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9

# Use of Proficiency Levels

Introduction.....	134
Generation of the proficiency levels.....	134
Other analyses with proficiency levels.....	139
Conclusion.....	141



## INTRODUCTION

The values for student performance in reading, mathematics, and science literacy are usually considered as continuous latent variables. In order to facilitate the interpretation of the scores assigned to students, the reading, mathematics and science scales were designed to have an average score of 500 points and a standard deviation of 100 across OECD countries. This means that about two-thirds of the OECD member country students perform between 400 and 600 points.

In order to render PISA results more accessible to policy makers and educators, proficiency scales have been developed for the assessment domains. Since these scales are divided according to levels of difficulty and performance, both a ranking of student performance and a description of the skill associated with that proficiency level can be obtained. Each successive level is associated with tasks of increased difficulty.

In PISA 2000, five levels of reading proficiency were defined and reported in the PISA 2000 initial report *Knowledge and Skills for Life: First Results from PISA 2000* (OECD, 2001). In PISA 2003, six levels of mathematics proficiency levels were also defined and reported in the PISA 2003 initial report *Learning for Tomorrow's World – First Results from PISA 2003* (OECD, 2004a). In PISA 2006, six levels of science proficiency were defined and reported in the PISA 2006 initial report *Science Competencies for Tomorrow's World* (OECD, 2007a).

This chapter will show how to derive the proficiency levels from the PISA databases and how to use them.

## GENERATION OF THE PROFICIENCY LEVELS

Proficiency levels are not included in the PISA databases, but they can be derived from the plausible values (PVs).

In PISA 2006, the cutpoints that frame the proficiency levels in science are 334.94, 409.54, 484.14, 558.73, 633.33 and 709.93.<sup>1</sup> While some researchers might understand that different possible scores can be assigned to a student, it is more difficult to understand that different levels can be assigned to a single student. Therefore, they might be tempted to compute the average of the five plausible values and then assign each student a proficiency level based on this average.

As discussed in Chapter 6 and Chapter 8, such a procedure is similar to assigning each student an expected *a posteriori* (EAP) score; the biases of such estimators are now well known. Since using EAP scores underestimates the standard deviation, the estimation of the percentages of students at each level of proficiency will consequently underestimate the percentages at the lowest and highest levels, and overestimate the percentages at the central levels.

As already stated, international education surveys do not aim to estimate the performance of particular students, but rather, they aim to describe population characteristics. Therefore, particular students can be allocated different proficiency levels for different plausible values. Thus, five plausible proficiency levels will be assigned to each student respectively according to their five plausible values. The SPSS® syntax for the generation of the plausible proficiency levels in science is provided in Box 9.1.

In Box 9.1, two vectors are defined. The first, labelled STUDEST, includes the five plausible values for the science combined scale (PV1SCIE to PV5SCIE) and the three science subscales (PV1EPS to PV5EPS, PV1ISI to PV5ISI, and PV1USE to PV5USE). The second, labelled PROFLEV, will create 20 new variables, labelled PL\_PV1SCIE to PL\_PV5SCIE for the science combined scale; PL\_PV1EPS to PL\_PV5EPS for the science/explaining phenomena scientifically subscale; PL\_PV1ISI to PL\_PV5ISI for the science/identifying scientific issues subscale; PL\_PV1USE to PL\_PV5USE to the science/use of scientific evidence subscale.



### Box 9.1 SPSS® syntax for generating the proficiency levels in science (e.g. PISA 2006)

```

GET FILE="C:\PISA\2006\DATA\INT_STU06_DEC07.SAV" .
SELECT IF (CNT="DEU") .

DO REPEAT
STUDEST= PV1SCIE PV2SCIE PV3SCIE PV4SCIE PV5SCIE
          PV1EPS PV2EPS PV3EPS PV4EPS PV5EPS
          PV1ISI PV2ISI PV3ISI PV4ISI PV5ISI
          PV1USE PV2USE PV3USE PV4USE PV5USE/
PROFLEV= PL_PV1SCIE PL_PV2SCIE PL_PV3SCIE PL_PV4SCIE PL_PV5SCIE
          PL_PV1EPS PL_PV2EPS PL_PV3EPS PL_PV4EPS PL_PV5EPS
          PL_PV1ISI PL_PV2ISI PL_PV3ISI PL_PV4ISI PL_PV5ISI
          PL_PV1USE PL_PV2USE PL_PV3USE PL_PV4USE PL_PV5USE.

IF (STUDEST <= 334.94) PROFLEV=0.
IF (STUDEST > 334.94 & STUDEST <= 409.54) PROFLEV=1.
IF (STUDEST > 409.54 & STUDEST <= 484.14) PROFLEV=2.
IF (STUDEST > 484.14 & STUDEST <= 558.73) PROFLEV=3.
IF (STUDEST > 558.73 & STUDEST <= 633.33) PROFLEV=4.
IF (STUDEST > 633.33 & STUDEST <= 707.93) PROFLEV=5.
IF (STUDEST > 707.93) PROFLEV=6.

END REPEAT.

FORMATS
PL_PV1SCIE PL_PV2SCIE PL_PV3SCIE PL_PV4SCIE PL_PV5SCIE
PL_PV1EPS PL_PV2EPS PL_PV3EPS PL_PV4EPS PL_PV5EPS
PL_PV1ISI PL_PV2ISI PL_PV3ISI PL_PV4ISI PL_PV5ISI
PL_PV1USE PL_PV2USE PL_PV3USE PL_PV4USE PL_PV5USE (F1.0) .
EXE.

SAVE OUTFILE="C:\TEMP\DEU1.SAV" .

```

The iterative process will recode each plausible value variable into a new variable with seven categories labelled 0 to 6 for science.

The computation of the percentage of students at each proficiency level and its respective standard error is similar to the computation of a mean estimate and its standard error, as described in Chapter 8, *i.e.*:

- For each plausible value, the percentage of students at each proficiency level and its respective standard error have to be computed. Per proficiency level, five percentage estimates denoted  $\hat{\pi}_1$ ,  $\hat{\pi}_2$ ,  $\hat{\pi}_3$ ,  $\hat{\pi}_4$  and  $\hat{\pi}_5$  will be obtained. Out of the 80 replicates applied on each of the 5 proficiency level variables, per level of proficiency, 5 sampling variances  $\sigma^2_{(\hat{\pi}_1)}$ ,  $\sigma^2_{(\hat{\pi}_2)}$ ,  $\sigma^2_{(\hat{\pi}_3)}$ ,  $\sigma^2_{(\hat{\pi}_4)}$  and  $\sigma^2_{(\hat{\pi}_5)}$ . These five percentage estimates and their respective sampling variances are given in Table 9.1.
- The final percentage estimate is equal to the average of the five percentage estimates, *i.e.*  $\hat{\pi} = \frac{1}{5}(\hat{\pi}_1 + \hat{\pi}_2 + \hat{\pi}_3 + \hat{\pi}_4 + \hat{\pi}_5)$
- The final sampling variance is equal to the average of the five sampling variances, *i.e.*  $\sigma^2_{(\hat{\pi})} = \frac{1}{5}(\sigma^2_{(\hat{\pi}_1)} + \sigma^2_{(\hat{\pi}_2)} + \sigma^2_{(\hat{\pi}_3)} + \sigma^2_{(\hat{\pi}_4)} + \sigma^2_{(\hat{\pi}_5)})$
- The imputation variance, also denoted measurement error variance, is computed<sup>2</sup> as  $\sigma^2_{(test)} = \frac{1}{4} \sum_{i=1}^5 (\hat{\pi}_i - \hat{\pi})^2$
- The sampling variance and the imputation variance are combined to obtain the final error variance as  $\sigma^2_{(error)} = \sigma^2_{(\hat{\pi})} + (1.2 \sigma^2_{(test)})$
- The standard error is equal to the square root of the error variance.

This process is repeated for each proficiency level.



Table 9.1

The 405 percentage estimates for a particular proficiency level

Weight	PV1	PV2	PV3	PV4	PV5
Final	$\hat{\pi}_1$	$\hat{\pi}_2$	$\hat{\pi}_3$	$\hat{\pi}_4$	$\hat{\pi}_5$
Replicate 1	$\hat{\pi}_{1,1}$	$\hat{\pi}_{2,1}$	$\hat{\pi}_{3,1}$	$\hat{\pi}_{4,1}$	$\hat{\pi}_{5,1}$
Replicate 2	$\hat{\pi}_{1,2}$	$\hat{\pi}_{2,2}$	$\hat{\pi}_{3,2}$	$\hat{\pi}_{4,2}$	$\hat{\pi}_{5,2}$
Replicate 3	$\hat{\pi}_{1,3}$	$\hat{\pi}_{2,3}$	$\hat{\pi}_{3,3}$	$\hat{\pi}_{4,3}$	$\hat{\pi}_{5,3}$
.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....
Replicate 80	$\hat{\pi}_{1,80}$	$\hat{\pi}_{2,80}$	$\hat{\pi}_{3,80}$	$\hat{\pi}_{4,80}$	$\hat{\pi}_{5,80}$
Sampling variance	$\sigma^2_{(\hat{\pi}_1)}$	$\sigma^2_{(\hat{\pi}_2)}$	$\sigma^2_{(\hat{\pi}_3)}$	$\sigma^2_{(\hat{\pi}_4)}$	$\sigma^2_{(\hat{\pi}_5)}$

In this way 405 percentages will be estimated per proficiency level. As there are 7 levels in science, 2 835 percentages will be estimated.

