



7

Computation of Standard Errors

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INTRODUCTION

As shown in Chapter 4, replicates have to be used for the computation of the standard error for any population estimate. This chapter will give examples of such computations.

For PISA, the Fay's variant of the Balanced Repeated Replication (BRR) is used. The general formula for computing the standard error with this method is:

$$\sigma_{(\hat{\theta})}^2 = \frac{1}{G(1-k)^2} \sum_{i=1}^G (\hat{\theta}_{(i)} - \hat{\theta})^2$$

Since the PISA databases include 80 replicates and since the Fay coefficient was set to 0.5, the above formula can be simplified as follows:

$$\sigma_{(\hat{\theta})}^2 = \frac{1}{G(1-k)^2} \sum_{i=1}^G (\hat{\theta}_{(i)} - \hat{\theta})^2 = \frac{1}{80(1-0.5)^2} \sum_{i=1}^{80} (\hat{\theta}_{(i)} - \hat{\theta})^2 = \frac{1}{20} \sum_{i=1}^{80} (\hat{\theta}_{(i)} - \hat{\theta})^2$$

THE STANDARD ERROR ON UNIVARIATE STATISTICS FOR NUMERICAL VARIABLES

To compute the mean and its respective standard error, it is necessary to first compute this statistic by weighting the data with the student final weight, *i.e.* `w_fstuwt`, and then to compute 80 other means, each of them by weighting the data with one of the 80 replicates, *i.e.* `w_fstr1` to `w_fstr80`.

Box 7.1 presents the SAS® syntax for computing these 81 means based on the social background index, denoted `HISEI`, for the PISA 2003 data for Germany. Table 7.1 presents the `HISEI` final estimates as well as the 80 replicate estimates.

Box 7.1 SAS® syntax for computing 81 means (e.g. PISA 2003)

```
data temp;
    set pisa2003.stud;
    if (cnt="DEU");
    keep cnt schoolid stidstd w_fstuwt w_fstr1-w_fstr80 hisei;
run;
proc means data=temp VARDEF=WGT;
    VAR hisei;
    WEIGHT w_fstuwt;
run;
proc means data=temp VARDEF=WGT;
    VAR hisei;
    WEIGHT w_fstr1;
run;
proc means data=temp VARDEF=WGT;
    VAR hisei;
    WEIGHT w_fstr2;
run;
.
.
.
proc means data=temp VARDEF=WGT;
    VAR hisei;
    WEIGHT w_fstr79;
run;
proc means data=temp VARDEF=WGT;
    VAR hisei;
    WEIGHT w_fstr80;
run;
```



Table 7.1
HISEI mean estimates

| Weight | Mean estimate | Weight | Mean estimate |
|---------------------|---------------|--------------|---------------|
| Final weight | 49.33 | | |
| Replicate 1 | 49.44 | Replicate 41 | 49.17 |
| Replicate 2 | 49.18 | Replicate 42 | 49.66 |
| Replicate 3 | 49.12 | Replicate 43 | 49.18 |
| Replicate 4 | 49.46 | Replicate 44 | 49.04 |
| Replicate 5 | 49.24 | Replicate 45 | 49.42 |
| Replicate 6 | 49.34 | Replicate 46 | 49.72 |
| Replicate 7 | 49.13 | Replicate 47 | 49.48 |
| Replicate 8 | 49.08 | Replicate 48 | 49.14 |
| Replicate 9 | 49.54 | Replicate 49 | 49.57 |
| Replicate 10 | 49.20 | Replicate 50 | 49.36 |
| Replicate 11 | 49.22 | Replicate 51 | 48.78 |
| Replicate 12 | 49.12 | Replicate 52 | 49.53 |
| Replicate 13 | 49.33 | Replicate 53 | 49.27 |
| Replicate 14 | 49.47 | Replicate 54 | 49.23 |
| Replicate 15 | 49.40 | Replicate 55 | 49.62 |
| Replicate 16 | 49.30 | Replicate 56 | 48.96 |
| Replicate 17 | 49.24 | Replicate 57 | 49.54 |
| Replicate 18 | 48.85 | Replicate 58 | 49.14 |
| Replicate 19 | 49.41 | Replicate 59 | 49.27 |
| Replicate 20 | 48.82 | Replicate 60 | 49.42 |
| Replicate 21 | 49.46 | Replicate 61 | 49.56 |
| Replicate 22 | 49.37 | Replicate 62 | 49.75 |
| Replicate 23 | 49.39 | Replicate 63 | 48.98 |
| Replicate 24 | 49.23 | Replicate 64 | 49.00 |
| Replicate 25 | 49.47 | Replicate 65 | 49.35 |
| Replicate 26 | 49.51 | Replicate 66 | 49.27 |
| Replicate 27 | 49.35 | Replicate 67 | 49.44 |
| Replicate 28 | 48.89 | Replicate 68 | 49.08 |
| Replicate 29 | 49.44 | Replicate 69 | 49.09 |
| Replicate 30 | 49.34 | Replicate 70 | 49.15 |
| Replicate 31 | 49.41 | Replicate 71 | 49.29 |
| Replicate 32 | 49.18 | Replicate 72 | 49.29 |
| Replicate 33 | 49.50 | Replicate 73 | 49.08 |
| Replicate 34 | 49.12 | Replicate 74 | 49.25 |
| Replicate 35 | 49.05 | Replicate 75 | 48.93 |
| Replicate 36 | 49.40 | Replicate 76 | 49.45 |
| Replicate 37 | 49.20 | Replicate 77 | 49.13 |
| Replicate 38 | 49.54 | Replicate 78 | 49.45 |
| Replicate 39 | 49.32 | Replicate 79 | 49.14 |
| Replicate 40 | 49.35 | Replicate 80 | 49.27 |

