CHAPTER 4

ASSESSMENT OF SCHOOL EFFECTIVENESS IN GREECE

4.1 Introduction

The aim of this section is to assess the effectiveness of Greek Lyceums, to detect potential differences in the performance of Lyceums and to explore those factors that affect students' achievement in the National Entrance Exams for the Universities and the Technical Institutions.

Thus, the data consist of prefectures, schools nested in prefectures and students nested in schools. The hierarchical structure of the data is apparent as well as the necessity for taking into account the fact that the students are subject to the influences of their grouping in schools. This is the reason why multilevel modeling is required for the analysis of this kind of data. On the other hand, it has been widely expounded in the previous chapters the stressing by the researchers for the need of making adjustments for the existing achievements of the students. Otherwise, the results produced by an unadjusted analysis would be insufficient and misleading as for the inferences about school differences.

Of course, each researcher use different examination score in order to assess the difference of performance between schools. Among the examination results that have been used, Goldstein (1996) used the GCSE examination results as explanatory variable and the A-level and AS-level results as response variable. Results of similar nature are going to be used in the present analysis, but it is evident that we will have to examine in which rank of the educational system in England the Greek examinations correspond

to and decide which Greek examination scores to use. For that reason, we will give a brief account of the educational system first in England and then in Greece. As far as England is concerned compulsory education begins at the age of five when students go to the Primary school. The Primary school lasts for six years. Then, students go to the Secondary school which is also compulsory and lasts for five years. At the end of the Secondary school students take the General Certificate of Secondary Education (GCSE) exams (8 subjects). Some students stay at Secondary school for a further two years and then take the Advanced Level General Certificate of Education (A-level GCE) exams (2 or 3 subjects). The Greek educational system is similar. Compulsory education begins at the age of six when students go to the Primary school, which lasts for six years. Then, students go to the Gymnasium which is also compulsory and lasts for three years. After Gymnasium, most of the students continue their study in the Lyceum, which is optional and lasts for three years. At the end of each school year students take examinations on all subjects that have attended. In the 3rd grade of Lyceum, the subjects are divided into: (a) general education and (b) preparatory studies for entering Universities and Technological Educational Institutions. These preparatory studies are divided in four different scientific orientations (desmes), depending on the kind of studies students want to follow. Each orientation includes four subjects and students have to choose only one orientation. Entrance to Greek Universities and Technological Institutions is determined by a National Exam that takes place in June. All students of each of the four scientific orientations take the same exam. The University and the Department they will enter depends solely on their performance in the National Exam and their ranking of the Departments that correspond to the scientific discipline (desmi) they have chosen.

Having these information in mind, we are going to use the results of the examinations taken for the entrance exams as response variable. Also, the results of the examinations taken at the end of the 3rd grade of Lyceum are going to be used as indicators of the existing achievements of the students.

Except from this explanatory variable it is also possible to examine differences between boys and girls, between public and private schools or even differences in the performance of students belonging to different scientific orientations. It would also be interesting to include the socioeconomic status of the students as explanatory variable and furthermore to observe the progress of the students in Universities and Technological Educational Institutions according to their achievements in Lyceum.

4.2 Variables

The variables that are going to be used in the analysis concisely are the following: the mean score of students in the National Entrance Exams, the 3rd-grade score, the type of school (public or private), the gender of students, the scientific orientation (desmi) they have chosen and the year in which the students took the National Entrance Exam. Let us now give a complete account of each variable.

Response Variable

The response variable is the mean score of students in the National Entrance Exams. Students take four subjects in these Exams and these subjects are different in each scientific orientation. More specifically, the subjects in each scientific orientation are the following:

1st orientation	**2nd orientation**	**3rd orientation**	**4th orientation**
Mathematics	Biology	Ancient Greek	Mathematics
Physics	Physics	Latin	Sociology
Chemistry	Chemistry	History	History
Composition	Composition	Composition	Composition

Thus, for each student the mean score of the subjects has been calculated and used as the response variable. Also, these scores have been transformed to

normality using normal scores, where this is a method of rescoring by assigning expected values from the standard Normal distribution according to the ranks of the original scores.

Explanatory variables

1. The only continuous explanatory variable that is going to be used in the analysis is the 3rd-grade score. This is the mean score of students in the 3rd grade of Lyceum. The scores have been standardized in order to follow the standard Normal distribution.

2. The type of school is going to be used also as explanatory variable. There are two kinds of schools that are to be compared in the analysis. The public Lyceums and the private ones. The variable indicating the kind of school is a dummy variable coded 1 for public Lyceums and 0 for private Lyceums.

3. It is also interesting to compare the performance of students according to their gender. Thus, a dummy variable has been included in the analysis, coded 1 for girls and 0 for boys.

4. Furthermore, three dummy variables indicating the scientific orientation that students have chosen have been included. The first one is coded 1 for the 1st orientation and 0 for the others. The second, is coded 1 for the 2nd orientation and 0 for the others. The third, is coded 1 for the 3rd orientation and 0 for the others, while the 4th orientation is the base category. Thus, a comparison between the four orientations can be made.

5. Finally, a dummy variable indicating the year in which students took the Exams is included. This variable is coded 1 for those who took the Exams in 1990 and 0 for those who took the Exams in 1991. It is important to mention at this point that in the analysis only students who took for the first time the Exams are included.

4.3 Descriptive Statistics

Let us now give some descriptive statistics for our data, separately for each year of Exams. First, the data of the National Entrance Exam taken in 1990 will be analyzed. The number of the level-3 units, that is the prefectures, is 51, the number of level-2 units, that is the schools, is 961 and the number of the level-1 units, that is the students participated in the exam, is 52,041. The number of schools and the number of students in each prefecture is displayed in tables 1 and 2 respectively in the Appendix. The total mean score of the students in National Entrance Exams is given in table 4.3.1.

Table 4.3.1 Descriptive statistics for the 1990 Greek National Entrance Exams score

Variable	Mean	Std Dev	Minimum	Maximum	N of cases
National Entrance Exams Score	10.17	4.81	0	19.72	52,041

Among the prefectures, the one with the highest mean score is Chios (prefecture 4) with mean National Entrance Exams score 11.58 and with 247 participating students. The prefecture with the second highest mean score is Corinthia (prefecture 7) with mean score 11.33 and 732 students. The prefecture with the lowest mean score is Evros (prefecture 47) with mean score 8.62 and 451 students. Analytic descriptive statistics for all prefectures are displayed in tables 3a and 3b in the Appendix. However, it is also interesting to set out the performance of students in these Exams according to: (a) the type of school, (b) the scientific orientation and (c) the gender of students. These data are reported in tables 4.3.2, 4.3.3 and 4.3.4 respectively.

Table 4.3.2 Descriptive statistics for the 1990 Greek National Entrance Exams score according to the type of school

Variable	Type	Mean	Std Dev	Minimum	Maximum	N of cases

National Entrance Exams Score	Public	10.16	4.80	0	19.72	51,358
	Private	11.07	5.00	0.13	19.47	683

As we can observe from the above table, private schools have higher mean score than the public ones, but the highest mean score for that year was accomplished by a student in a public school. Besides, we have to take into consideration the small number of students attending private schools.