The seven proficiency levels in science are:

1. Below level 1,
2. Level 1,
3. Level 2,
4. Level 3,
5. Level 4,
6. Level 5,
7. Level 6.

Sequentially applying the MCR\_SE\_GRPCT macro five times, as described in Chapter 7, will return, per proficiency level, five percentage estimates and five standard error estimates that can be combined to get the final estimate and its standard error.

Box 9.2 presents the SPSS® syntax for sequentially running the MCR\_SE\_GRPCT macro five times. Table 9.2 presents the five estimates and their respective sampling variances, per proficiency level.

#### Box 9.2 SPSS® syntax for computing the percentages of students by proficiency level in science and its standard errors (e.g. PISA 2006)

```

INSERT FILE="C:\PISA\MACRO\MCR_SE_GRPCT.SPS".

GRPPCT WITHIN = CNT/ GRP = PL_PV1SCIE/ LIMIT_CRITERIA = 100 10 5 1/
  INFILE = "C:\TEMP\DEU1.SAV"/.
SAVE OUTFILE="C:\TEMP\RESULTS1.SAV".
GRPPCT WITHIN = CNT/ GRP = PL_PV2SCIE/ LIMIT_CRITERIA = 100 10 5 1/
  INFILE = "C:\TEMP\DEU1.SAV"/.
SAVE OUTFILE="C:\TEMP\RESULTS2.SAV".
GRPPCT WITHIN = CNT/ GRP = PL_PV3SCIE/ LIMIT_CRITERIA = 100 10 5 1/
  INFILE = "C:\TEMP\DEU1.SAV"/.
SAVE OUTFILE="C:\TEMP\RESULTS3.SAV".
GRPPCT WITHIN = CNT/ GRP = PL_PV4SCIE/ LIMIT_CRITERIA = 100 10 5 1/
  INFILE = "C:\TEMP\DEU1.SAV"/.
SAVE OUTFILE="C:\TEMP\RESULTS4.SAV".
GRPPCT WITHIN = CNT/ GRP = PL_PV5SCIE/ LIMIT_CRITERIA = 100 10 5 1/
  INFILE = "C:\TEMP\DEU1.SAV"/.
SAVE OUTFILE="C:\TEMP\RESULTS5.SAV".

```



To combine the results:

- Per proficiency level, the five percentage estimates are averaged.
- Per proficiency level, the five sampling variances are averaged.
- By comparing the final estimate and the five PV estimates, the imputation variance is computed.
- The final sampling variance and the imputation variance are combined as usual to get the final error variance.
- The standard error is obtained by taking the square root of the error variance.

**Table 9.2**  
Estimates and sampling variances per proficiency level in science for Germany (PISA 2006)

Level		PV1	PV2	PV3	PV4	PV5
Below Level 1	$\hat{\pi}_i$	4.12	3.82	4.25	4.03	4.13
	$\sigma_{(\hat{\pi}_i)}^2$	(0.60) <sup>2</sup>	(0.59) <sup>2</sup>	(0.72) <sup>2</sup>	(0.67) <sup>2</sup>	(0.71) <sup>2</sup>
Level 1	$\hat{\pi}_i$	11.93	11.8	11.03	11.09	10.70
	$\sigma_{(\hat{\pi}_i)}^2$	(0.86) <sup>2</sup>	(0.81) <sup>2</sup>	(0.72) <sup>2</sup>	(0.73) <sup>2</sup>	(0.71) <sup>2</sup>
Level 2	$\hat{\pi}_i$	20.26	21.59	21.87	21.16	21.91
	$\sigma_{(\hat{\pi}_i)}^2$	(0.73) <sup>2</sup>	(0.71) <sup>2</sup>	(0.73) <sup>2</sup>	(0.80) <sup>2</sup>	(0.76) <sup>2</sup>
Level 3	$\hat{\pi}_i$	28.70	27.46	27.33	27.92	27.93
	$\sigma_{(\hat{\pi}_i)}^2$	(1.00) <sup>2</sup>	(0.94) <sup>2</sup>	(0.69) <sup>2</sup>	(0.91) <sup>2</sup>	(0.92) <sup>2</sup>
Level 4	$\hat{\pi}_i$	23.39	23.45	23.57	23.66	23.77
	$\sigma_{(\hat{\pi}_i)}^2$	(0.91) <sup>2</sup>	(0.93) <sup>2</sup>	(0.92) <sup>2</sup>	(0.92) <sup>2</sup>	(0.96) <sup>2</sup>
Level 5	$\hat{\pi}_i$	9.82	10.07	10.14	10.24	9.69
	$\sigma_{(\hat{\pi}_i)}^2$	(0.61) <sup>2</sup>	(0.53) <sup>2</sup>	(0.53) <sup>2</sup>	(0.64) <sup>2</sup>	(0.49) <sup>2</sup>
Level 6	$\hat{\pi}_i$	1.79	1.81	1.82	1.89	1.87
	$\sigma_{(\hat{\pi}_i)}^2$	(0.25) <sup>2</sup>	(0.28) <sup>2</sup>	(0.23) <sup>2</sup>	(0.20) <sup>2</sup>	(0.21) <sup>2</sup>

The final results are presented in Table 9.3.

**Table 9.3**  
Final estimates of the percentage of students, per proficiency level, in science and its standard errors for Germany (PISA 2006)

Proficiency level	%	S.E.
Below Level 1	4.07	0.68
Level 1	11.31	0.96
Level 2	21.36	1.06
Level 3	27.87	1.07
Level 4	23.57	0.95
Level 5	9.99	0.62
Level 6	1.84	0.24

A SPSS® macro has been developed for computing the percentage of students at each proficiency level as well as its respective standard error in one run. Box 9.3 presents the SPSS® syntax for running the macro and Table 9.4 presents the structure of the output data file.



### Box 9.3 SPSS® syntax for computing the percentage of students by proficiency level in science and its standard errors (e.g. PISA 2006)

```
INSERT FILE="C:\PISA\MACRO\MCR_SE_PCTLEV.SPS".
PCTLEV  NREP=80/
        PROFLEV=PL_PV1SCIE PL_PV2SCIE PL_PV3SCIE PL_PV4SCIE PL_PV5SCIE/
        WITHIN=CNT/
        WGT=W_FSTUWT/
        RWGT=W_FSTR/
        CONS=0.05/
        LIMIT_CRITERIA=100 10 5 1/
        PSU=SCHOOLID/
        INFILE="C:\TEMP\DEU1.SAV"/.
```

This macro has nine arguments. Besides the usual arguments, the proficiency level variable names have to be specified. As indicated in Table 9.4, the number of cases at Level 6 is less than 100.

**Table 9.4**  
Output data file from Box 9.3

CNT	PROFLEV	STAT	SE	FLAG_STD	FLAG_SCH	FLAG_PCT
DEU	0	4.07	0.68	0	0	1
DEU	1	11.31	0.96	0	0	0
DEU	2	21.36	1.06	0	0	0
DEU	3	27.87	1.07	0	0	0
DEU	4	23.57	0.95	0	0	0
DEU	5	9.99	0.62	0	0	0
DEU	6	1.84	0.24	1	0	1

As before, several breakdown variables can be used. For instance, the distribution of students across proficiency levels per gender can be obtained, as in Box 9.4.

### Box 9.4 SPSS® syntax for computing the percentage of students by proficiency level and its standard errors by gender (e.g. PISA 2006)

```
PCTLEV  NREP=80/
        PROFLEV=PL_PV1SCIE PL_PV2SCIE PL_PV3SCIE PL_PV4SCIE PL_PV5SCIE /
        WITHIN=CNT_ST04Q01/
        WGT=W_FSTUWT/
        RWGT=W_FSTR/
        CONS=0.05/
        LIMIT_CRITERIA=100 10 5 1 /
        PSU=SCHOOLID/
        INFILE="C:\TEMP\DEU1.SAV"/.
```

In this case, the sum of the percentages will be equal to 100 per country and per gender, as shown in Table 9.5.

