other things, region 1 from Country 4 gets a lower score than all other regions regardless of the country. Remember that we must compare the difference between the groups to the average difference that exists between the observations of the even band. In our case, it would be the difference between regions from the same Country. By calculating, for each Country, the difference that exists between each region and the average of the regions of this Country, we obtain the internal difference in the Country called the within-group difference (Within country). When the between-group (between-country) difference is much larger than the within-group difference, we reject H_0 and conclude that the difference is statistically significant. Thus, in our case, before concluding that the regions of certain Countries are superior in Ecological Aptitude to the regions of other Countries, it must be demonstrated that the average difference between the Countries is greater than the average difference between the regions, all countries combined.

2.2.4.2. THE BETWEEN-GROUP SUM OF SQUARES ($SS_{BETWEEN}$) AND THE ($MS_{BETWEEN}$) BETWEEN-GROUP MEAN SQUARE

The Sum of Squares Between-group (Between country) (**$SS_{Between}$**): formula 4

$$\textbf{SSBetween} = \sum_{j=1}^{k} nj\ (Mj - M.)^2 \qquad \text{Formula 4}$$

For the data in Table 1, the grand mean is: This grand mean is the best estimate we have of (Ecological Aptitude) under the null hypothesis which specifies that the regions of the five countries come from the same population possessing the same means for be able in the same way to fight against the harmful effects of climate change. The grand mean will be useful for calculating the mean difference between the groups, i.e. the between-group difference (**$SS_{Between}$**). To continue the analysis of our case, the between-group Sum of Squares is:

$$\begin{aligned} &= [5 \times (40 - 49.8)^2] + [5 \times (50 - 49.8)^2] + [5 \times (60 - 49.8)^2] + [5 \times (40.6 - 49.8)^2] + [5 \times (58.4 - 49.8)^2] \\ SS_{Between} &= [5\times 96.04]+[5\times 0.04]+[5\times 104.04] + [5\times 84.64] + [5\times 73.96] \\ &= 1793.6 \end{aligned}$$

Let's go back to formula 5

$$\text{MSbetween} = {}^{SSbet}\!/_{DF\ \text{between}} = \frac{\sum_{j=1}^{k} nj\ (Mj - M.)^2}{dl\ \text{Between}} \qquad \text{Formula 5}$$

The noted between-group Degree of Freedom (df Between = K – 1) is equal (4 = 5-1). $MS_{Between}$ is equal to1793.6/ 4 =448.4.

2.2.4.3. THE WITHIN-GROUP SUM OF SQUARES (SS_{WITHIN}) AND THE WITHIN-GROUP MEAN SQUARE MS_{WITHIN}

Let's use formula 6 to calculate the Within Sum of Squres:

$$SS\ within = \sum_{j=1}^{k} \sum_{i=1}^{n} (Xij - Mj)^2 \qquad \text{Formula 6}$$

For our data in Table 1, the within-country Sum of Squares for Country 1 is: (30 –40)2 + (35 – 40)2 + … + (50 –40)2 (For Country 2, we calculate (40 – 50)2 + (45 – 50)2 + … + (60 – 50)2 and so on. Adding each sum, we get the within-group Sum of Squares: **SS_{Within}** =1226.4. As with the between-group Sum of Squares, the **SS_{Within}** will be larger if there are more observations and more groups. It will therefore be necessary to separate these two influences by dividing the quantity **SS_{Within}** by the number of degrees of freedom, which must take into consideration the total number of observations (N) as well as the number of groups (k).

Let us recall the calculation of the **MS_{Within}**. Formula 9

$$MS_{within} = {SS_{within}}/{dl_{within}} = \frac{\sum_{j=1}^{k} \sum_{i=1}^{n} (Xij - Mj)2}{N - k} \qquad \text{Formula 8}$$

When we have 5 countries, each composed of 5 regions, the number of within-group degrees of freedom is *N*– k = (5 × 5) – 5 = 20.

Now calculate the F statistic from the formula

$$F = \frac{\sum nj\ (Mj - M.)2}{k - 1} \Bigg/ \frac{\sum_{j=1}^{k} \sum_{i=1}^{n} (Xij - Mj)2}{N - K} \qquad \text{Formula 3}$$

Or if the two terms are related to produce the statistic F which is described by Formula 1 (see title I)

$$F = {{SC_{inter}}/{dl_{inter}}} \Big/ {{SC_{within}}/{dl_{within}}} \qquad \text{Formula 9}$$

Or from the less developed “Formula 10”:

$$F = {CM_{inter}}/{CM_{within}} \qquad \text{Formula 10}$$

$MS_{Between}$ =448.4 and MS_{Within} =61.32. So we can calculate the F statistic:

F =448.4/61.32 = 7.3124592

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We got F =7.32. This means that the mean difference between groups is approximately 8 times greater than the mean difference within groups. But is it likely? If such a difference is likely, we will conclude that the difference is statistically significant. But if it is not probable, we will draw the opposite conclusion. We then need to establish the probability of obtaining a ratio F of this size if all the groups come from the same population. To establish this probability, one must first examine the distribution of the F statistic.