Table 4.3.3 Descriptive statistics for the 1990 Greek National Entrance Exams score according to the scientific orientation

Variable	Orientation	Mean	Std Dev	Minimum	Maximum	N of cases
National Entrance Exams Score	1st orient.	9.81	4.62	0.06	19.63	11,561
	2nd orient.	12.05	4.74	0.03	19.66	4,552
	3rd orient.	12.65	4.46	0	19.72	12,640
	4th orient.	8.63	4.40	0.03	19.66	23,288

Table 4.3.4 Descriptive statistics for the 1990 Greek National Entrance Exams score according to the gender of the students

Variable	Orientation	Mean	Std Dev	Minimum	Maximum	N of cases
National Entrance Exams Score	Boys	9.66	4.87	0	19.63	21,887
	Girls	10.54	4.73	0	19.72	30,154

The data of the Exams taken in 1991 are also analyzed. The number of the level-3 units, that is the prefectures, is 51, the number of level-2 units, that is the schools, is 978 and the number of the level-1 units, that is the students, is 54,200. The number of schools and the number of students in each prefecture is displayed in tables 4 and 5 respectively in the Appendix. The total mean score of the students in the 1991 National Entrance Exams is given in the table 4.3.5.

Table 4.3.5 Descriptive statistics for the 1991 Greek National Entrance Exams score

Variable	Mean	Std Dev	Minimum	Maximum	N of cases
National Entrance Exams Score	9.58	4.92	0	19.59	54,200

It is important to point out the lowering of the mean score for the Exams taken in 1991 as compared to that of 1990. Among the prefectures, the one with the highest mean score is again Chios (prefecture 4) with mean National Entrance Exams score 11.01 and with 289 students. The prefecture with the second highest mean score is Trikala (prefecture 31) with mean score 10.39 and 814 students. The prefecture with the lowest mean score is Evritania (prefecture 27) with mean score 7.44 and 77 students. Analytic descriptive statistics for all prefectures are displayed in table 6a and 6b in the Appendix. Besides, the performance of students in these Exams according to: (a) the type of school, (b) the scientific orientation and (c) the gender of students is set out, too. These data are reported in tables 4.3.6, 4.3.7 and 4.3.8 respectively.

Table 4.3.6 Descriptive statistics for the 1991 Greek National Entrance Exams score according to the type of school

Variable	Type	Mean	Std Dev	Minimum	Maximum	N of cases
National Entrance Exams Score	Public	9.58	4.92	0	19.59	53,386
	Private	9.87	5.35	0.06	19.44	814

As in the previous year, the private schools do better than the public ones, but now the difference is much smaller.

Table 4.3.7 Descriptive statistics for the 1991 Greek National Entrance Exams score according to the scientific orientation

Variable	Orientation	Mean	Std Dev	Minimum	Maximum	N of cases
National	1st orient.	8.95	3.89	0.06	19.03	12,292

Entrance	2nd orient.	11.60	4.40	0	19.41	4,551
Exams	3rd orient.	13.39	4.32	0.06	19.59	12,874
Score	4th orient.	7.52	4.45	0	19.53	24,483

The students of the 3rd scientific orientation do better than the students of the other orientations, while the differences in mean scores between the four orientations are large.

Table 4.3.8 Descriptive statistics for the 1991 Greek National Entrance Exams score according to the gender of the students

Variable	Orientation	Mean	Std Dev	Minimum	Maximum	N of cases
National Entrance Exams Score	Boys	8.84	4.74	0	19.56	22,700
	Girls	10.12	4.99	0	19.59	31,500

In the Exams taken in 1991 girls do better than boys, just as in the previous year, but this time with larger difference.

4.4 Data Analysis

As a first stage of the analysis, we shall fit a simple 3-level model to the data with the National Entrance Exams score as response variable and the score in the 3rd grade of Lyceum as explanatory variable. More specifically, there are students nested in schools and schools nested in prefectures. Thus, the level-1 units are students, the level-2 units are schools and the level-3 units are prefectures. The parameter values, estimated by the first model, are displayed in table 4.4.1.

Table 4.4.1 Parameter estimates for model 1 and model 2

Parameter	Estimate (s.e.) Model 1	Estimate (s.e.) Model 2

Fixed:		
Constant	-0.186	-0.190
3rd-grade score	0.807 (0.002)	0.810 (0.005)
Random:		
σ^2_{v0} (between prefectures)	0.021 (0.005)	0.022 (0.005)
σ_{v10}		-0.003 (0.001)
σ^2_{v1}		0.001 (0.000)
σ^2_{u0} (between schools)	0.123 (0.004)	0.122 (0.004)
σ_{u10}		-0.005 (0.001)
σ^2_{u1}		0.006 (0.000)
σ^2_{e0} (between students)	0.325 (0.001)	0.319 (0.001)
-2*log(likelihood)	187634.400	186879.600

It is obvious from table 4.4.1 that there is a positive relation between the score in the National Entrance Exams and in the 3rd-grade score, which is highly significant, since the estimate of the standard error of the parameter is less than a third of the parameter estimate. Furthermore, in order to assess the significance of the level-2 variance a likelihood ratio test is carried out by estimating the deviance for the current model and the one omitting the level-2 variance. The deviance of the model that does not contain the level-2 variance σ^2_{u0} is 209443.700, compared to 187851.900 when the level-2 variance is included in the model. Their difference is referred to tables of the chi-squared distribution with one degree of freedom and is found to be statistically significant. Moreover, in order to evaluate the significance of the level-3 variance we compare the model 1 to model that does not contain the level-3 variance. The deviance of the model that does not contain the level-3 variance is 187851.900, compared to 187634.400 when the level-3 variance is included in the model. Their difference is referred to tables of the chi-squared distribution with one degree of freedom and it is obvious that is highly

statistically significant. However, the assumptions about the residuals should be checked also. In figure 4.4.1 a plot of the standardized level-1 residuals against their equivalent normal scores is displayed, while in figure 4.4.2 another plot of these residuals against the fixed part predicted value is displayed, too. From these plots we can conclude that the assumption of normality for the residuals is rational. The same holds true about the assumption of constant level-1 variance. For the level-2 and the level-3 residuals equivalent plots have been produced (figures 4.4.3-4.4.6) in order to check the assumptions of normality of the residuals and constant level-2 and level-3 variance. From these plots it is apparent that the assumptions are met.