The mean that will be reported is equal to 49.33, *i.e.* the estimate obtained with the student final weight w_fstuw . The 80 replicate estimates are just used to compute the standard error on the mean of 49.33.

There are three major steps for computing the standard error:

1. Each replicate estimate will be compared with the final estimate 49.33 and the difference will be squared. Mathematically, it corresponds to $(\hat{\theta}_{(i)} - \hat{\theta})^2$ or in this particular case, $(\hat{\mu}_{(i)} - \hat{\mu})^2$. For the first replicate, it will be equal to $(49.44 - 49.33)^2 = 0.0140$. For the second replicate, it corresponds to $(49.18 - 49.33)^2 = 0.0228$. Table 7.2 presents the squared differences.
2. The sum of the squared differences is computed, and then divided by 20. Mathematically, it corresponds to $\frac{1}{20} \sum_{i=1}^{80} (\hat{\mu}_{(i)} - \hat{\mu})^2$. In the example, the sum is equal to $0.0140 + 0.0228 + \dots + 0.0354 + 0.0031 = 3.5195$. The sum divided by 20 is therefore equal to $\frac{3.5195}{20} = 0.1760$. This value represents the sampling variance on the mean estimate for HISEI.
3. The standard error is equal to the square root of the sampling variance, *i.e.* $\sigma_{(\hat{\mu})} = \sqrt{\sigma_{(\hat{\mu})}^2} = \sqrt{0.1760} = 0.4195$.



This means that the sampling distribution on the HISEI mean for Germany has a standard error of 0.4195. This value also allows building a confidence interval around this mean. With a risk of type I error equal to 0.05, usually denoted α , the confidence interval will be equal to:

$$[49.33 - (1.96 \cdot 0.4195); 49.33 + (1.96 \cdot 0.4195)]$$

$$[48.51; 50.15]$$

In other words, there are 5 chances out of 100 that an interval formed in this way will fail to capture the population mean. It also means that the German population mean for HISEI is significantly different from, for example, a value of 51, as this number is not included in the confidence interval.

Chapter 11 will show how this standard error can be used for comparisons either between two or several countries, or between subpopulations within a particular country.

Table 7.2

Squared differences between replicate estimates and the final estimate

| Weight | Squared difference | Weight | Squared difference |
|--------------|--------------------|-----------------------------------|--------------------|
| Replicate 1 | 0.0140 | Replicate 41 | 0.0239 |
| Replicate 2 | 0.0228 | Replicate 42 | 0.1090 |
| Replicate 3 | 0.0421 | Replicate 43 | 0.0203 |
| Replicate 4 | 0.0189 | Replicate 44 | 0.0818 |
| Replicate 5 | 0.0075 | Replicate 45 | 0.0082 |
| Replicate 6 | 0.0002 | Replicate 46 | 0.1514 |
| Replicate 7 | 0.0387 | Replicate 47 | 0.0231 |
| Replicate 8 | 0.0583 | Replicate 48 | 0.0349 |
| Replicate 9 | 0.0472 | Replicate 49 | 0.0590 |
| Replicate 10 | 0.0167 | Replicate 50 | 0.0014 |
| Replicate 11 | 0.0124 | Replicate 51 | 0.3003 |
| Replicate 12 | 0.0441 | Replicate 52 | 0.0431 |
| Replicate 13 | 0.0000 | Replicate 53 | 0.0032 |
| Replicate 14 | 0.0205 | Replicate 54 | 0.0086 |
| Replicate 15 | 0.0048 | Replicate 55 | 0.0868 |
| Replicate 16 | 0.0009 | Replicate 56 | 0.1317 |
| Replicate 17 | 0.0074 | Replicate 57 | 0.0438 |
| Replicate 18 | 0.2264 | Replicate 58 | 0.0354 |
| Replicate 19 | 0.0077 | Replicate 59 | 0.0034 |
| Replicate 20 | 0.2604 | Replicate 60 | 0.0081 |
| Replicate 21 | 0.0182 | Replicate 61 | 0.0563 |
| Replicate 22 | 0.0016 | Replicate 62 | 0.1761 |
| Replicate 23 | 0.0041 | Replicate 63 | 0.1173 |
| Replicate 24 | 0.0093 | Replicate 64 | 0.1035 |
| Replicate 25 | 0.0199 | Replicate 65 | 0.0008 |
| Replicate 26 | 0.0344 | Replicate 66 | 0.0030 |
| Replicate 27 | 0.0007 | Replicate 67 | 0.0139 |
| Replicate 28 | 0.1919 | Replicate 68 | 0.0618 |
| Replicate 29 | 0.0139 | Replicate 69 | 0.0557 |
| Replicate 30 | 0.0001 | Replicate 70 | 0.0324 |
| Replicate 31 | 0.0071 | Replicate 71 | 0.0016 |
| Replicate 32 | 0.0215 | Replicate 72 | 0.0011 |
| Replicate 33 | 0.0302 | Replicate 73 | 0.0603 |
| Replicate 34 | 0.0411 | Replicate 74 | 0.0052 |
| Replicate 35 | 0.0778 | Replicate 75 | 0.1575 |
| Replicate 36 | 0.0052 | Replicate 76 | 0.0157 |
| Replicate 37 | 0.0150 | Replicate 77 | 0.0378 |
| Replicate 38 | 0.0445 | Replicate 78 | 0.0155 |
| Replicate 39 | 0.0000 | Replicate 79 | 0.0354 |
| Replicate 40 | 0.0004 | Replicate 80 | 0.0031 |
| | | Sum of squared differences | 3.5195 |