**Table 9.5**  
Output data file from Box 9.4

CNT	ST04Q01	PROFLEV	STAT	SE	FLAG_STD	FLAG_SCH	FLAG_PCT
DEU	1	0	3.73	0.67	1	0	1
DEU	1	1	12.12	1.19	0	0	0
DEU	1	2	21.08	1.26	0	0	0
DEU	1	3	29.94	1.47	0	0	0
DEU	1	4	23.29	1.07	0	0	0
DEU	1	5	8.42	0.73	0	0	1
DEU	1	6	1.42	0.38	1	0	1
DEU	2	0	4.39	0.84	0	0	1
DEU	2	1	10.55	1.09	0	0	0
DEU	2	2	21.62	1.23	0	0	0
DEU	2	3	25.93	1.21	0	0	0
DEU	2	4	23.83	1.35	0	0	0
DEU	2	5	11.46	1.03	0	0	0
DEU	2	6	2.22	0.37	1	0	1



As shown in Table 9.5, the percentage of males at Level 5 and 6 is higher than the percentage of females at Level 5 and 6.

The statistical significance of these differences cannot be evaluated with this procedure, however. More details on this issue will be provided in Chapter 11.

## OTHER ANALYSES WITH PROFICIENCY LEVELS

Proficiency levels constitute a powerful tool for communicating the results on the cognitive test. Researchers and/or policy makers might therefore be interested in estimating the influence of some variables (such as the social background or self-confidence measures) on the proficiency levels.

PISA 2003, for instance, constructed an index of mathematics self-efficacy, denoted MATHEFF.

Analysing the relationship between proficiency levels and mathematics self-efficacy is relevant, as there is probably a reciprocal relationship between these two concepts. Better self-perception in mathematics is thought to increase a student's proficiency in mathematics, but an increase in the latter might in return affect the former.

Suppose that the statistic of interest is the average self-efficacy per proficiency level. In statistical terms, mathematics self-efficacy is considered as the dependent variable and the level of proficiency, the independent variable. There is no macro that can directly compute the mean of a continuous variable per proficiency level. On the other hand, the MCR\_SE\_UNIV macro described in Chapter 7 can be applied sequentially five times and the results could be combined in an Excel® spreadsheet for instance. This will be the case whenever proficiency levels are used as independent or as classification variables.

Box 9.5 presents SPSS® syntax for preparing the PISA 2003 data file.

### Box 9.5 SPSS® syntax for generating the proficiency levels in mathematics (e.g. PISA 2003)

```
GET FILE="C:\PISA\2003\DATA\INT_STUI_2003.SAV" .
SELECT IF (CNT="DEU") .

DO REPEAT
STUDEST=PV1MATH PV2MATH PV3MATH PV4MATH PV5MATH/
PROFLEV=PL_PV1MATH PL_PV2MATH PL_PV3MATH PL_PV4MATH PL_PV5MATH .

IF (STUDEST <= 357.77) PROFLEV=0.
IF (STUDEST > 357.77 & STUDEST <= 420.07) PROFLEV=1.
IF (STUDEST > 420.07 & STUDEST <= 482.38) PROFLEV=2.
IF (STUDEST > 482.38 & STUDEST <= 544.68) PROFLEV=3.
IF (STUDEST > 544.68 & STUDEST <= 606.99) PROFLEV=4.
IF (STUDEST > 606.99 & STUDEST <= 669.30) PROFLEV=5.
IF (STUDEST > 669.30) PROFLEV=6.

END REPEAT.

FORMATS
PL_PV1MATH PL_PV2MATH PL_PV3MATH PL_PV4MATH PL_PV5MATH (F1.0) .
EXE.
SAVE OUTFILE="C:\TEMP\DEU2.SAV" .
```



Box 9.6 presents SPSS® syntax for computing the mean of student self-efficacy per proficiency level.

Box 9.6 **SPSS® syntax for computing the mean of self-efficacy in mathematics and its standard errors by proficiency level (e.g. PISA 2003)**

```

INSERT FILE="C:\PISA\MACRO\MCR_SE_UNIV.SPS" .

UNIVAR STAT=MEAN/ DEP=MATHEFF/ GRP=CNT PL_PV1MATH/
INFILE="C:\TEMP\DEU2.SAV" / .
COMPUTE PV=1 .
STRING LEVEL (A5) .
COMPUTE LEVEL=PL_PV1MATH .
SAVE OUTFILE="C:\TEMP\RESULTS6.SAV" /DROP=PL_PV1MATH .

UNIVAR STAT=MEAN/ DEP=MATHEFF/ GRP=CNT PL_PV2MATH/
INFILE="C:\TEMP\DEU2.SAV" / .
COMPUTE PV=2 .
STRING LEVEL (A5) .
COMPUTE LEVEL=PL_PV2MATH .
SAVE OUTFILE="C:\TEMP\RESULTS7.SAV" /DROP=PL_PV2MATH .

UNIVAR STAT=MEAN/ DEP=MATHEFF/ GRP=CNT PL_PV3MATH/
INFILE="C:\TEMP\DEU2.SAV" / .
COMPUTE PV=3 .
STRING LEVEL (A5) .
COMPUTE LEVEL=PL_PV3MATH .
SAVE OUTFILE="C:\TEMP\RESULTS8.SAV" /DROP=PL_PV3MATH .

UNIVAR STAT=MEAN/ DEP=MATHEFF/ GRP=CNT PL_PV4MATH/
INFILE="C:\TEMP\DEU2.SAV" / .
COMPUTE PV=4 .
STRING LEVEL (A5) .
COMPUTE LEVEL=PL_PV4MATH .
SAVE OUTFILE="C:\TEMP\RESULTS9.SAV" /DROP=PL_PV4MATH .

UNIVAR STAT=MEAN/ DEP=MATHEFF/ GRP=CNT PL_PV5MATH/
INFILE="C:\TEMP\DEU2.SAV" / .
COMPUTE PV=5 .
STRING LEVEL (A5) .
COMPUTE LEVEL=PL_PV5MATH .
SAVE OUTFILE="C:\TEMP\RESULTS10.SAV" /DROP=PL_PV5MATH .

GET FILE="C:\TEMP\RESULTS6.SAV" .
ADD FILES /FILE=*
/FILE="C:\TEMP\RESULTS7.SAV"
/FILE="C:\TEMP\RESULTS8.SAV"
/FILE="C:\TEMP\RESULTS9.SAV"
/FILE="C:\TEMP\RESULTS10.SAV" .
EXECUTE .
SORT CASES BY CNT(A) LEVEL(A) PV(A) .
COMPUTE VAR=SE_MATHEFF*SE_MATHEFF .
AGGREGATE
/OUTFILE="C:\TEMP\AGR.SAV"
/PRESORTED
/BREAK=CNT LEVEL
/STAT=MEAN (MATHEFF)
/MES_ERROR=SD (MATHEFF)
/SAMP_VAR=MEAN (VAR) .
GET FILE="C:\TEMP\AGR.SAV" .
COMPUTE FINAL_VAR=( (MES_ERROR*MES_ERROR)*1.2) + (SAMP_VAR) .
COMPUTE SE=SQRT ( FINAL_VAR) .
SAVE OUTFILE='C:\TEMP\FINAL.SAV' /KEEP = CNT LEVEL STAT SE .
GET FILE="C:\TEMP\FINAL.SAV" .

```

Table 9.6 presents the mean estimates and standard errors for self-efficacy in mathematics per proficiency level.