Figure 4.4.1

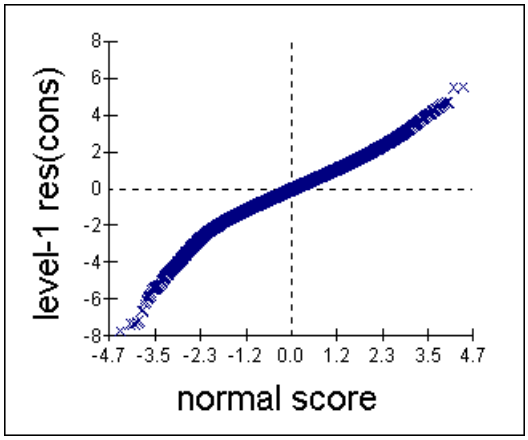


Figure 4.4.2

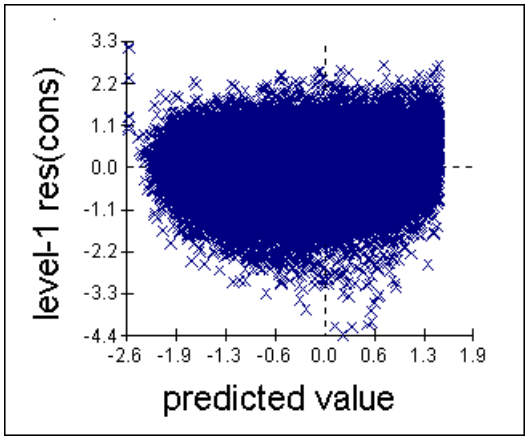


Figure 4.4.3

Figure 4.4.4

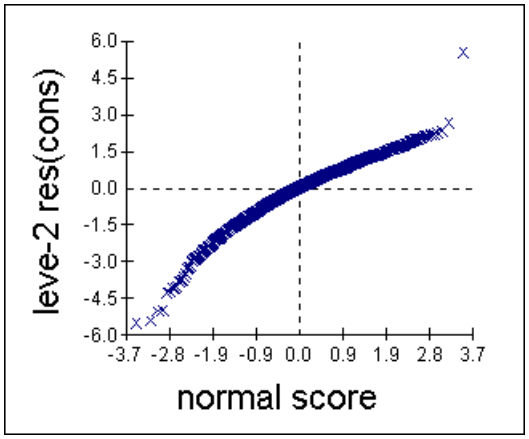


Figure 4.4.5

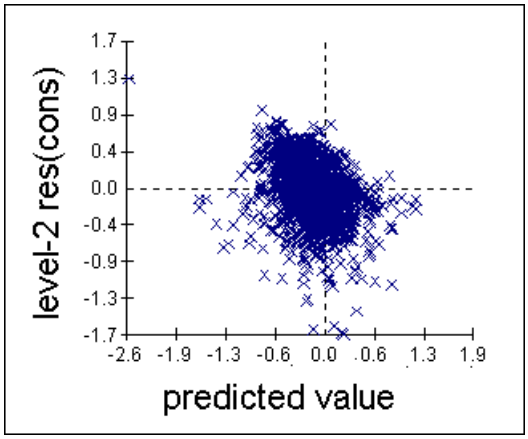
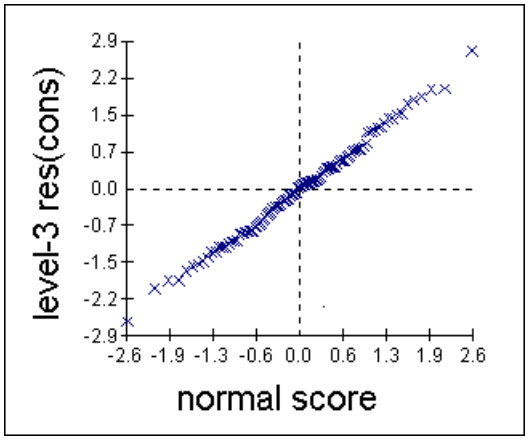
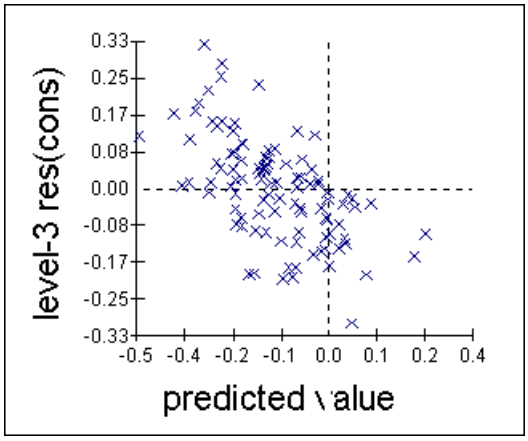


Figure 4.4.6





The model presented above can be elaborated by setting the slope to be different in each school and each prefecture. The parameter estimates from the second model are displayed in the second column of table 4.4.1. The estimates are little changed as far as the fixed parameters are concerned. But now the level-3 and the level-2 variances are quadratic functions of the 3rd-grade score, namely

Total level-3 variance

$$\mathrm{var}(v_{0k}x_0 + v_{1k}x_{1ijk}) = \sigma^2_{v0}x_0^2 + 2\sigma_{v01}x_0x_{1ijk} + \sigma^2_{v1}x^2_{1ijk}$$

Total level-2 variance

$$\mathrm{var}(u_{0jk}x_0 + u_{1jk}x_{1ijk}) = \sigma^2_{u0}x_0^2 + 2\sigma_{u01}x_0x_{1ijk} + \sigma^2_{u1}x^2_{1ijk}$$

where x_{1ijk} is the 3rd-grade score and x_0 is the constant term, while the level-1 variance is still of simple form and slightly decreased. Likewise, if we compare the current model to model 1 using their deviances, 186879.600 and 187634.400 respectively, we conclude that the current model is better, since their difference is 754.8, which, when referred to tables of the chi-squared distribution with four degrees of freedom, is found to be highly significant. As before, the assumptions about the level-1, the level-2 and the level-3 residuals should be checked. In figures 4.4.7 and 4.4.8 the plots of the standardized level-1 residuals against their normal scores and the fixed part predicted values are displayed respectively. It is clear that the assumptions of normality and of constant level-1 variance are met. Now, for checking the same assumptions for the level-2 variance we have to produce the plots of the standardized level-2 residuals against their normal scores and the fixed part predicted values for the constant term and for the explanatory variable (figures 4.4.9 and 4.4.10). The same plots for the level-3 residuals have to be produced. These plots are demonstrated in figures 4.4.11 and 4.4.12 and it is clear that the assumptions for the level-2 residuals and the level-3 residuals are sound, too.