THE SAS® MACRO FOR COMPUTING THE STANDARD ERROR ON A MEAN

Writing all the SAS® syntax to compute these 81 means and then transferring them into a Microsoft® Excel® spreadsheet to finally obtain the standard error would be very time consuming. Fortunately, SAS® macros simplify iterative computations. The software package will execute N times the commands included between the beginning command (DO I=1 TO N) and the ending command (END). Further, it also saves the results in a temporary file that can be used subsequently for the computation of the standard error.

Several SAS® macros have been written to simplify the main PISA computations as reported in the PISA initial reports. These macros have been saved in different files (with the extension .sas). Box 7.2 shows a SAS® syntax where a macro is called for computing the mean and standard error of the variable HISEI.

Box 7.2 SAS® syntax for computing the mean of HISEI and its standard error (e.g. PISA 2003)

```
libname PISA2003 "c:\pisa\2003\data\";
options nofmtterr notes;
run;

%include "c:\pisa\macro\proc_means_no_pv.sas";

data temp1;
  set pisa2003.stud;
  if (cnt="DEU") ;
  w_fstr0=w_fstuw;
  if (not missing (st03q01));
  keep cnt schoolid stidstd hisei bsmj st01q01 st03q01
      w_fstr0-w_fstr80 ;
run;

%BRR_PROCMEAN(INFILE=temp1,
              REPLI_ROOT=w_fstr,
              BYVAR=cnt,
              VAR=hisei,
              STAT=mean,
              LIMIT=yes,
              LIMIT_CRITERIA=50 5 3 1,
              ID_SCHOOL=schoolid,
              OUTFILE=exercisel);

run;

proc print data=exercisel;
  var cnt stat sestat;
run;
```

After the definition of the SAS® library and a few options, the command (%include "c:\pisa\macro\proc_means_no_pv.sas";) will create and save a new procedure for later use.

The "data" statement will create a temporary file by selecting from the PISA 2003 student database, the data for Germany (if (cnt="DEU")). To facilitate the iterative process, the final weight, w_fstuw, is recoded with the same replicate root, i.e. w_fstr. The number 0 is added after this root to avoid any possible confusion with the 80 replicates.

As these iterative computations might be central-processing-unit (CPU) consuming, it is advised to reduce the size of the input database by selecting the variables requested to perform a set of analyses. This can be easily done using the "keep" statement. In the example:



- the three international identification variables are kept, *i.e.*
 - CNT for the alphanumerical country code,
 - SCHOOLID for the alphanumerical school code,
 - STIDSTD for the alphanumerical student code;
- the socio-economic index, denoted HISEI;
- the 81 final and replicate weights;
- a few other variables that will be used later in this chapter.

To ensure their efficiency, all SAS® macros start by creating a temporary data file that only includes the variables requested by the macro.

The next nine lines call the macro. Nine pieces of information need to be provided:

- The input data file (`INFILE=temp`).
- The root of the final and replicate weights (`REPLI_ROOT=w_fstr`).
- One or several breakdown variables (`BYVAR=cnt`).
- The variable on which an estimate and its respective standard error will be computed (`VAR=hisei`).
- The requested statistic (`STAT=mean`).
- The request of flagging statistics for not reaching one of the sample size minimal requirements (`LIMIT=yes`). The other alternative is `no`. If no sample size requirements are set *i.e.* (`LIMIT=no`), no additional information are required for the next two arguments.
- The sample size minimal requirements per cell as defined by the `BYVAR` statement:¹
 - The minimal number of students.
 - The minimal number of schools.
 - The minimal percentage of the population.
 - The *N* first variables of the `BYVAR` statement used for the computation of the percentages; it is recommended that the percentages are computed at the country level. For that purpose, the first variable included in the `BYVAR` statement will be `CNT` and the last component of the `LIMIT_CRITERIA` will be 1, indicating that only the first variable of the `BYVAR` statement will be used as a basis for the computation of the percentages.²
 - As a minimal sample size can be specified on the number of schools, it is necessary to indicate the variable name of the school identification (`ID_SCHOOL=schoolid`).
- The output data file in which the estimates and their respective standard errors will be stored (`OUTFILE=exercise1`).