**Table 9.6**  
Mean estimates and standard errors for self-efficacy in mathematics per proficiency level (PISA 2003)

Level		PV1	PV2	PV3	PV4	PV5
Below Level 1	$\hat{\mu}_i$	-0.68	-0.70	-0.74	-0.72	-0.77
	$\hat{\sigma}_{(\hat{\mu}_i)}^2$	(0.06) <sup>2</sup>	(0.06) <sup>2</sup>	(0.06) <sup>2</sup>	(0.05) <sup>2</sup>	(0.06) <sup>2</sup>
Level 1	$\hat{\mu}_i$	-0.44	-0.45	-0.42	-0.43	-0.40
	$\hat{\sigma}_{(\hat{\mu}_i)}^2$	(0.06) <sup>2</sup>	(0.05) <sup>2</sup>	(0.06) <sup>2</sup>	(0.04) <sup>2</sup>	(0.05) <sup>2</sup>
Level 2	$\hat{\mu}_i$	-0.18	-0.16	-0.17	-0.18	-0.18
	$\hat{\sigma}_{(\hat{\mu}_i)}^2$	(0.03) <sup>2</sup>	(0.03) <sup>2</sup>	(0.03) <sup>2</sup>	(0.03) <sup>2</sup>	(0.03) <sup>2</sup>
Level 3	$\hat{\mu}_i$	0.09	0.09	0.12	0.11	0.10
	$\hat{\sigma}_{(\hat{\mu}_i)}^2$	(0.03) <sup>2</sup>	(0.03) <sup>2</sup>	(0.03) <sup>2</sup>	(0.03) <sup>2</sup>	(0.03) <sup>2</sup>
Level 4	$\hat{\mu}_i$	0.43	0.45	0.41	0.45	0.44
	$\hat{\sigma}_{(\hat{\mu}_i)}^2$	(0.03) <sup>2</sup>	(0.03) <sup>2</sup>	(0.03) <sup>2</sup>	(0.03) <sup>2</sup>	(0.03) <sup>2</sup>
Level 5	$\hat{\mu}_i$	0.85	0.84	0.86	0.79	0.82
	$\hat{\sigma}_{(\hat{\mu}_i)}^2$	(0.04) <sup>2</sup>	(0.04) <sup>2</sup>	(0.03) <sup>2</sup>	(0.04) <sup>2</sup>	(0.04) <sup>2</sup>
Level 6	$\hat{\mu}_i$	1.22	1.23	1.27	1.28	1.29
	$\hat{\sigma}_{(\hat{\mu}_i)}^2$	(0.05) <sup>2</sup>	(0.05) <sup>2</sup>	(0.06) <sup>2</sup>	(0.05) <sup>2</sup>	(0.07) <sup>2</sup>

**Table 9.7**  
Output data file from Box 9.6

CNT	LEVEL	STAT	SE
DEU	0	-0.72	0.07
DEU	1	-0.43	0.06
DEU	2	-0.17	0.03
DEU	3	0.10	0.03
DEU	4	0.44	0.03
DEU	5	0.83	0.05
DEU	6	1.26	0.07

To combine the results:

- Per proficiency level, the five mean estimates are averaged.
- Per proficiency level, the five sampling variances are averaged.
- By comparing the final estimate and the five PV estimates, the imputation variance is computed.
- The final sampling variance and the imputation variance are combined as usual to get the final error variance.
- The standard error is obtained by taking the square root of the error variance.

Final results are presented in Table 9.7. It shows that high self-efficacy in mathematics (STAT) is associated with higher proficiency levels (LEVEL).

## CONCLUSION

This chapter has shown how to compute the percentage of students per proficiency level and its standard errors. As shown, the algorithm is similar to the one used for other statistics.

The difficulty of conducting analyses using proficiency levels as the explanatory (independent) variables was also discussed.



## Notes

1. In PISA 2000, the cutpoints that frame the proficiency levels in reading are: 334.75, 407.47, 480.18, 552.89 and 625.61. In PISA 2003, the cutpoints that frame the proficiency levels in mathematics are: 357.77, 420.07, 482.38, 544.68, 606.99 and 669.3.
2. This formula is a simplification of the general formula provided in Chapter 5.  $M$ , denoting the number of plausible values, has been replaced by 5.



# References

- Beaton, A.E.** (1987), *The NAEP 1983-1984 Technical Report*, Educational Testing Service, Princeton.
- Beaton, A.E., et al.** (1996), *Mathematics Achievement in the Middle School Years, IEA's Third International Mathematics and Science Study*, Boston College, Chestnut Hill, MA.
- Bloom, B.S.** (1979), *Caractéristiques individuelles et apprentissage scolaire*, Éditions Labor, Brussels.
- Bressoux, P.** (2008), *Modélisation statistique appliquée aux sciences sociales*, De Boeck, Brussels.
- Bryk, A.S. and S.W. Raudenbush** (1992), *Hierarchical Linear Models for Social and Behavioural Research: Applications and Data Analysis Methods*, Sage Publications, Newbury Park, CA.
- Buchmann, C.** (2000), *Family structure, parental perceptions and child labor in Kenya: What factors determine who is enrolled in school?* *aSoc. Forces*, No. 78, pp. 1349-79.
- Cochran, W.G.** (1977), *Sampling Techniques*, J. Wiley and Sons, Inc., New York.
- Dunn, O.J.** (1961), "Multiple Comparisons among Menas", *Journal of the American Statistical Association*, Vol. 56, American Statistical Association, Alexandria, pp. 52-64.
- Kish, L.** (1995), *Survey Sampling*, J. Wiley and Sons, Inc., New York.
- Knighton, T. and P. Bussière** (2006), "Educational Outcomes at Age 19 Associated with Reading Ability at Age 15", Statistics Canada, Ottawa.
- Gonzalez, E. and A. Kennedy** (2003), *PIRLS 2001 User Guide for the International Database*, Boston College, Chestnut Hill, MA.
- Ganzeboom, H.B.G., P.M. De Graaf and D.J. Treiman** (1992), "A Standard International Socio-economic Index of Occupation Status", *Social Science Research* 21(1), Elsevier Ltd, pp 1-56.
- Goldstein, H.** (1995), *Multilevel Statistical Models*, 2nd Edition, Edward Arnold, London.
- Goldstein, H.** (1997), "Methods in School Effectiveness Research", *School Effectiveness and School Improvement* 8, Swets and Zeitlinger, Lisse, Netherlands, pp. 369-395.
- Hubin, J.P.** (ed.) (2007), *Les indicateurs de l'enseignement*, 2nd Edition, Ministère de la Communauté française, Brussels.
- Husen, T.** (1967), *International Study of Achievement in Mathematics: A Comparison of Twelve Countries*, Almqvist and Wiksells, Uppsala.
- International Labour Organisation (ILO)** (1990), *International Standard Classification of Occupations: ISCO-88*. Geneva: International Labour Office.
- Lafontaine, D. and C. Monseur** (forthcoming), "Impact of Test Characteristics on Gender Equity Indicators in the Assessment of Reading Comprehension", *European Educational Research Journal*, Special Issue on PISA and Gender.
- Lietz, P.** (2006), "A Meta-Analysis of Gender Differences in Reading Achievement at the Secondary Level", *Studies in Educational Evaluation* 32, pp. 317-344.
- Monseur, C. and M. Crahay** (forthcoming), "Composition académique et sociale des établissements, efficacité et inégalités scolaires : une comparaison internationale – Analyse secondaire des données PISA 2006", *Revue française de pédagogie*.
- OECD** (1998), *Education at a Glance – OECD Indicators*, OECD, Paris.
- OECD** (1999a), *Measuring Student Knowledge and Skills – A New Framework for Assessment*, OECD, Paris.
- OECD** (1999b), *Classifying Educational Programmes – Manual for ISCED-97 Implementation in OECD Countries*, OECD, Paris.
- OECD** (2001), *Knowledge and Skills for Life – First Results from PISA 2000*, OECD, Paris.
- OECD** (2002a), *Programme for International Student Assessment – Manual for the PISA 2000 Database*, OECD, Paris.

- OECD (2002b), *Sample Tasks from the PISA 2000 Assessment – Reading, Mathematical and Scientific Literacy*, OECD, Paris.
- OECD (2002c), *Programme for International Student Assessment – PISA 2000 Technical Report*, OECD, Paris.
- OECD (2002d), *Reading for Change: Performance and Engagement across Countries – Results from PISA 2000*, OECD, Paris.
- OECD (2003a), *Literacy Skills for the World of Tomorrow – Further Results from PISA 2000*, OECD, Paris.
- OECD (2003b), *The PISA 2003 Assessment Framework – Mathematics, Reading, Science and Problem Solving Knowledge and Skills*, OECD, Paris.
- OECD (2004a), *Learning for Tomorrow's World – First Results from PISA 2003*, OECD, Paris.
- OECD (2004b), *Problem Solving for Tomorrow's World – First Measures of Cross-Curricular Competencies from PISA 2003*, OECD, Paris.
- OECD (2005a), *PISA 2003 Technical Report*, OECD, Paris.
- OECD (2005b), *PISA 2003 Data Analysis Manual*, OECD, Paris.
- OECD (2006), *Assessing Scientific, Reading and Mathematical Literacy: A Framework for PISA 2006*, OECD, Paris.
- OECD (2007), *PISA 2006: Science Competencies for Tomorrow's World*, OECD, Paris.
- OECD (2009), *PISA 2006 Technical Report*, OECD, Paris.
- Peaker, G.F. (1975), *An Empirical Study of Education in Twenty-One Countries: A Technical report. International Studies in Evaluation VIII*, Wiley, New York and Almqvist and Wiksell, Stockholm.
- Rust, K.F. and J.N.K. Rao (1996), "Variance Estimation for Complex Surveys Using Replication Techniques", *Statistical Methods in Medical Research*, Vol. 5, Hodder Arnold, London, pp. 283-310.
- Rutter, M., et al. (2004), "Gender Differences in Reading Difficulties: Findings from Four Epidemiology Studies", *Journal of the American Medical Association* 291, pp. 2007-2012.
- Schulz, W. (2006), *Measuring the socio-economic background of students and its effect on achievement in PISA 2000 and PISA 2003*, Paper presented at the Annual Meetings of the American Educational Research Association (AERA) in San Francisco, 7-11 April.
- Wagemaker, H. (1996), *Are Girls Better Readers. Gender Differences in Reading Literacy in 32 Countries*, IEA, The Hague.
- Warm, T.A. (1989), "Weighted Likelihood Estimation of Ability in Item Response Theory", *Psychometrika*, Vol. 54(3), Psychometric Society, Williamsburg, VA., pp. 427-450.
- Wright, B.D. and M.H. Stone (1979), *Best Test Design: Rasch Measurement*, MESA Press, Chicago.