Figure 4.4.7

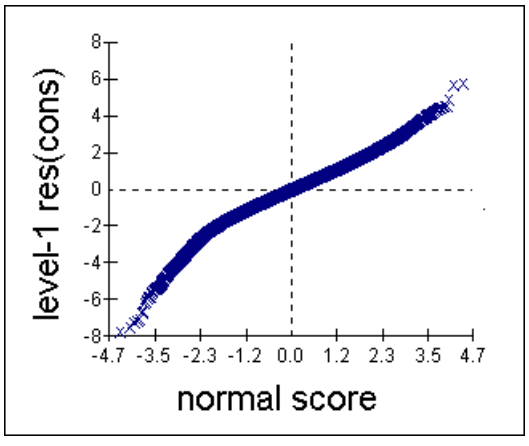


Figure 4.4.8

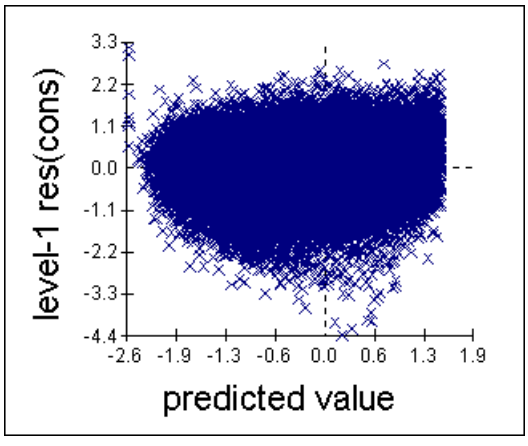


Figure 4.4.9

Figure 4.4.10

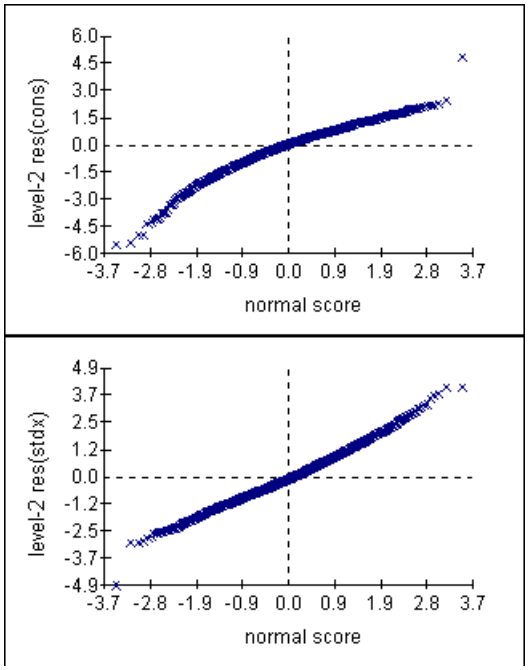


Figure 4.4.11

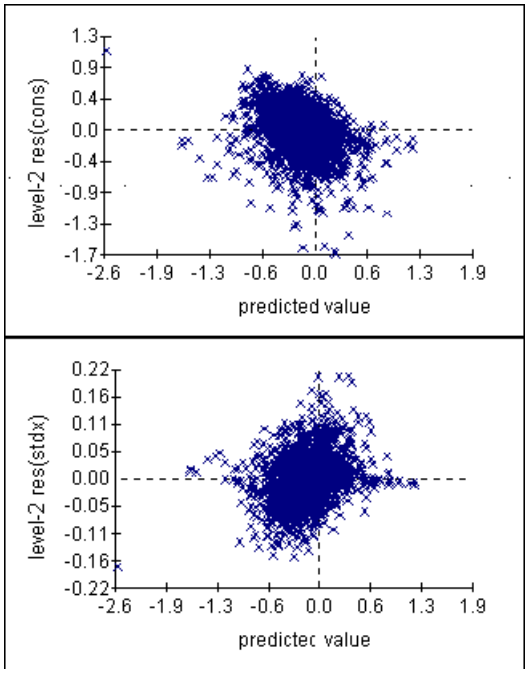
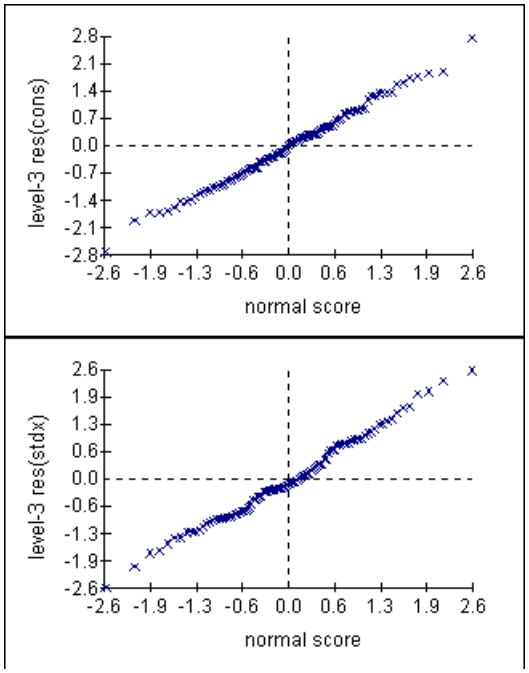
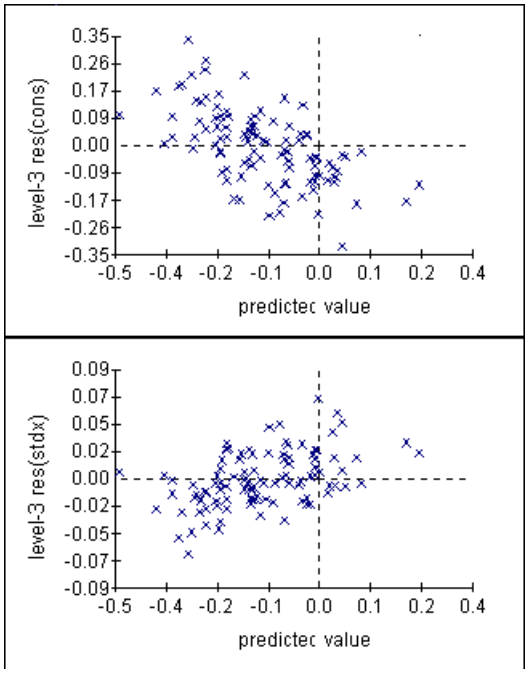


Figure 4.4.12





We can expand more the model by adding another explanatory variable; the type of the school. This is a dummy variable coded 1 for public schools and 0 for private schools. The estimates of the parameters from the third model are shown in the first column of table 4.4.2. The estimate for the 3rd-grade score is not changed, while the type of school difference is in favor of public schools

and statistically significant, since the estimate of the standard error of the parameter is less than a third of the parameter estimate. The random parameters are little changed and the level-2 and the level-3 variance are, again, quadratic functions of the 3rd-grade score. The difference of the deviances of this model and the previous one is 108.2 and when referred to the tables of the chi-squared distribution with one degree of freedom is found to be highly significant. The assumptions for the level-1, the level-2 and the level-3 residuals are examined in figures 4.4.13-4.4.18 and with a careful inspection we conclude the fulfillment of the assumptions.