From the temporary input data file denoted “`temp`”, this macro will compute per country the mean of HISEI and its standard error by using the 81 final and replicate weights denoted `w_fstr0` to `w_fstr80`. The results will be stored in a file that will be labelled “`exercise1`”. This macro will return exactly the same values for the mean estimate and its respective standard error as the ones obtained through Table 7.1 and Table 7.2.

The structure of the output data file is presented in Table 7.3.



Table 7.3
Output data file exercise1 from Box 7.2

| CNT | STAT | SESTAT | FLAG_STUD | FLAG_SCH | FLAG_PCT |
|-----|-------|--------|-----------|----------|----------|
| DEU | 49.33 | 0.42 | 0 | 0 | 0 |

If the dataset had not been reduced to the data for Germany, then the number of rows in the output data file would be equal to the number of countries in the database.

As the three flags are equal to 0, the mean estimate has been computed on at least on 50 students, 5 schools and represents at least 3% of the population, *i.e.* Germany in this case. This last result is useless as the mean estimate was requested at the country level. These sample size requirements are more useful when statistics are requested at a subnational level. With a required percentage set at 95, the FLAG_PCT would be equal to 1. It would indicate in that particular case that more than 5% of the data for HISEI are missing.

There are a few restrictions, as well as a few options, with this macro:

- Only one input data file can be specified.
- The final and the replicate weights need to have the same root. The final weight will be assigned the number 0 while the 80 replicates, as already defined in the dataset, will range from 1 to 80.
- Several breakdown variables can be specified. For instance, if results per gender are needed, then the breakdown variables will be CNT and ST03Q01³ (BYVAR=cnt st03q01).
- Only one numerical variable can be specified in the VAR statement.
- Only one statistic can be specified. The available statistics are presented in Table 7.4.
- Only one output data file can be specified.

Table 7.4
Available statistics with the PROC_MEANS_NO_PV macro^a

| Statistics available | Meaning |
|----------------------|---|
| SUMWGT | Sum of the weight |
| MEAN | Mean |
| VAR | Variance |
| STD | Standard deviation |
| CV | Coefficient of variation |
| MEDIAN | Median |
| Q1 | First quartile |
| Q3 | Third quartile |
| QRANGE | Range between Q1 and Q3 |
| Px | Percentile, with P1, P5, P10, P25, P50, P75, P90, P95 and P99 |

a. Some other statistics are also available through the PROC MEANS procedure in SAS®, such as the minimum, the maximum, the range, the number of observations, and so on. Nevertheless, they are not included in the table, either because it does not make sense to apply these statistics to the PISA data, or because Fay's method cannot be applied on these statistics. For instance, as no weights are set to 0 in any replicates, the minimum or maximum value for a particular variable will always be the same. Therefore, the macro will return the value of 0, which is meaningless.



Box 7.3 presents the syntax for computing the standard deviation per gender and Table 7.5 sets out the structure of the output data file. As sample size limits are not requested, the output data file will not include the three flagging variables.

Box 7.3 **SAS® syntax for computing the standard deviation of HISEI and its standard error by gender (e.g. PISA 2003)**

```
%BRR_PROCMEAN (INFILE=temp1,
                REPLI_ROOT=w_fstr,
                BYVAR=cnt st03q01,
                VAR=hisei,
                STAT=std,
                LIMIT=no,
                LIMIT_CRITERIA=,
                ID_SCHOOL=,
                OUTFILE=exercise2);
run;
```

Table 7.5

Output data file exercise2 from Box 7.3

| CNT | ST03Q01 | STAT | SESTAT |
|-----|---------|-------|--------|
| DEU | 1 | 16.12 | 0.29 |
| DEU | 2 | 16.34 | 0.23 |

THE STANDARD ERROR ON PERCENTAGES

For variables such as gender, the statistic of interest is usually the percentage per category. The procedure for estimating the standard error is identical to the procedure used for the estimation of the standard error on a mean or a standard deviation, *i.e.* per category of the variable, 81 percentages have to be computed.

Box 7.4 presents the SAS® syntax for running the macro that will compute the percentages and their respective standard errors for each category of the gender variable. The structure of the output data file is presented in Table 7.6.