# Table of contents

<b>FOREWORD</b> .....	<b>3</b>
<b>USER'S GUIDE</b> .....	<b>17</b>
<b>CHAPTER 1 THE USEFULNESS OF PISA DATA FOR POLICY MAKERS, RESEARCHERS AND EXPERTS ON METHODOLOGY</b> .....	<b>19</b>
<b>PISA – an overview</b> .....	<b>20</b>
▪ The PISA surveys.....	20
<b>How can PISA contribute to educational policy, practice and research?</b> .....	<b>22</b>
▪ Key results from PISA 2000, PISA 2003 and PISA 2006.....	23
<b>Further analyses of PISA datasets</b> .....	<b>25</b>
▪ Contextual framework of PISA 2006.....	28
▪ Influence of the methodology on outcomes.....	31
<b>CHAPTER 2 EXPLORATORY ANALYSIS PROCEDURES</b> .....	<b>35</b>
<b>Introduction</b> .....	<b>36</b>
<b>Weights</b> .....	<b>36</b>
<b>Replicates for computing the standard error</b> .....	<b>39</b>
<b>Plausible values</b> .....	<b>43</b>
<b>Conclusion</b> .....	<b>45</b>
<b>CHAPTER 3 SAMPLE WEIGHTS</b> .....	<b>47</b>
<b>Introduction</b> .....	<b>48</b>
<b>Weights for simple random samples</b> .....	<b>49</b>
<b>Sampling designs for education surveys</b> .....	<b>51</b>
<b>Why do the PISA weights vary?</b> .....	<b>55</b>
<b>Conclusion</b> .....	<b>56</b>
<b>CHAPTER 4 REPLICATE WEIGHTS</b> .....	<b>57</b>
<b>Introduction</b> .....	<b>58</b>
<b>Sampling variance for simple random sampling</b> .....	<b>58</b>
<b>Sampling variance for two-stage sampling</b> .....	<b>63</b>
<b>Replication methods for simple random samples</b> .....	<b>68</b>
<b>Replication methods for two-stage samples</b> .....	<b>70</b>
▪ The Jackknife for unstratified two-stage sample designs.....	70
▪ The Jackknife for stratified two-stage sample designs.....	71
▪ The Balanced Repeated Replication method.....	72
<b>Other procedures for accounting for clustered samples</b> .....	<b>74</b>
<b>Conclusion</b> .....	<b>74</b>



<b>CHAPTER 5 THE RASCH MODEL</b> .....	<b>77</b>
<b>Introduction</b> .....	78
<b>How can the information be summarised?</b> .....	78
<b>The Rasch Model for dichotomous items</b> .....	79
▪ Introduction to the Rasch Model.....	79
▪ Item calibration.....	83
▪ Computation of a student's score.....	85
▪ Computation of a student's score for incomplete designs.....	89
▪ Optimal conditions for linking items.....	90
▪ Extension of the Rasch Model.....	91
<b>Other item response theory models</b> .....	92
<b>Conclusion</b> .....	92
 <b>CHAPTER 6 PLAUSIBLE VALUES</b> .....	 <b>93</b>
<b>Individual estimates versus population estimates</b> .....	94
<b>The meaning of plausible values (PVs)</b> .....	94
<b>Comparison of the efficiency of WLEs, EAP estimates and PVs for the estimation of some population statistics</b> .....	97
<b>How to perform analyses with plausible values</b> .....	100
<b>Conclusion</b> .....	101
 <b>CHAPTER 7 COMPUTATION OF STANDARD ERRORS</b> .....	 <b>103</b>
<b>Introduction</b> .....	104
<b>The standard error on univariate statistics for numerical variables</b> .....	104
<b>The SPSS® macro for computing the standard error on a mean</b> .....	107
<b>The standard error on percentages</b> .....	110
<b>The standard error on regression coefficients</b> .....	112
<b>The standard error on correlation coefficients</b> .....	114
<b>Conclusion</b> .....	115
 <b>CHAPTER 8 ANALYSES WITH PLAUSIBLE VALUES</b> .....	 <b>117</b>
<b>Introduction</b> .....	118
<b>Univariate statistics on plausible values</b> .....	118
<b>The standard error on percentages with PVs</b> .....	121
<b>The standard error on regression coefficients with PVs</b> .....	121
<b>The standard error on correlation coefficients with PVs</b> .....	124
<b>Correlation between two sets of plausible values</b> .....	124
<b>A fatal error shortcut</b> .....	128
<b>An unbiased shortcut</b> .....	129
<b>Conclusion</b> .....	130
 <b>CHAPTER 9 USE OF PROFICIENCY LEVELS</b> .....	 <b>133</b>
<b>Introduction</b> .....	134
<b>Generation of the proficiency levels</b> .....	134
<b>Other analyses with proficiency levels</b> .....	139
<b>Conclusion</b> .....	141



<b>CHAPTER 10 ANALYSES WITH SCHOOL-LEVEL VARIABLES</b> .....	<b>143</b>
<b>Introduction</b> .....	144
<b>Limits of the PISA school samples</b> .....	145
<b>Merging the school and student data files</b> .....	146
<b>Analyses of the school variables</b> .....	146
<b>Conclusion</b> .....	148
<b>CHAPTER 11 STANDARD ERROR ON A DIFFERENCE</b> .....	<b>149</b>
<b>Introduction</b> .....	150
<b>Statistical issues and computing standard errors on differences</b> .....	150
<b>The standard error on a difference without plausible values</b> .....	152
<b>The standard error on a difference with plausible values</b> .....	157
<b>Multiple comparisons</b> .....	161
<b>Conclusion</b> .....	162
<b>CHAPTER 12 OECD TOTAL AND OECD AVERAGE</b> .....	<b>163</b>
<b>Introduction</b> .....	164
<b>Recoding of the database to estimate the pooled OECD total and the pooled OECD average</b> .....	166
<b>Duplication of the data to avoid running the procedure three times</b> .....	168
<b>Comparisons between the pooled OECD total or pooled OECD average estimates and a country estimate</b> .....	169
<b>Comparisons between the arithmetic OECD total or arithmetic OECD average estimates and a country estimate</b> .....	171
<b>Conclusion</b> .....	171
<b>CHAPTER 13 TRENDS</b> .....	<b>173</b>
<b>Introduction</b> .....	174
<b>The computation of the standard error for trend indicators on variables other than performance</b> .....	175
<b>The computation of the standard error for trend indicators on performance variables</b> .....	177
<b>Conclusion</b> .....	181
<b>CHAPTER 14 STUDYING THE RELATIONSHIP BETWEEN STUDENT PERFORMANCE AND INDICES DERIVED FROM CONTEXTUAL QUESTIONNAIRES</b> .....	<b>183</b>
<b>Introduction</b> .....	184
<b>Analyses by quarters</b> .....	184
<b>The concept of relative risk</b> .....	186
▪ <b>Instability of the relative risk</b> .....	187
▪ <b>Computation of the relative risk</b> .....	188
<b>Effect size</b> .....	191
<b>Linear regression and residual analysis</b> .....	193
▪ <b>Independence of errors</b> .....	193
<b>Statistical procedure</b> .....	196
<b>Conclusion</b> .....	197