Figure 4.4.13

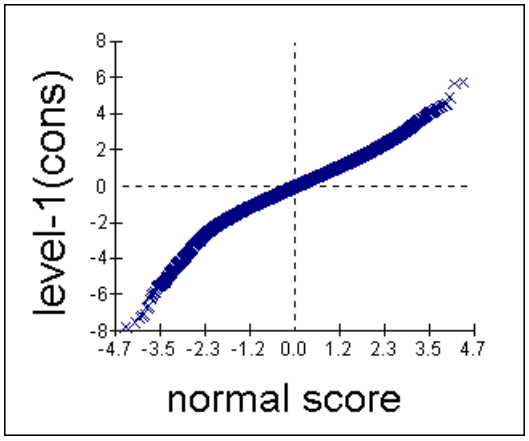


Figure 4.4.14

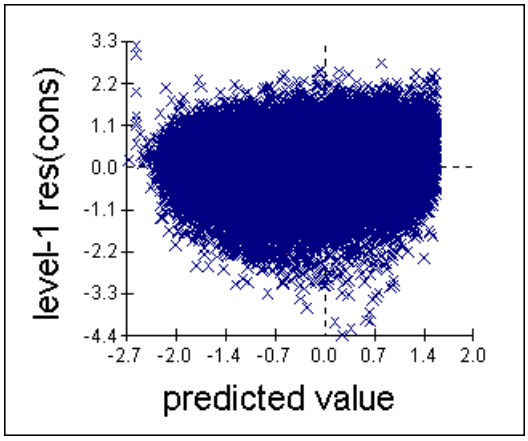


Figure 4.4.15

Figure 4.4.16

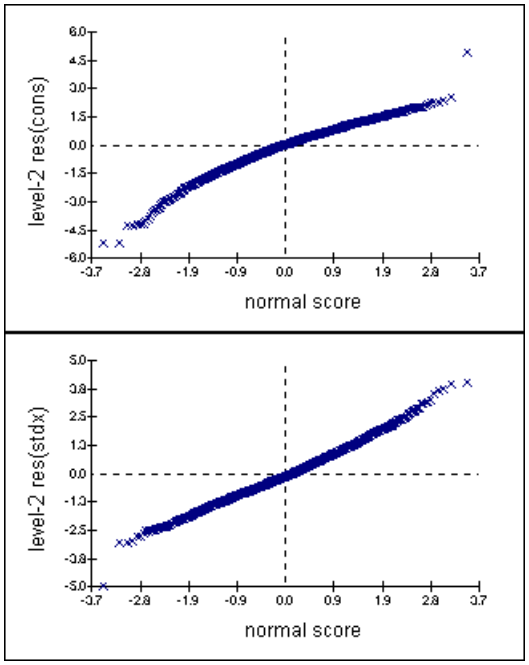


Figure 4.4.17

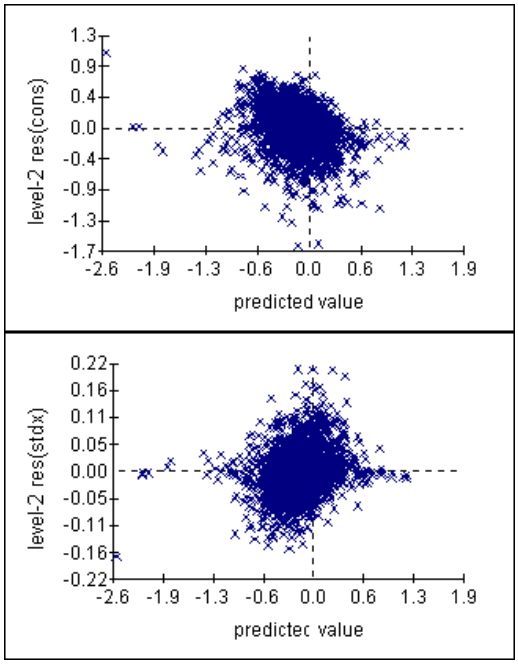
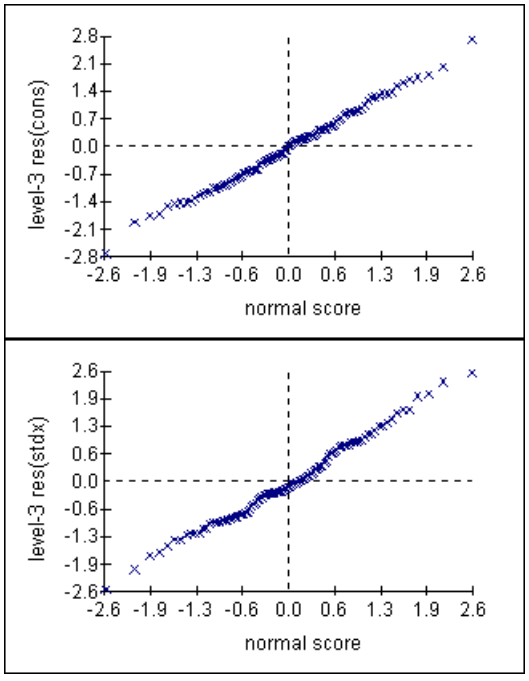


Figure 4.4.18



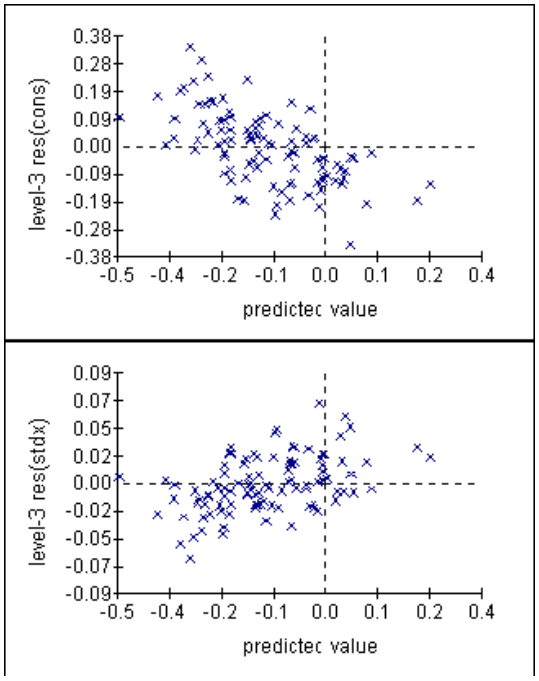


Table 4.4.2 Parameter estimates for model 3 and model 4

Parameter	**Estimate (s.e.)**	**Estimate (s.e.)**

	Model 3	Model 4
Fixed:		
Constant	-0.767	-0.712
3rd-grade score	0.810 (0.005)	0.823 (0.005)
Type of school	0.581 (0.055)	0.595 (0.055)
Gender of student		-0.114 (0.004)
Random:		
σ^2_{v0} (between prefectures)	0.023 (0.005)	0.023 (0.005)
σ_{v10}	-0.003 (0.001)	-0.003 (0.001)
σ^2_{v1}	0.001 (0.000)	0.001 (0.000)
σ^2_{u0} (between schools)	0.115 (0.004)	0.116 (0.004)
σ_{u10}	-0.004 (0.001)	-0.004 (0.001)
σ^2_{u1}	0.006 (0.000)	0.006 (0.000)
σ^2_{e0} (between students)	0.319 (0.001)	0.316 (0.001)
-2*log(likelihood)	186771.400	185813.400

Next, another variable is included in the model and this is the gender of the student. This variable is also a dummy one and is coded 1 for girls and 0 for boys. The estimates of the parameters are shown in the second column of table 4.4.2. As we notice from the table, the estimates for the 3rd-grade score and the type of school has been little altered but both of them are still highly significant. The gender difference is in favor of boys and is highly significant, too, since the estimate of the standard error of the parameter is less than a third of the parameter estimate. As far as the random parameters are concerned we observe that the level-1 variance is decreased with the inclusion of the gender in the model. However, the comparison of the two models presented in table 4.4.2, gives a difference of their deviances equal to 958 and when referred to the tables of the chi-squared distribution with one degree of freedom is found to be highly significant. Furthermore, a cautious checking in the plots presented

in figures 4.4.19-4.4.24 shows that the assumption of normality and of constant variance are met for level-1, level-2 and level-3 residuals.

Figure 4.4.19

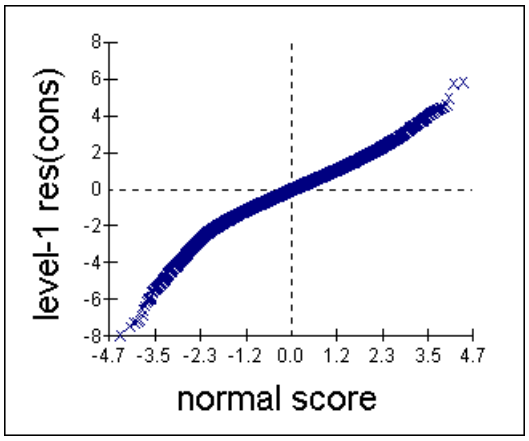


Figure 4.4.20

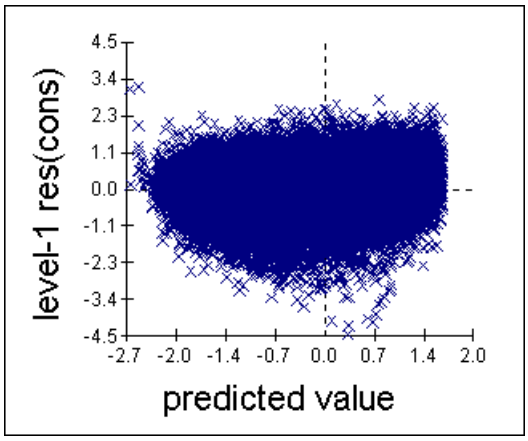
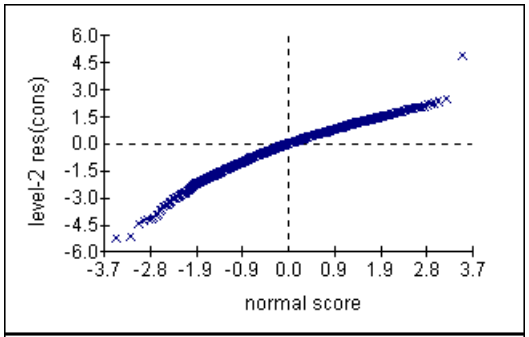