Box 7.4 **SAS® syntax for computing the percentages and their standard errors for gender (e.g. PISA 2003)**

```
%include "c:\pisa\macro\proc_freq_no_pv.sas";
%BRR_FREQ ( INFILE=temp1,
            REPLI_ROOT=w_fstr,
            BYVAR=cnt,
            VAR=st03q01,
            LIMIT=yes,
            LIMIT_CRITERIA=100 10 5 1,
            ID_SCHOOL=schoolid,
            OUTFILE=exercise3);
run;
```

Table 7.6

Output data file exercise3 from Box 7.4

| CNT | ST03Q01 | STAT | SESTAT | FLAG_STUD | FLAG_SCH | FLAG_PCT |
|-----|---------|-------|--------|-----------|----------|----------|
| DEU | 1 | 49.66 | 1.04 | 0 | 0 | 0 |
| DEU | 2 | 50.34 | 1.04 | 0 | 0 | 0 |



Table 7.7 presents the estimates of the percentage of females for the 81 weights and the squared differences. The percentage of females that will be reported is equal to 49.66, *i.e.* the percentage obtained with the final student weight.

As previously, there are three major steps for computing the standard error.

- Each replicate estimate will be compared with the final estimate 49.66 and the difference will be squared. Mathematically, it corresponds to $(\hat{\pi}_{(i)} - \hat{\pi})^2$. For the first replicate, it will be equal to $(49.82 - 49.66)^2 = 0.0256$.
- The sum of the squared differences is computed, and then divided by 20. Mathematically, it corresponds to $\frac{1}{20} \sum_{i=1}^{80} (\hat{\pi}_{(i)} - \hat{\pi})^2$. In the example, the sum is equal to $(0.0252 + 0.1044 + \dots + 0.3610 + 0.1313) = 21.4412$. The sum divided by 20 is therefore equal to $\frac{21.4412}{20} = 1.07$. This value represents the sampling variance on the percentage estimate of females.
- The standard error is equal to the square root of the sampling variance, *i.e.* $\sigma_{(\hat{\pi})} = \sqrt{\sigma_{(\hat{\pi})}^2} = \sqrt{1.07} = 1.035$.

Table 7.7

Percentage of girls for the final and replicate weights and squared differences

| Weight | % estimate | Squared difference | Weight | % estimate | Squared difference |
|---------------------|--------------|--------------------|-----------------------------------|------------|--------------------|
| Final weight | 49.66 | | | | |
| Replicate 1 | 49.82 | 0.03 | Replicate 41 | 50.00 | 0.11 |
| Replicate 2 | 49.98 | 0.10 | Replicate 42 | 49.95 | 0.09 |
| Replicate 3 | 49.44 | 0.05 | Replicate 43 | 49.70 | 0.00 |
| Replicate 4 | 49.32 | 0.11 | Replicate 44 | 50.59 | 0.87 |
| Replicate 5 | 49.39 | 0.07 | Replicate 45 | 49.07 | 0.35 |
| Replicate 6 | 49.06 | 0.36 | Replicate 46 | 48.82 | 0.71 |
| Replicate 7 | 48.59 | 1.14 | Replicate 47 | 49.88 | 0.05 |
| Replicate 8 | 48.85 | 0.66 | Replicate 48 | 49.14 | 0.27 |
| Replicate 9 | 49.06 | 0.36 | Replicate 49 | 49.53 | 0.02 |
| Replicate 10 | 49.72 | 0.00 | Replicate 50 | 49.81 | 0.02 |
| Replicate 11 | 50.05 | 0.15 | Replicate 51 | 49.87 | 0.04 |
| Replicate 12 | 49.31 | 0.13 | Replicate 52 | 49.82 | 0.02 |
| Replicate 13 | 49.29 | 0.13 | Replicate 53 | 49.42 | 0.06 |
| Replicate 14 | 49.47 | 0.04 | Replicate 54 | 48.99 | 0.45 |
| Replicate 15 | 49.90 | 0.06 | Replicate 55 | 50.07 | 0.17 |
| Replicate 16 | 50.82 | 1.35 | Replicate 56 | 50.68 | 1.04 |
| Replicate 17 | 49.11 | 0.30 | Replicate 57 | 50.34 | 0.46 |
| Replicate 18 | 49.51 | 0.02 | Replicate 58 | 49.54 | 0.02 |
| Replicate 19 | 49.79 | 0.02 | Replicate 59 | 48.75 | 0.83 |
| Replicate 20 | 50.75 | 1.18 | Replicate 60 | 50.14 | 0.23 |
| Replicate 21 | 50.24 | 0.33 | Replicate 61 | 49.45 | 0.05 |
| Replicate 22 | 49.79 | 0.02 | Replicate 62 | 49.46 | 0.04 |
| Replicate 23 | 49.87 | 0.04 | Replicate 63 | 50.11 | 0.20 |
| Replicate 24 | 49.37 | 0.08 | Replicate 64 | 49.64 | 0.00 |
| Replicate 25 | 49.50 | 0.02 | Replicate 65 | 49.72 | 0.00 |
| Replicate 26 | 49.82 | 0.02 | Replicate 66 | 50.79 | 1.27 |
| Replicate 27 | 49.92 | 0.07 | Replicate 67 | 49.73 | 0.00 |
| Replicate 28 | 49.55 | 0.01 | Replicate 68 | 49.96 | 0.09 |
| Replicate 29 | 50.22 | 0.31 | Replicate 69 | 50.31 | 0.42 |
| Replicate 30 | 49.16 | 0.25 | Replicate 70 | 49.17 | 0.24 |
| Replicate 31 | 50.51 | 0.73 | Replicate 71 | 50.10 | 0.19 |
| Replicate 32 | 49.98 | 0.10 | Replicate 72 | 49.93 | 0.07 |
| Replicate 33 | 50.67 | 1.02 | Replicate 73 | 49.55 | 0.01 |
| Replicate 34 | 49.29 | 0.13 | Replicate 74 | 49.42 | 0.06 |
| Replicate 35 | 48.96 | 0.49 | Replicate 75 | 49.60 | 0.00 |
| Replicate 36 | 49.98 | 0.10 | Replicate 76 | 49.45 | 0.05 |
| Replicate 37 | 50.23 | 0.33 | Replicate 77 | 49.80 | 0.02 |
| Replicate 38 | 48.25 | 1.99 | Replicate 78 | 49.91 | 0.07 |
| Replicate 39 | 49.56 | 0.01 | Replicate 79 | 49.06 | 0.36 |
| Replicate 40 | 49.66 | 0.00 | Replicate 80 | 50.02 | 0.13 |
| | | | Sum of squared differences | | 21.44 |