2.2.4.4. THE SOURCES OF VARIANCE TABLE

The Table 3 is the source of variance table for the data in Table 1, which describes the Ecological Aptitude of regions in five countries of the European Union. It indicates, in the second column, the sum of the between-group and within-group squares and the total of these two quantities, the total sum of the squares. This last quantity reflects all the differences that exist in our database.

Table (3): Sources of variance

	Sum of Squares (SS)	**Degree of Freedom**	**Mean Squares (MS)**	**F**	**Meaning threshold**
Between-group	1793.6	4	448.4	7.3124592	0.06
Within-group	1226.4	20	61.32		
Total	3,020.00	24	509.72		

The "Mean Squares" (MS) column is obtained by dividing the sum of the squares (SS) by the corresponding degrees of freedom (df). The F statistic is obtained by dividing the Between-group (Between country) Mean Square by the within-group Mean Square. The resulting statistic, F =7.32 seems to indicate a large difference between countries (there is at least 7 times more mean between-group differences than mean within-group differences). Therefore, we would be tempted to reject H_0 and conclude that the Ecological Aptitude is not the same for the regions of the five countries. But is this really the case? We find the critical value of F for an α threshold of 5% ($p < 0.05$) for $v1 = 4$ and $v2 = 10$ in the F statistic table. This critical value is $F_{critical} = 7.32$ while the observed F is 2.866, a value that is higher than it. We then conclude that H_0 is rejected: it is very probable (less than 5% of the chances) of obtaining such a difference between the regions of the different Countries if the aptitude in ecological performance in the Countries is in fact the same. The difference is statistically significant.

At last, let’s check the last column of the variance sources table which indicates the exact probability of committing a «The First Kind of Error » (concluding to the rejection of H_0,

whereas the five groups come from the same population). In this case, the probability is p = 0.006: there is therefore a 6 chance out of 1,000 that we will make an inference error by concluding that the competence in ecological performance is not the same for the regions of the five countries. This probability (0.006) being lower than the conventional minimum alpha threshold (0.05) we conclude to the statistical significance.

2.3. THE "SCHÉFFE" TEST OF MULTIPLE COMPARISONS WHERE ARE YOU "*POST-HOC*"

In our case, the F-statistic that ANOVA produces is the ratio of between-group and within-group variabilities (mean sum of squares). We have five groups (country 1, country 2, country 3, country 4, country 5). We compare the Ecological Aptitude levels of the five groups by ANOVA. If we conclude that the observed F is statistically significant, this means that the five countries do not have the same level of Ecological Aptitude. From this statistically significant result, all of the following conclusions are potentially, but not necessarily, fair:

- **i.** $\mu_1 \neq \mu_2$ the Ecological Aptitude of country 1 is different from the Ecological Aptitude of country 2.
- **ii.** $\mu_1 \neq \mu_3$ the Ecological Aptitude of country 1 is different from the Ecological Aptitude of country 3.
- **iii.** $\mu_1 \neq \mu_4$ the Ecological Aptitude of country 1 is different from the Ecological Aptitude of country 4.
- **iv.** $\mu_1 \neq \mu_5$ the Ecological Aptitude of country 1 is different from the Ecological Aptitude of country 5.
- **v.** $\mu_2 \neq \mu_3$ the Ecological Aptitude of country 2 is different from the Ecological Aptitude of country 3.
- **vi.** $\mu_2 \neq \mu_4$ the Ecological Aptitude of country 2 is different from the Ecological Aptitude of country 4.
- **vii.** $\mu_2 \neq \mu_5$ the Ecological Aptitude of country 2 is different from the Ecological Aptitude of country 5.
- **viii.** $\mu_3 \neq \mu_4$ the Ecological Aptitude of country 3 is different from the Ecological Aptitude of country 4.
- **ix.** $\mu_3 \neq \mu_5$ the Ecological Aptitude of country 3 is different from the Ecological Aptitude of country 5.
- **x.** $\mu_4 \neq \mu_5$ the Ecological Aptitude of country 4 is different from the Ecological Aptitude of country 5.