Figure 4.4.21



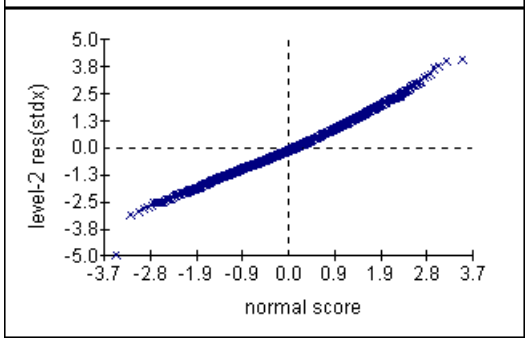
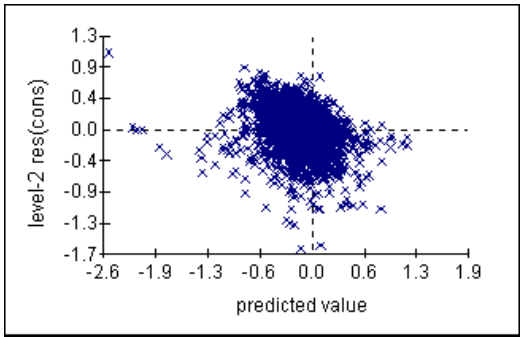


Figure 4.4.22



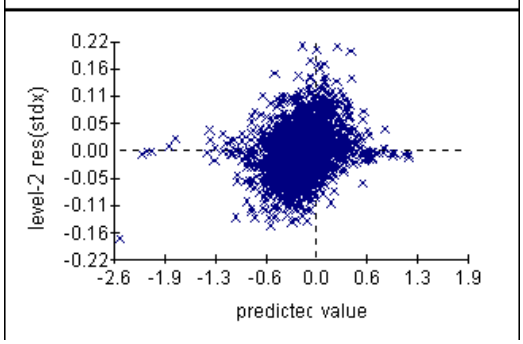
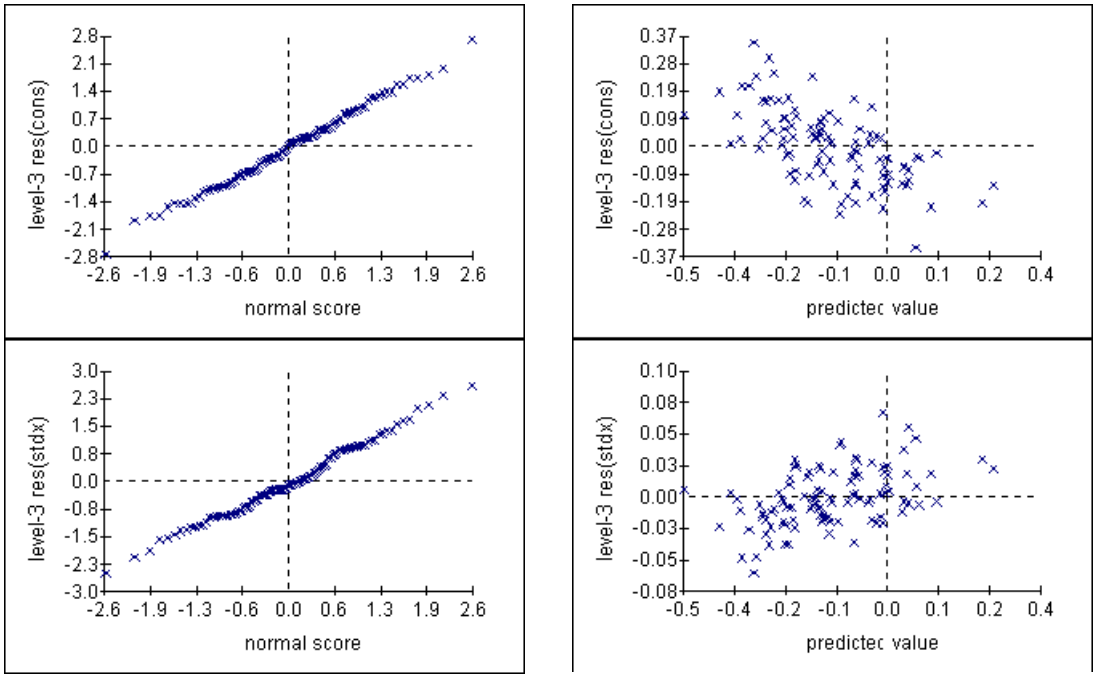


Figure 4.4.23

Figure 4.4.24



Another explanatory variable defined at student level is the scientific orientation (desmi). There are four scientific orientations and the student can follow only one of them. This is also a dummy variable and the base category is the fourth scientific orientation. The parameter estimates for the fifth model is presented in the first column of table 4.4.3.

Table 4.4.3 Parameter estimates for model 5 and model 6

Parameter	**Estimate (s.e.)**	**Estimate (s.e.)**

	Model 5	Model 6
Fixed:		
Constant	-0.728	-0.792
3rd-grade score	0.784 (0.005)	0.783 (0.005)
Type of school	0.560 (0.053)	0.560 (0.053)
Gender of student	-0.211 (0.006)	-0.211 (0.004)
Scientific Orientation 1	-0.029 (0.005)	-0.029 (0.005)
Scientific Orientation 2	0.063 (0.006)	0.063 (0.006)
Scientific Orientation 3	0.446 (0.005)	0.446 (0.005)
Year of the Exams		0.130 (0.031)
Random:		
σ^2_{v0} (between prefectures)	0.022 (0.005)	0.017 (0.004)
σ_{v10}	-0.003 (0.001)	-0.002 (0.001)
σ^2_{v1}	0.001 (0.000)	0.001 (0.000)
σ^2_{u0} (between schools)	0.112 (0.004)	0.111 (0.004)
σ_{u10}	-0.007 (0.001)	-0.007 (0.001)
σ^2_{u1}	0.005 (0.000)	0.005 (0.000)
σ^2_{e0} (between students)	0.285 (0.001)	0.285 (0.0p1)
-2*log(likelihood)	174963.500	174948.400

As the table shows, the parameter estimates for the 3rd-grade score, the type of school and the gender of the students, are little changed but are still statistically significant. Also, the dummy variables indicating the three different scientific orientations are highly significant because the estimate of the standard error of the parameter is less than a third of the parameter estimate. The scientific orientations differences indicate that the students in the fourth subject category do better than those in the first, but worse comparing with the students in the second and the third scientific orientation. As far as the random parameters are concerned, we observe that the level-1 variance is decreased, while the rest random parameters are little altered. However, the difference of the deviances

of this model and the previous one is 10849.9 and, if referred to the tables of the chi-squared distribution with three degrees of freedom, is found highly significant. The assumptions of normality and of constant variance for the level-1, level-2 and the level-3 residuals can be examined by the corresponding plots in figures 4.4.25-4.4.30 and it is conspicuous, with a observant view, that the assumptions are fulfilled.