<b>CHAPTER 15 MULTILEVEL ANALYSES</b> .....	<b>199</b>
<b>Introduction</b> .....	200
<b>Two-level modelling with SPSS®</b> .....	202
▪ Decomposition of the variance in the empty model.....	202
▪ Models with only random intercepts.....	205
▪ Shrinkage factor.....	207
▪ Models with random intercepts and fixed slopes.....	207
▪ Models with random intercepts and random slopes.....	209
▪ Models with Level 2 independent variables.....	214
▪ Computation of final estimates and their respective standard errors.....	217
<b>Three-level modelling</b> .....	219
<b>Limitations of the multilevel model in the PISA context</b> .....	221
<b>Conclusion</b> .....	222
 <b>CHAPTER 16 PISA AND POLICY RELEVANCE – THREE EXAMPLES OF ANALYSES</b> .....	 <b>223</b>
<b>Introduction</b> .....	224
<b>Example 1: Gender differences in performance</b> .....	224
<b>Example 2: Promoting socio-economic diversity within school?</b> .....	228
<b>Example 3: The influence of an educational system on the expected occupational status of students at age 30</b> .....	234
<b>Conclusion</b> .....	237
 <b>CHAPTER 17 SPSS® MACRO</b> .....	 <b>239</b>
<b>Introduction</b> .....	240
<b>Structure of the SPSS® Macro</b> .....	240
 <b>REFERENCES</b> .....	 <b>321</b>
 <b>APPENDICES</b> .....	 <b>323</b>
<b>Appendix 1</b> Three-level regression analysis.....	324
<b>Appendix 2</b> PISA 2006 International database.....	332
<b>Appendix 3</b> PISA 2006 Student questionnaire.....	341
<b>Appendix 4</b> PISA 2006 Information communication technology (ICT) Questionnaire.....	350
<b>Appendix 5</b> PISA 2006 School questionnaire.....	352
<b>Appendix 6</b> PISA 2006 Parent questionnaire.....	359
<b>Appendix 7</b> Codebook for PISA 2006 student questionnaire data file.....	363
<b>Appendix 8</b> Codebook for PISA 2006 non-scored cognitive and embedded attitude items.....	407
<b>Appendix 9</b> Codebook for PISA 2006 scored cognitive and embedded attitude items.....	427
<b>Appendix 10</b> Codebook for PISA 2006 school questionnaire data file.....	439
<b>Appendix 11</b> Codebook for PISA 2006 parents questionnaire data file.....	450
<b>Appendix 12</b> PISA 2006 questionnaire indices.....	456





## LIST OF BOXES

Box 2.1	WEIGHT statement in SPSS®.....	37
<hr/>		
Box 7.1	SPSS® syntax for computing 81 means (e.g. PISA 2003).....	104
Box 7.2	SPSS® syntax for computing the mean of HISEI and its standard error (e.g. PISA 2003).....	107
Box 7.3	SPSS® syntax for computing the standard deviation of HISEI and its standard error by gender (e.g. PISA 2003).....	109
Box 7.4	SPSS® syntax for computing the percentages and their standard errors for gender (e.g. PISA 2003).....	110
Box 7.5	SPSS® syntax for computing the percentages and its standard errors for grades by gender (e.g. PISA 2003).....	112
Box 7.6	SPSS® syntax for computing regression coefficients, $R^2$ and its respective standard errors: Model 1 (e.g. PISA 2003).....	113
Box 7.7	SPSS® syntax for computing regression coefficients, $R^2$ and its respective standard errors: Model 2 (e.g. PISA 2003).....	114
Box 7.8	SPSS® syntax for computing correlation coefficients and its standard errors (e.g. PISA 2003).....	114
<hr/>		
Box 8.1	SPSS® syntax for computing the mean on the science scale by using the MCR_SE_UNIV macro (e.g. PISA 2006).....	119
Box 8.2	SPSS® syntax for computing the mean and its standard error on PVs (e.g. PISA 2006).....	120
Box 8.3	SPSS® syntax for computing the standard deviation and its standard error on PVs by gender (e.g. PISA 2006).....	131
Box 8.4	SPSS® syntax for computing regression coefficients and their standard errors on PVs by using the MCR_SE_REG macro (e.g. PISA 2006).....	122
Box 8.5	SPSS® syntax for running the simple linear regression macro with PVs (e.g. PISA 2006).....	123
Box 8.6	SPSS® syntax for running the correlation macro with PVs (e.g. PISA 2006).....	124
Box 8.7	SPSS® syntax for the computation of the correlation between mathematics/quantity and mathematics/space and shape by using the MCR_SE_COR_2PV macro (e.g. PISA 2003).....	126
<hr/>		
Box 9.1	SPSS® syntax for generating the proficiency levels in science (e.g. PISA 2006).....	135
Box 9.2	SPSS® syntax for computing the percentages of students by proficiency level in science and its standard errors (e.g. PISA 2006).....	136
Box 9.3	SPSS® syntax for computing the percentage of students by proficiency level in science and its standard errors (e.g. PISA 2006).....	138
Box 9.4	SPSS® syntax for computing the percentage of students by proficiency level and its standard errors by gender (e.g. PISA 2006).....	138
Box 9.5	SPSS® syntax for generating the proficiency levels in mathematics (e.g. PISA 2003).....	139
Box 9.6	SPSS® syntax for computing the mean of self-efficacy in mathematics and its standard errors by proficiency level (e.g. PISA 2003).....	140
<hr/>		
Box 10.1	SPSS® syntax for merging the student and school data files (e.g. PISA 2006).....	146
Box 10.2	Question on school location in PISA 2006.....	147
Box 10.3	SPSS® syntax for computing the percentage of students and the average performance in science, by school location (e.g. PISA 2006).....	147
<hr/>		
Box 11.1	SPSS® syntax for computing the mean of job expectations by gender (e.g. PISA 2003).....	152
Box 11.2	SPSS® macro for computing standard errors on differences (e.g. PISA 2003).....	155



Box 11.3	Alternative SPSS® macro for computing the standard error on a difference for a dichotomous variable (e.g. PISA 2003).....	156
Box 11.4	SPSS® syntax for computing standard errors on differences which involve PVs (e.g. PISA 2003).....	158
Box 11.5	SPSS® syntax for computing standard errors on differences that involve PVs (e.g. PISA 2006).....	160
<hr/>		
Box 12.1	SPSS® syntax for computing the pooled OECD total for the mathematics performance by gender (e.g. PISA 2003).....	166
Box 12.2	SPSS® syntax for the pooled OECD average for the mathematics performance by gender (e.g. PISA 2003).....	167
Box 12.3	SPSS® syntax for the creation of a larger dataset that will allow the computation of the pooled OECD total and the pooled OECD average in one run (e.g. PISA 2003).....	168
<hr/>		
Box 14.1	SPSS® syntax for the quarter analysis (e.g. PISA 2006).....	185
Box 14.2	SPSS® syntax for computing the relative risk with five antecedent variables and five outcome variables (e.g. PISA 2006).....	189
Box 14.3	SPSS® syntax for computing the relative risk with one antecedent variable and one outcome variable (e.g. PISA 2006).....	190
Box 14.4	SPSS® syntax for computing the relative risk with one antecedent variable and five outcome variables (e.g. PISA 2006).....	190
Box 14.5	SPSS® syntax for computing effect size (e.g. PISA 2006).....	192
Box 14.6	SPSS® syntax for residual analyses (e.g. PISA 2003).....	196
<hr/>		
Box 15.1	Normalisation of the final student weights (e.g. PISA 2006).....	203
Box 15.2	SPSS® syntax for the decomposition of the variance in student performance in science (e.g. PISA 2006).....	203
Box 15.3	SPSS® syntax for normalising PISA 2006 final student weights with deletion of cases with missing values and syntax for variance decomposition (e.g. PISA 2006).....	206
Box 15.4	SPSS® syntax for a multilevel regression model with random intercepts and fixed slopes (e.g. PISA 2006).....	208
Box 15.5	Results for the multilevel model in Box 15.4.....	208
Box 15.6	SPSS® syntax for a multilevel regression model (e.g. PISA 2006).....	210
Box 15.7	Results for the multilevel model in Box 15.6.....	211
Box 15.8	Results for the multilevel model with covariance between random parameters.....	212
Box 15.9	Interpretation of the within-school regression coefficient.....	214
Box 15.10	SPSS® syntax for a multilevel regression model with a school-level variable (e.g. PISA 2006).....	214
Box 15.11	SPSS® syntax for a multilevel regression model with interaction (e.g. PISA 2006).....	215
Box 15.12	Results for the multilevel model in Box 15.11.....	216
Box 15.13	SPSS® syntax for using the multilevel regression macro (e.g. PISA 2006).....	217
Box 15.14	SPSS® syntax for normalising the weights for a three-level model (e.g. PISA 2006).....	219
<hr/>		
Box 16.1	SPSS® syntax for testing the gender difference in standard deviations of reading performance (e.g. PISA 2000).....	225
Box 16.2	SPSS® syntax for computing the 5th percentile of the reading performance by gender (e.g. PISA 2000).....	227
Box 16.3	SPSS® syntax for preparing a data file for the multilevel analysis.....	230