2.3.2. CALCULATION AND ILLUSTRATION OF C OBSERVED AND C CRITICAL

We begin with a presentation of the formulas for the calculation of the $C_{observed}$ and $C_{critical}$ statistics, which we illustrate using the data in Table 1. The construction of the «Scheffé test» first requires the calculation of the $C_{observed}$ statistic, which is given with the Formula 11

$$C_{observed} = \frac{\text{M1} + \text{M2}}{\sqrt{CM_{intra}(\frac{1}{n1} + \frac{1}{n2})}} \qquad \text{Formula 11}$$

Where M_1 and M_2 are the means of the groups to be compared, Within-MS is the Within-group Mean Square, taken directly from the ANOVA sources of variance table, and n_1And n_2 are the numbers of observations associated with each region being compared. Note the simplicity of Scheffé's design (Formula 11). It answers the following question: is the difference between the

two groups in question greater or less than the average difference between people, all groups combined? We must then calculate the statistic $C_{critical}$:

$$C_{critical} = \sqrt{(k-1)F_{critique}} \qquad \text{Formula 12}$$

Where the $F_{critical}$ is the one found in the table of the distribution of the values of F for the number of degrees of freedom coming from the initial analysis of variance. The $F_{critical}$ value is that which comes from the table of the distribution of the values of F, for the between-group degrees of freedom (in this case ν1 = 20), and for the within-group degrees of freedom (ν2 = 4). For an alpha threshold of 0.05, this value is 2.86. The data from Table 1 and the data from the sources of variance table (Table 2) are required for the calculation of the two statistics: the $C_{observed}$ and the $C_{critical}$. Since we obtained (Table 2) a statistically significant result as a result of the ANOVA, we can now determine whether the difference between, for example, Country 1 and Country 3 is statistically significant: Do groups 1 and 3 come from two different populations or from the same one? The means obtained for these two groups are M_1 = 40; M_3=60.

$$C_{observed} = \frac{40 - 60}{\sqrt{61.32(\frac{1}{5} + 1/5)}} == \frac{20}{\sqrt{24.52}} = 4.04$$

Calculating the $C_{observed}$ may seem a bit long. The numerator of Formula 11 is completely and exclusively determined by the average of the groups being compared ($M_1 - M_2$ or $M_1 - M_3$, etc.). This quantity will be different for the various comparisons. But when we analyse the difference between groups of the same size (n_1=n_2=n_3), it is necessary to calculate the denominator of Formula 11 only once and this value will be valid for the comparison between all groups. For the data in Table 1, each region has the same number of observations ($n_1 = n_2 = n_3 = 5$). The quantity $\mathbf{MS_{Within}}$ = 62.5 is the same for all comparisons. Therefore, the denominator of Formula 11 is the same for all comparisons. It now becomes easy to determine where the differences lie.

$$C_{critical} = \sqrt{(k-1)F_{critical}} = \sqrt{(5-1)2{,}86} = 3{,}39$$

Table (3): CALCULATION OF Cobserved

	COUNTRY 1	COUNTRY 2	COUNTRY 3	COUNTRY 4	COUNTRY 5
COUNTRY 1	0	2.02	4.04	0.12	3.72
COUNTRY 2		0	-2	1.90	-1.70
COUNTRY 3			0	3.92	0.32
COUNTRY 4				0	-3.59
COUNTRY 5					0

The $C_{observed}$ (2) being higher than the $C_{critical}$, we conclude that the Ecological Aptitude of the regions of Country 1 is different (lower) than that of the regions of Country 3. The regions of Country 1 do not belong to the same "population of 'Ecological Aptitude ' than the regions of Country 3.

Table (4):Multiple comparisons of means with the Scheffe procedure

Comparison	$C_{observed}$	Abs. val. $C_{observed}$	$C_{critical}$	Conclusion
P1 VS P2	2.02	2.02	3.39	Equal, no rejection H°
P1 VS P3	4.04	4.04		Different, rejection H°,p<0.05
P1 VS P4	0.12	0.12		Equal, no rejection H°
P1 VS P5	3.72	3.72		Different, rejection H°,p<0.05
P3 VS P2	-2	2		Equal, no rejection H°
P4 VS P2	1.90	1.90		Equal, no rejection H°
P5 VS P2	-1.70	1.70		Equal, no rejection H°
P3 VS P4	3.92	3.92		Different, rejection H°,p<0.05
P3 VS P5	0.32	0.32		Equal, no rejection H°
P4 VS P5	-3.59	3.59		Different, rejection H°,p<0.05

These possible outcomes lead to very different Interpretations. There are 4 real differences among ten comparisons: P_1 differs from P_3 and from P_5. P_4 is different from P_3 and P_5. Thus we conclude that P_1 and P_4 differ from P_3 and P_5. It can already be noted that the efforts to be made are on the side of the two countries P_1 and P_4 to see their respective results adjust to those of Countries 3 and 5 which have the highest averages.