Figure 4.4.25

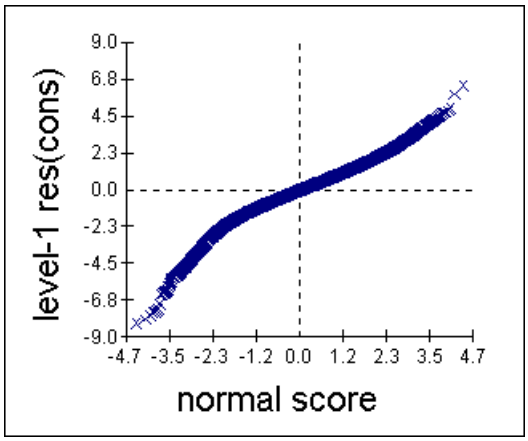


Figure 4.4.26

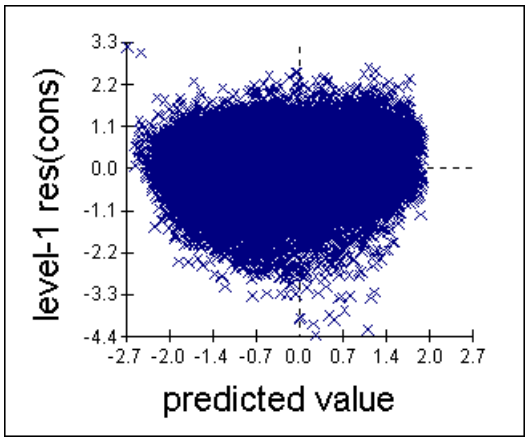
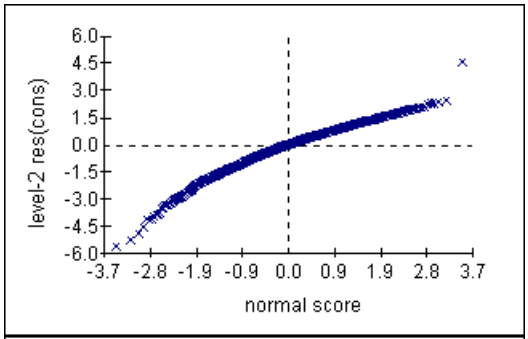


Figure 4.4.27



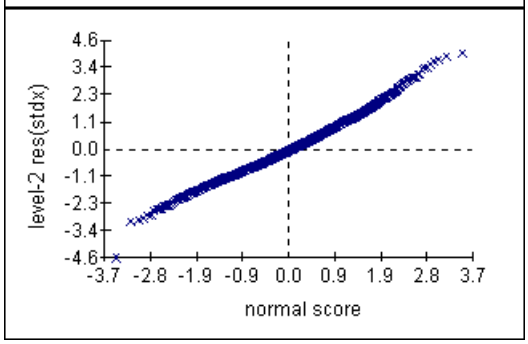
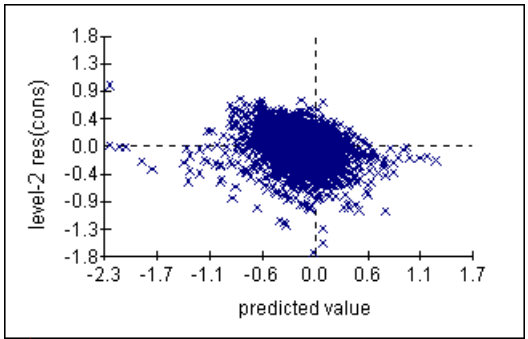


Figure 4.4.28



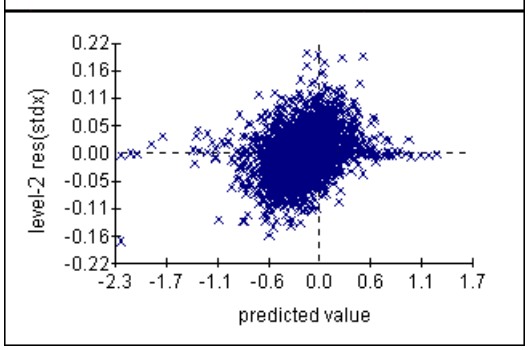
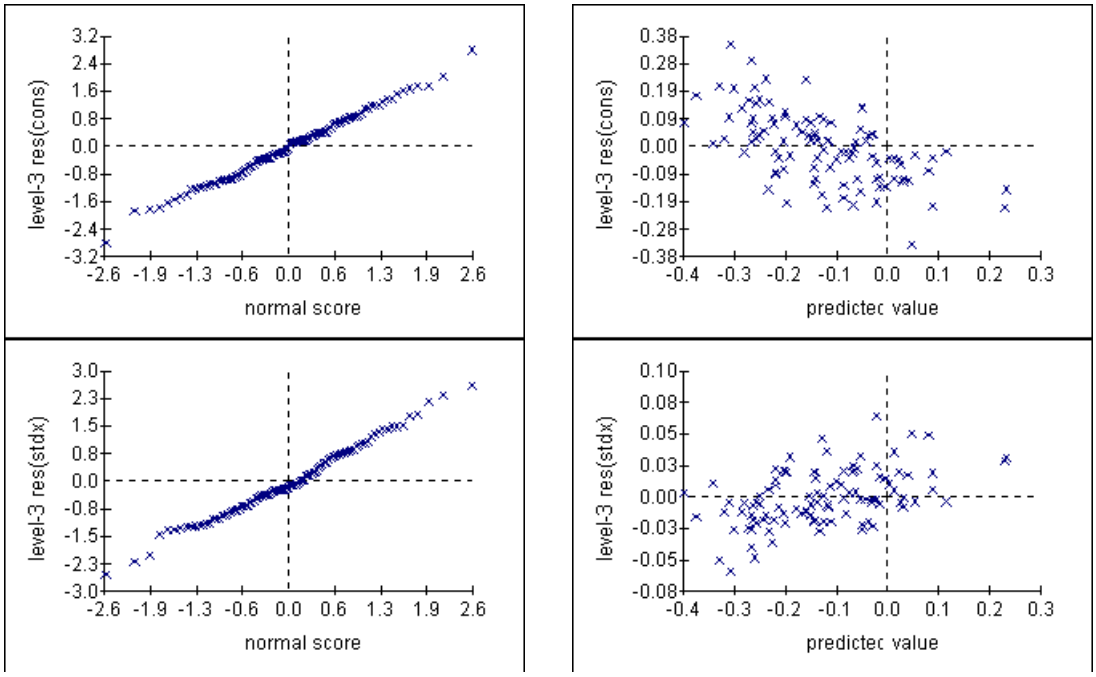


Figure 4.4.29

Figure 4.4.30



Another variable that can be included in the model is the year in which the students took the National Entrance Exams. This is also a dummy variable coded 1 for the students taking the Entrance Exams in 1990 and 0 for those taking the Entrance Exams in 1991. The parameter estimates for the sixth model are displayed in the second column of table 4.4.3. From this table we notice that the fixed parameters have not changed, while taking into consideration the estimation of the year of the Exams factor we conclude that the students that took the Exams in 1990 did better than those who took the Exams in 1991. Also, this difference is highly significant because the estimate of the standard error of the parameter is less than a third of the parameter estimate. As far as the random parameters are concerned, these are little changed, while the level-2 and the level-3 variance are still quadratic functions of the 3rd-grade score. In order to check the assumptions of normality and constant variance for the level-1, level-2 and level-3 residuals we explore the plots displayed in figures 4.4.31-4.4.36. A cautious checking of these plots shows that these assumptions are met.