Box 16.4	SPSS® syntax for running a preliminary multilevel analysis with one PV .....	231
Box 16.5	Estimates of fixed parameters in the multilevel model.....	231
Box 16.6	SPSS® syntax for running preliminary analysis with the MCR_ML_PV macro.....	233
Box 17.1	SPSS® macro of MCR_SE_UNI.sps.....	243
Box 17.2	SPSS® macro of MCR_SE_PV.sps.....	247
Box 17.3	SPSS® macro of MCR_SE_PERCENTILES_PV.sps .....	251
Box 17.4	SPSS® macro of MCR_SE_GrpPct.sps.....	254
Box 17.5	SPSS® macro of MCR_SE_PctLev.sps.....	257
Box 17.6	SPSS® macro of MCR_SE_REG.sps .....	261
Box 17.7	SPSS® macro of MCR_SE_REG_PV.sps.....	265
Box 17.8	SPSS® macro of MCR_SE_COR.sps.....	270
Box 17.9	SPSS® macro of MCR_SE_COR_1PV.sps.....	273
Box 17.10	SPSS® macro of MCR_SE_COR_2PV.sps.....	277
Box 17.11	SPSS® macro of MCR_SE_DIFF.sps.....	281
Box 17.12	SPSS® macro of MCR_SE_DIFF_PV.sps.....	285
Box 17.13	SPSS® macro of MCR_SE_PV_WLEQRT.sps.....	290
Box 17.14	SPSS® macro of MCR_SE_RR.sps.....	295
Box 17.15	SPSS® macro of MCR_SE_RR_PV.sps.....	298
Box 17.16	SPSS® macro of MCR_SE_EFFECT.sps.....	302
Box 17.17	SPSS® macro of MCR_SE_EFFECT_PV.sps .....	306
Box 17.18	SPSS® macro of MCR_ML.sps.....	311
Box 17.19	SPSS® macro of MCR_ML_PV.sps .....	315
Box A1.1	Descriptive statistics of background and explanatory variables.....	326
Box A1.2	Background model for student performance.....	327
Box A1.3	Final net combined model for student performance.....	328
Box A1.4	Background model for the impact of socio-economic background.....	329
Box A1.5	Model of the impact of socio-economic background: “school resources” module.....	330
Box A1.6	Model of the impact of socio-economic background: “accountability practices” module .....	331
Box A1.7	Final combined model for the impact of socio-economic background.....	331
<b>LIST OF FIGURES</b>		
Figure 1.1	Relationship between social and academic segregations.....	27
Figure 1.2	Relationship between social segregation and the correlation between science performance and student HISEI .....	27
Figure 1.3	Conceptual grid of variable types.....	29
Figure 1.4	Two-dimensional matrix with examples of variables collected or available from other sources .....	30
Figure 2.1	Science mean performance in OECD countries (PISA 2006).....	37
Figure 2.2	Gender differences in reading in OECD countries (PISA 2000).....	38
Figure 2.3	Regression coefficient of ESCS on mathematic performance in OECD countries (PISA 2003).....	38
Figure 2.4	Design effect on the country mean estimates for science performance and for ESCS in OECD countries (PISA 2006) .....	41
Figure 2.5	Simple random sample and unbiased standard errors of ESCS on science performance in OECD countries (PISA 2006) .....	42



Figure 4.1	Distribution of the results of 36 students.....	58
Figure 4.2	Sampling variance distribution of the mean.....	60
Figure 5.1	Probability of success for two high jumpers by height (dichotomous).....	80
Figure 5.2	Probability of success for two high jumpers by height (continuous).....	81
Figure 5.3	Probability of success to an item of difficulty zero as a function of student ability.....	81
Figure 5.4	Student score and item difficulty distributions on a Rasch continuum.....	84
Figure 5.5	Response pattern probabilities for the response pattern (1, 1, 0, 0).....	86
Figure 5.6	Response pattern probabilities for a raw score of 1.....	87
Figure 5.7	Response pattern probabilities for a raw score of 2.....	88
Figure 5.8	Response pattern probabilities for a raw score of 3.....	88
Figure 5.9	Response pattern likelihood for an easy test and a difficult test.....	89
Figure 5.10	Rasch item anchoring.....	90
Figure 6.1	Living room length expressed in integers.....	94
Figure 6.2	Real length per reported length.....	95
Figure 6.3	A posterior distribution on a test of six items.....	96
Figure 6.4	EAP estimators.....	97
Figure 8.1	A two-dimensional distribution.....	125
Figure 8.2	Axes for two-dimensional normal distributions.....	125
Figure 13.1	Trend indicators in PISA 2000, PISA 2003 and PISA 2006.....	175
Figure 14.1	Percentage of schools by three school groups (PISA 2003).....	194
Figure 15.1	Simple linear regression analysis versus multilevel regression analysis.....	201
Figure 15.2	Graphical representation of the between-school variance reduction.....	209
Figure 15.3	A random multilevel model.....	210
Figure 15.4	Change in the between-school residual variance for a fixed and a random model.....	212
Figure 16.1	Relationship between the segregation index of students' expected occupational status and the segregation index of student performance in reading (PISA 2000).....	236
Figure 16.2	Relationship between the segregation index of students' expected occupational status and the correlation between HISEI and students' expected occupational status.....	236

**LIST OF TABLES**

Table 1.1	Participating countries/economies in PISA 2000, PISA 2003, PISA 2006 and PISA 2009.....	21
Table 1.2	Assessment domains covered by PISA 2000, PISA 2003 and PISA 2006.....	22
Table 1.3	Correlation between social inequities and segregations at schools for OECD countries.....	28
Table 1.4	Distribution of students per grade and per ISCED level in OECD countries (PISA 2006).....	31
Table 2.1	Design effect and type I errors.....	40
Table 2.2	Mean estimates and standard errors.....	44



Table 2.3	Standard deviation estimates and standard errors.....	44
Table 2.4	Correlation estimates and standard errors.....	45
Table 2.5	ESCS regression coefficient estimates and standard errors.....	45
<hr/>		
Table 3.1	Height and weight of ten persons .....	50
Table 3.2	Weighted and unweighted standard deviation estimate .....	50
Table 3.3	School, within-school, and final probability of selection and corresponding weights for a two-stage, simple random sample with the first-stage units being schools of equal size.....	52
Table 3.4	School, within-school, and final probability of selection and corresponding weights for a two-stage, simple random sample with the first-stage units being schools of unequal size .....	52
Table 3.5	School, within-school, and final probability of selection and corresponding weights for a simple and random sample of schools of unequal size (smaller schools) .....	53
Table 3.6	School, within-school, and final probability of selection and corresponding weights for a simple and random sample of schools of unequal size (larger schools) .....	53
Table 3.7	School, within-school, and final probability of selection and corresponding weights for PPS sample of schools of unequal size .....	54
Table 3.8	Selection of schools according to a PPS and systematic procedure.....	55
<hr/>		
Table 4.1	Description of the 630 possible samples of 2 students selected from 36 students, according to their mean.....	59
Table 4.2	Distribution of all possible samples with a mean between 8.32 and 11.68.....	61
Table 4.3	Distribution of the mean of all possible samples of 4 students out of a population of 36 students.....	62
Table 4.4	Between-school and within-school variances on the mathematics scale in PISA 2003.....	65
Table 4.5	Current status of sampling errors.....	65
Table 4.6	Between-school and within-school variances, number of participating schools and students in Denmark and Germany in PISA 2003 .....	66
Table 4.7	The Jackknives replicates and sample means.....	68
Table 4.8	Values on variables X and Y for a sample of ten students.....	69
Table 4.9	Regression coefficients for each replicate sample.....	69
Table 4.10	The Jackknife replicates for unstratified two-stage sample designs.....	70
Table 4.11	The Jackknife replicates for stratified two-stage sample designs.....	71
Table 4.12	Replicates with the Balanced Repeated Replication method.....	72
Table 4.13	The Fay replicates .....	73
<hr/>		
Table 5.1	Probability of success when student ability equals item difficulty.....	82
Table 5.2	Probability of success when student ability is less than the item difficulty by 1 unit.....	82
Table 5.3	Probability of success when student ability is greater than the item difficulty by 1 unit .....	82
Table 5.4	Probability of success when student ability is less than the item difficulty by 2 units .....	83
Table 5.5	Probability of success when student ability is greater than the item difficulty by 2 units.....	83
Table 5.6	Possible response pattern for a test of four items.....	85
Table 5.7	Probability for the response pattern (1, 1, 0, 0) for three student abilities.....	85
Table 5.8	Probability for the response pattern (1, 0) for two students of different ability in an incomplete test design.....	89
Table 5.9	PISA 2003 test design .....	91