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2.4. THE SIZE OF THE EFFECT: THE CORRELATION RATIO THE STATISTIC ETA SQUARED (Η²)

2.4.1. AN ILLUSTRATION OF THE EFFECT SIZE

Consider the data from Table 1 and the table of sources of variance (Table 2). We tested the difference in Ecological Aptitude of 25 regions (N = 25) in five countries (K = 5). We found $F_{observed} = 7.31$ which implies a statistically significant difference. The Ecological Aptitude is not the same for the five regions of the five countries. But is this difference big or small? From the sources of variance table (Table 2), we see that the Between-group (Betweencountry) Sum of Squares $SS_{Between} = 1793.6$ and the Within-group Sum of Squares = 1226.4. The total Sum of Squares is therefore $SS_{Between} + SS_{Within} = 1793.6 + 1226.4 = 3020$. For the calculation of eta squared, we use Formula 14:

$$\eta 2 = SS_{inter} / SS_{total} = \frac{SCinter}{SS_{inter} + SS_{intra}} \qquad \text{Formula 14}$$

$$\eta^2 = \frac{1793{,}6}{3\ 020} = \mathbf{0.59390728}$$

2.4.2. THE CORRELATION RATIO ANALYSIS: INTERPRETATION AND CONCLUSION

Expressing eta squared as a percentage, we get roughly 60%. The interpretation of this result is straightforward: of all the differences in Ecological Aptitude that exist between regions, 60% of these differences are explained by the Country from which the region originates. One could also say that knowing the country of origin reduces the uncertainty in relation to its Ecological Aptitude by 60%. The Country is therefore an important element to take into consideration to understand the competence in ecological performance of the regions. Could it be that some countries misuse the means available for the fight against climate change in such a way that this disturbs the Ecological Aptitude s of some regions? How can we interpret the value of 60% of the effect size? *Ceteribus paribus*, the 60% value is explained by a small within-group difference and a large between-group difference. In other words, the difference between the groups is significant sufficient to have a practical impact: it helps to distinguish between a statistically significant difference and a practical difference. Statistically, the difference between the groups is significant: it looks like they come from different populations.

CONCLUSION

The analysis of variance, called "ANOVA", more often used in social sciences and economics, generalizes the "t test" and makes it possible to determine whether several groups belong to one or more than one population. The ANOVA uses the F-statistic, which compares the difference between groups relative to the difference between observations that come from the same groups. The interpretation of the F statistic is done by comparing its value to the critical value found in the table of critical values. By using multiple comparison tests, it is possible, after performing an ANOVA, to determine more precisely how many populations are represented by the groups. Finally, the «the size effect» gives us a numerical indication, and in percentage, of the size of the difference between the groups. This last statistic is essential for estimating the practical significance of a difference detected by the analysis of variance. The resulting F statistic ($F = 7.31$) means that the average difference between groups is approximately 8 times greater than the average difference within groups. It is highly probable that the uses of the means of combating global warming within the European Union is subject to a large gap between the countries caused above all by a difference between the regions. According to the multiple comparisons of the Schéffé test, we were able to observe that we have 4 real differences among 10 comparisons: P_1 and P_4 differ from P_3 and P_5. It can already be noted that the efforts to be made are on the side of the two countries P_1 and P_4 to see their respective results adjust to those of Countries 3 and 5 which have the highest averages in term of climate performance.

According to the correlation ratio, which measures the size of the effect, of all the differences in Ecological Aptitude that exist between regions, 60% of these differences are explained by the Country from which the region originates. One could also say that knowing the country of origin reduces the uncertainty in relation to its Ecological Aptitude by 60%. It would be more appropriate for European policies to combat climate change to focus on the national and not the regional aspect. Country of origin is therefore an important element to consider in understanding the difference in Ecological Aptitude between regions. Could it be that some countries misuse the means available for the fight against climate change in such a way that it disturbs some regions Ecological Aptitude? it is very likely that it is. However, what is certain is that the two countries P_3 and P_5 are two examples to be followed in the fight against climate change by the three that remain.

The verification of the extrapolation possibility of the results obtained on this sample could be the subject of a subsequent study by carrying out a statistical inference to allow (or not) to

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generalize the measures taken in the fight against global warming to the whole European Union country. Also, this study could be refined by the deployment of a MANOVA (Multivariate Analysis of Variance) which goes into more detail of the region's classification according to the financial means or according to their geographical or historical situations possibly advantageous compared to the other regions of the same or different countries.

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