The same process can be used for the percentage of males. It should be noted that the standard error for males is equal to the one for females. Indeed, it can be mathematically shown that the standard error on π is equal to the standard error on $1-\pi$, *i.e.* $\sigma_{(p)} = \sigma_{(1-p)}$. Nevertheless, if missing data for gender are kept in the data file, the standard error on the percentage of males can differ slightly from the standard error on the percentage of females.

Just as for the macro for numerical variables, more than one breakdown variable can be used. In PISA 2003, the first question in the student questionnaire provides the students' grade. German 15-year-olds are distributed from grade 7 to grade 11.

Box 7.5 presents the SAS® syntax for computing the percentage for each grade per gender and its standard error and Table 7.8 presents the output data file. The percentages within the VAR group variable add up to 100%. In this example, the percentages of pupils in grades 7 to 11 within gender and country add up to 100%.

**Box 7.5 SAS® syntax for computing the percentages
and its standard errors for grades by gender (e.g. PISA 2003)**

```
%BRR_FREQ( INFILE=temp1,
            REPLI_ROOT=w_fstr,
            BYVAR=cnt st03Q01,
            VAR=st01q01,
            LIMIT=yes,
            LIMIT_CRITERIA=100 10 5 1,
            ID_SCHOOL=schoolid,
            OUTFILE=exercise4);

run;
```

As shown in Table 7.8, more males tend to be in lower grades than females and more females tend to be in upper grades in Germany. A few rows are flagged in Table 7.8. Grade 7 and grade 11 count less than 100 males and less than 100 females. Further, these four subpopulations (males in grades 7 and 11 and females in grades 7 and 11) each represent less than 5% of the German population. Finally, the computations in grade 11 are based on less than ten schools both for males and females.

Table 7.8
Output data file exercise4 from Box 7.5

| CNT | ST03Q01 | ST01Q01 | STAT | SESTAT | FLAG_STUD | FLAG_SCH | FLAG_PCT |
|-----|---------|---------|-------|--------|-----------|----------|----------|
| DEU | 1 | 7 | 1.15 | 0.26 | 1 | 0 | 1 |
| DEU | 1 | 8 | 13.09 | 0.83 | 0 | 0 | 0 |
| DEU | 1 | 9 | 59.33 | 1.00 | 0 | 0 | 0 |
| DEU | 1 | 10 | 26.28 | 1.08 | 0 | 0 | 0 |
| DEU | 1 | 11 | 0.17 | 0.08 | 1 | 1 | 1 |
| DEU | 2 | 7 | 2.28 | 0.45 | 1 | 0 | 1 |
| DEU | 2 | 8 | 16.92 | 1.04 | 0 | 0 | 0 |
| DEU | 2 | 9 | 60.32 | 1.06 | 0 | 0 | 0 |
| DEU | 2 | 10 | 20.41 | 0.79 | 0 | 0 | 0 |
| DEU | 2 | 11 | 0.08 | 0.05 | 1 | 1 | 1 |



THE STANDARD ERROR ON REGRESSION COEFFICIENTS

For any requested statistic, the computation of the estimate and its standard error will follow exactly the same procedure as the ones described for the mean of HISEI and for the percentages for gender. The remainder of this chapter will explain the use of two other SAS® macros developed for analysing PISA data.