Table 6.1	Structure of the simulated data.....	98
Table 6.2	Means and variances for the latent variables and the different student ability estimators.....	98
Table 6.3	Percentiles for the latent variables and the different student ability estimators.....	99
Table 6.4	Correlation between HISEI, gender and the latent variable, the different student ability estimators.....	99
Table 6.5	Between- and within-school variances.....	100
<hr/>		
Table 7.1	HISEI mean estimates .....	105
Table 7.2	Squared differences between replicate estimates and the final estimate.....	106
Table 7.3	Output data file from Box 7.2.....	108
Table 7.4	Available statistics with the UNIVAR macro .....	109
Table 7.5	Output data file from Box 7.3.....	109
Table 7.6	Output data file from Box 7.4.....	110
Table 7.7	Percentage of girls for the final and replicate weights and squared differences.....	111
Table 7.8	Output data file from Box 7.5.....	112
Table 7.9	Output data file from Box 7.6.....	113
Table 7.10	Output data file from Box 7.7.....	114
Table 7.11	Output data file from Box 7.8.....	114
<hr/>		
Table 8.1	The 405 mean estimates.....	118
Table 8.2	Mean estimates and their respective sampling variances on the science scale for Belgium (PISA 2006).....	119
Table 8.3	Output data file from Box 8.2.....	121
Table 8.4	Output data file from Box 8.3.....	121
Table 8.5	The 450 regression coefficient estimates.....	123
Table 8.6	HISEI regression coefficient estimates and their respective sampling variance on the science scale in Belgium after accounting for gender (PISA 2006).....	123
Table 8.7	Output data file from Box 8.5.....	123
Table 8.8	Output data file from Box 8.6.....	124
Table 8.9	Correlation between the five plausible values for each domain, mathematics/quantity and mathematics/space and shape.....	126
Table 8.10	The five correlation estimates between mathematics/quantity and mathematics/space and shape and their respective sampling variance.....	127
Table 8.11	Standard deviations for mathematics scale using the correct method (plausible values) and by averaging the plausible values at the student level (pseudo-EAP) (PISA 2003).....	128
Table 8.12	Unbiased shortcut for a population estimate and its standard error .....	129
Table 8.13	Standard errors from the full and shortcut computation (PISA 2006).....	130
<hr/>		
Table 9.1	The 405 percentage estimates for a particular proficiency level .....	136
Table 9.2	Estimates and sampling variances per proficiency level in science for Germany (PISA 2006) .....	137
Table 9.3	Final estimates of the percentage of students, per proficiency level, in science and its standard errors for Germany (PISA 2006).....	137
Table 9.4	Output data file from Box 9.3.....	138
Table 9.5	Output data file from Box 9.4.....	138
Table 9.6	Mean estimates and standard errors for self-efficacy in mathematics per proficiency level (PISA 2003).....	141
Table 9.7	Output data file from Box 9.6.....	141



Table 10.1	Percentage of students per grade and ISCED level, by country (PISA 2006).....	144
Table 10.2	Output data file from the first model in Box 10.3.....	148
Table 10.3	Output data file from the second model in Box 10.3.....	148
<hr/>		
Table 11.1	Output data file from Box 11.1.....	153
Table 11.2	Mean estimates for the final and 80 replicate weights by gender (PISA 2003).....	153
Table 11.3	Difference in estimates for the final weight and 80 replicate weights between females and males (PISA 2003).....	155
Table 11.4	Output data file from Box 11.2.....	156
Table 11.5	Output data file from Box 11.3.....	157
Table 11.6	Gender difference estimates and their respective sampling variances on the mathematics scale (PISA 2003).....	157
Table 11.7	Output data file from Box 11.4.....	158
Table 11.8	Gender differences on the mathematics scale, unbiased standard errors and biased standard errors (PISA 2003).....	159
Table 11.9	Gender differences in mean science performance and in standard deviation for science performance (PISA 2006).....	159
Table 11.10	Regression coefficient of HISEI on the science performance for different models (PISA 2006).....	160
Table 11.11	Cross tabulation of the different probabilities.....	161
<hr/>		
Table 12.1	Regression coefficients of the index of instrumental motivation in mathematics on mathematic performance in OECD countries (PISA 2003).....	165
Table 12.2	Output data file from Box 12.1.....	166
Table 12.3	Output data file from Box 12.2.....	167
Table 12.4	Difference between the country mean scores in mathematics and the OECD total and average (PISA 2003).....	170
<hr/>		
Table 13.1	Trend indicators between PISA 2000 and PISA 2003 for HISEI, by country.....	176
Table 13.2	Linking error estimates.....	178
Table 13.3	Mean performance in reading by gender in Germany.....	180
<hr/>		
Table 14.1	Distribution of the questionnaire index of cultural possession at home in Luxembourg (PISA 2006).....	184
Table 14.2	Output data file from Box 14.1.....	186
Table 14.3	Labels used in a two-way table.....	186
Table 14.4	Distribution of 100 students by parents' marital status and grade repetition.....	187
Table 14.5	Probabilities by parents' marital status and grade repetition.....	187
Table 14.6	Relative risk for different cutpoints.....	187
Table 14.7	Output data file from Box 14.2.....	189
Table 14.8	Mean and standard deviation for the student performance in reading by gender, gender difference and effect size (PISA 2006).....	191
Table 14.9	Output data file from the first model in Box 14.5.....	197
Table 14.10	Output data file from the second model in Box 14.5.....	197
Table 14.11	Mean of the residuals in mathematics performance for the bottom and top quarters of the PISA index of economic, social and cultural status, by school group (PISA 2003).....	195



Table 15.1	Between- and within-school variance estimates and intraclass correlation (PISA 2006).....	204
Table 15.2	Fixed parameter estimates .....	211
Table 15.3	Variance/covariance estimates before and after centering.....	213
Table 15.4	Output data file of the fixed parameters file.....	215
Table 15.5	Average performance and percentage of students by student immigrant status and by type of school.....	216
Table 15.6	Variables for the four groups of students .....	216
Table 15.7	Comparison of the regression coefficient estimates and their standard errors in Belgium (PISA 2006).....	218
Table 15.8	Comparison of the variance estimates and their respective standard errors in Belgium (PISA 2006) .....	218
Table 15.9	Three-level regression analyses.....	220
<hr/>		
Table 16.1	Differences between males and females in the standard deviation of student performance (PISA 2000).....	226
Table 16.2	Distribution of the gender differences (males – females) in the standard deviation of the student performance .....	226
Table 16.3	Gender difference on the PISA combined reading scale for the 5 <sup>th</sup> , 10 <sup>th</sup> , 90 <sup>th</sup> and 95 <sup>th</sup> percentiles (PISA 2000) .....	227
Table 16.4	Gender difference in the standard deviation for the two different item format scales in reading (PISA 2000) .....	228
Table 16.5	Random and fixed parameters in the multilevel model with student and school socio-economic background.....	229
Table 16.6	Random and fixed parameters in the multilevel model with socio-economic background and grade retention at the student and school levels .....	233
Table 16.7	Segregation indices and correlation coefficients by country (PISA 2000).....	234
Table 16.8	Segregation indices and correlation coefficients by country (PISA 2006).....	235
Table 16.9	Country correlations (PISA 2000).....	237
Table 16.10	Country correlations (PISA 2006).....	237
<hr/>		
Table 17.1	Synthesis of the 19 SPSS® macros.....	241
<hr/>		
Table A2.1	Cluster rotation design used to form test booklets for PISA 2006 .....	332
<hr/>		
Table A12.1	Mapping of ISCED to accumulated years of education .....	457
Table A12.2	ISCO major group white-collar/blue-collar classification .....	459
Table A12.3	ISCO occupation categories classified as science-related occupations .....	459
Table A12.4	Household possessions and home background indices.....	463
Table A12.5	Factor loadings and internal consistency of ESCS 2006 in OECD countries.....	473
Table A12.6	Factor loadings and internal consistency of ESCS 2006 in partner countries/economies.....	474





# User's Guide

## Preparation of data files

All data files (in text format) and the SPSS® control files are available on the PISA website ([www.pisa.oecd.org](http://www.pisa.oecd.org)).

## SPSS® users

By running the SPSS® control files, the PISA data files are created in the SPSS® format. Before starting analysis in the following chapters, save the PISA 2000 data files in the folder of "c:\pisa2000\data\", the PISA 2003 data files in "c:\pisa2003\data\", and the PISA 2006 data files in "c:\pisa2006\data\".

## SPSS® syntax and macros

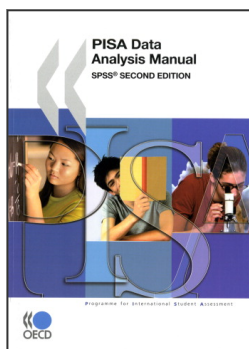
All syntaxes and macros in this manual can be copied from the PISA website ([www.pisa.oecd.org](http://www.pisa.oecd.org)). These macros were developed for SPSS 17.0. The 19 SPSS® macros presented in Chapter 17 need to be saved under "c:\pisa\macro\", before starting analysis. Each chapter of the manual 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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