The first macro is for simple linear regression analyses. Besides the seven arguments common to SAS® macros previously described in this manual, *i.e.* (i) INFILE=; (ii) REPLI_ROOT=; (iii) BYVAR=; (iv) OUTFILE=; (v) LIMIT=; (vi) LIMIT_CRITERIA=; and (vii) ID_SCHOOL=, two arguments need to be specified: the dependent variable and the independent variables. Only one dependent variable can be specified, whereas several independent variables can be specified.

Box 7.6 provides the syntax for running the simple linear regression macro. In this example, the dependent variable is the socio-economic index derived from the expected student job at the age of 30 (BSMJ) and the independent variables are the family socio-economic index (HISEI) and the student gender after recoding females into 1 and males into 0 (GENDER). Germany (DEU) and Austria (AUT) are selected.

Box 7.6 SAS® syntax for computing regression coefficients, R² and its respective standard errors: Model 1 (e.g. PISA 2003)

```
%include "c:\pisa\macro\proc_reg_no_pv.sas";
data temp2;
  set pisa2003.stud;
  if (cnt in ("DEU", "AUT"));
  w_fstr0=w_fstuwt;
  if (st03q01=1) then gender=1;
  if (st03q01=2) then gender=0;
  if (not missing(st03q01));
run;
%BRR_REG( INFILE=temp2,
          REPLI_ROOT=w_fstr,
          VARDEP=bsmj,
          EXPLICA=hisei gender,
          BYVAR=cnt ,
          LIMIT=yes,
          LIMIT_CRITERIA=100 10 5 1,
          ID_SCHOOL=schoolid,
          OUTFILE=exercise5);
run;
```

Table 7.9 presents the structure of the output data file of the regression analysis in Box 7.6.

Table 7.9
Output data file exercise5 from Box 7.6

| CNT | CLASS | STAT | SESTAT |
|-----|-----------|-------|--------|
| AUT | Intercept | 32.25 | 1.20 |
| AUT | HISEI | 0.36 | 0.02 |
| AUT | GENDER | 3.99 | 0.98 |
| AUT | _RSQ_ | 0.13 | 0.02 |
| DEU | Intercept | 32.9 | 1.29 |
| DEU | HISEI | 0.37 | 0.03 |
| DEU | GENDER | 2.07 | 0.62 |
| DEU | _RSQ_ | 0.12 | 0.02 |



There are two ways to determine whether the regression coefficients are significantly different from 0. The first method consists of building a confidence interval around the estimated regression coefficient. The confidence interval for the GENDER regression coefficient on BSMJ in Germany can be computed for a value of α equal to 0.05 as: $[2.07 - (1.96 * 0.62); 2.07 + (1.96 * 0.62)] = [0.85; 3.29]$.

As the value 0 is not included in this confidence interval, the regression coefficient is significantly different from 0. As the value 0 was assigned to males and the value 1 to females in the GENDER variable, it can be concluded that on average, females have significantly higher job expectations in Germany.

Another way to test the null hypothesis of the regression coefficient consists of dividing the regression coefficient by its standard error. This procedure will standardise the regression coefficient. It also means that the sampling distribution of the standardised regression coefficient, under the null hypothesis, has an expected mean of 0 and a standard deviation of 1. Therefore, if the ratio of the regression coefficient to its standard error is lower than -1.96 or higher than 1.96 , it will be considered as significantly different from 0.

Table 7.9 also includes the R^2 of the regression and its standard error. As several rows are necessary for reporting the results of the regression analysis, the outcomes of sample size requirements are included in another output file, denoted in this example exercise5_criteria. This file includes, per subpopulation defined by the variables included in the BYVAR statement, a row with the three flagging variables.

It should be mentioned that exercise6 will provide different results from exercise5. In exercise5, GENDER is considered as an explanatory variable. With exercise6, GENDER is used as a breakdown variable. In the second model, there is only one explanatory variable, *i.e.* HISEI.

Box 7.7 SAS® syntax for computing regression coefficients, R^2 and its respective standard errors: Model 2 (e.g. PISA 2003)

```
%BRR_REG( INFILE=temp2,
          REPLI_ROOT=w_fstr,
          VARDEP=bsmj,
          EXPLICA=hisei,
          BYVAR=cnt gender,
          LIMIT=yes,
          LIMIT_CRITERIA=100 10 5 1,
          ID_SCHOOL=schoolid,
          OUTFILE=exercise6);

run;
```

Table 7.10
Output data file exercise6 from Box 7.7

| CNT | GENDER | CLASS | STAT | SESTAT |
|-----|--------|-----------|-------|--------|
| AUT | 0 | Intercept | 32.00 | 1.64 |
| AUT | 0 | HISEI | 0.37 | 0.03 |
| AUT | 0 | _RSQ_ | 0.12 | 0.02 |
| AUT | 1 | Intercept | 36.49 | 1.52 |
| AUT | 1 | HISEI | 0.36 | 0.03 |
| AUT | 1 | _RSQ_ | 0.11 | 0.02 |
| DEU | 0 | Intercept | 32.54 | 1.44 |
| DEU | 0 | HISEI | 0.37 | 0.03 |
| DEU | 0 | _RSQ_ | 0.13 | 0.02 |
| DEU | 1 | Intercept | 35.33 | 1.66 |
| DEU | 1 | HISEI | 0.36 | 0.03 |
| DEU | 1 | _RSQ_ | 0.10 | 0.02 |



Table 7.11
Output data file exercise6_criteria from Box 7.7

| CNT | GENDER | FLAG_STUD | FLAG_SCH | FLAG_PCT |
|-----|--------|-----------|----------|----------|
| AUT | 0 | 0 | 0 | 0 |
| AUT | 1 | 0 | 0 | 0 |
| DEU | 0 | 0 | 0 | 0 |
| DEU | 1 | 0 | 0 | 0 |

Table 7.10 presents the structure of the output data file for the second model in Box 7.7 and Table 7.11 presents the structure of the output file devoted to the sampling requirements.

THE STANDARD ERROR ON CORRELATION COEFFICIENTS

Box 7.8 and Table 7.12 present, respectively, the SAS[®] syntax and the structure of the output data file for running the macro devoted to computing a correlation between two and only two variables.

Box 7.8 **SAS[®] syntax for computing correlation coefficients and its standard errors (e.g. PISA 2003)**

```
%include "c:\pisa\macro\proc_corr_no_pv.sas";

%BRR_CORR(  INFILE=temp2,
             REPLI_ROOT=w_fstr,
             BYVAR=cnt,
             VAR1=hisei,
             VAR2=bsmj,
             LIMIT=yes,
             LIMIT_CRITERIA=100 10 5 1,
             ID_SCHOOL=schoolid,
             OUTFILE=exercise7);

run;
```

Table 7.12
Output data file exercise7 from Box 7.8

| CNT | STAT | SESTAT | FLAG_STUD | FLAG_SCH | FLAG_PCT |
|-----|------|--------|-----------|----------|----------|
| AUT | 0.34 | 0.02 | 0 | 0 | 0 |
| DEU | 0.34 | 0.02 | 0 | 0 | 0 |

CONCLUSION

This chapter described the computation of a standard error by using 80 replicates. For any given statistic, the procedure is the same.

Further, the SAS[®] syntax for running the SAS[®] macros, which were developed to facilitate the computation of the standard errors, has been provided in various examples.

However, all macros described in this chapter are for computing various statistics **without** using plausible values. Chapter 8 will describe how to conduct computation with plausible values.



Notes

1. The minimal numbers of students and schools are computed without weights and the minimal percentage of the population is computed with weights.
2. In general, PISA does not report estimates based on fewer than 30 students or less than 3% of students, unless otherwise stated.
3. In PISA 2006, the gender variable is ST04Q01.



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User's Guide

Preparation of data files

All data files (in text format) and the SAS® control files are available on the PISA website (www.pisa.oecd.org).

SAS® users

By running the SAS® control files, the PISA data files are created in the SAS® format. Before starting analysis, assigning the folder in which the data files are saved as a SAS® library.

For example, if the PISA 2000 data files are saved in the folder of "c:\pisa2000\data\", the PISA 2003 data files are in "c:\pisa2003\data\", and the PISA 2006 data files are in "c:\pisa2006\data\", the following commands need to be run to create SAS® libraries:

```
libname PISA2000 "c:\pisa2000\data\" ;  
libname PISA2003 "c:\pisa2003\data\" ;  
libname PISA2006 "c:\pisa2006\data\" ;  
run;
```

SAS® syntax and macros

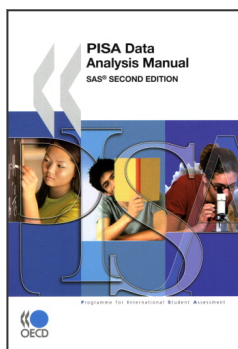
All syntaxes and macros in this manual can be copied from the PISA website (www.pisa.oecd.org). The 17 SAS® macros presented in Chapter 17 need to be saved under "c:\pisa\macro\", before starting analysis. Each chapter of the manual contains a complete set of syntaxes, which must be done sequentially, for all of them to run correctly, within the chapter.

Rounding of figures

In the tables and formulas, figures were rounded to a convenient number of decimal places, although calculations were always made with the full number of decimal places.

Country abbreviations used in this manual

| | | | | | |
|-----|----------------|-----|----------------|-----|-----------------|
| AUS | Australia | FRA | France | MEX | Mexico |
| AUT | Austria | GBR | United Kingdom | NLD | Netherlands |
| BEL | Belgium | GRC | Greece | NOR | Norway |
| CAN | Canada | HUN | Hungary | NZL | New Zealand |
| CHE | Switzerland | IRL | Ireland | POL | Poland |
| CZE | Czech Republic | ISL | Iceland | PRT | Portugal |
| DEU | Germany | ITA | Italy | SVK | Slovak Republic |
| DNK | Denmark | JPN | Japan | SWE | Sweden |
| ESP | Spain | KOR | Korea | TUR | Turkey |
| FIN | Finland | LUX | Luxembourg | USA | United States |



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