Figure 4.4.31 **Figure 4.4.32**

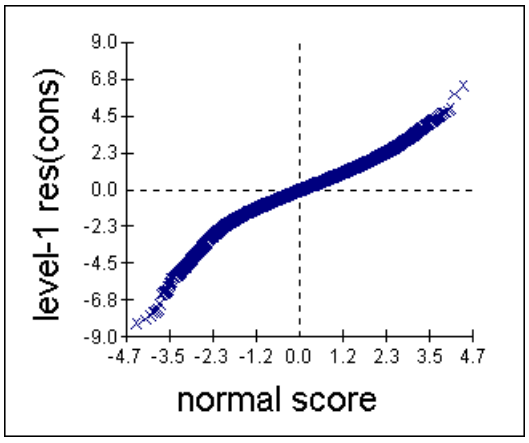


Figure 4.4.33

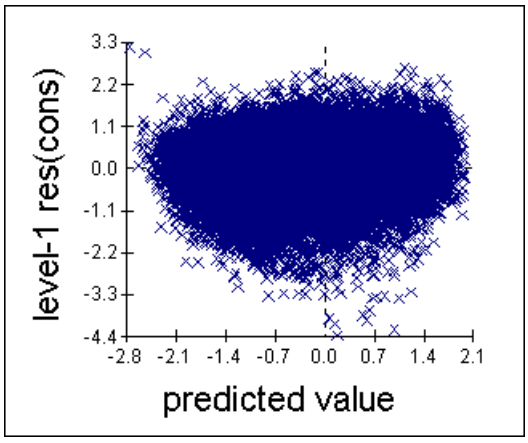


Figure 4.4.34

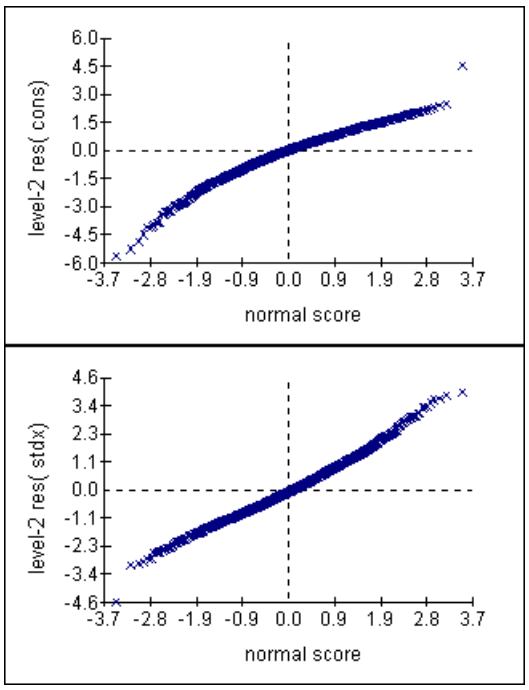


Figure 4.4.35

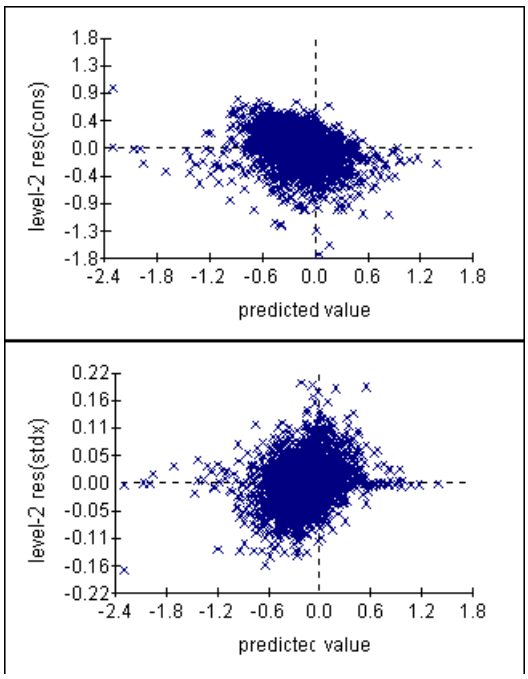
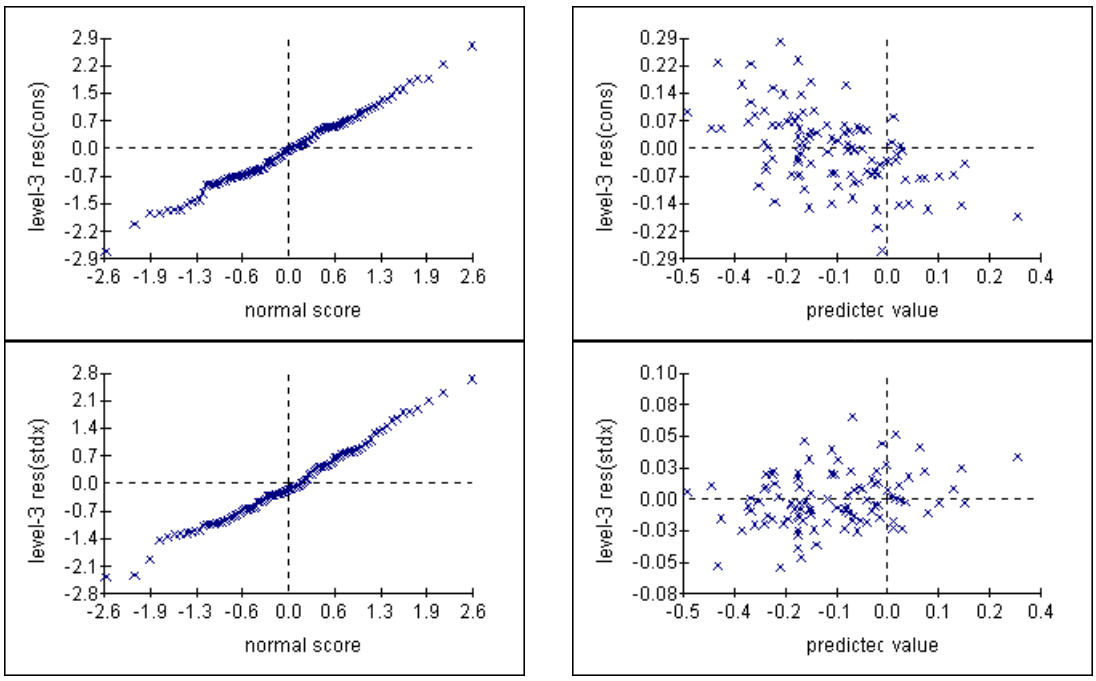


Figure 4.4.36



It is stimulating at this point, and before proceeding to the expansion of the previous model, to present a model which makes no adjustment for the 3rd-grade score. There is a strong belief that institutional comparisons based on unadjusted examination results are insufficient and most of the time produce equivocal estimates for the effectiveness of institutions. Thus, in the seventh model, presented in the first column of table 4.4.4, the 3rd-grade score has been removed. As we can observe from the table the estimates of the parameters are completely altered. Now, the type of school difference is not statistically significant, while the gender difference is in favor of the girls. If we compare the performance of student in National Entrance Exams in relation to their subject category, we conclude that the students in the first category do better than those in the fourth category, while the students in the second and especially in the third category do much more better than the students in the fourth category. Besides, the level-2 variance turns out to be clearly decreased, but the level-1 variance is highly increased, indicating that a great deal of the level-1 variance is explained by the 3rd-grade score. Furthermore, the difference of the deviances of the models equals 23433.23 and this fact gives evidence

first of significance of the 3rd-grade score and second that misleading results can be produced if there is no adjustment for the background of the students.

Table 4.4.4 Parameter estimates for model 7

Parameter	**Estimate (s.e.)**
	Model 7
Fixed:	
Constant	-0.724
3rd-grade score	
Type of school	0.159 (0.050)
Gender of student	0.079 (0.006)
Scientific Orientation 1	0.252 (0.007)
Scientific Orientation 2	0.718 (0.010)
Scientific Orientation 3	0.966 (0.007)
Year of the Exams	0.136 (0.023)
Random:	
σ^2_{v0} (between prefectures)	0.005 (0.002)
σ^2_{u0} (between schools)	0.068 (0.003)
σ^2_{e0} (between students)	0.765 (0.003)
-2*log(likelihood)	276294.300

In the sequel, we amplify the model 6 and we model the level-1 variance as a function of gender. The parameter estimates produced by this model can be seen in the first column of table 4.4.5. The fixed parameters have been altered, but all of them preserve their significance.

Table 4.4.5 Parameter estimates for model 8 and model 9

Parameter	**Estimate (s.e.)**	**Estimate (s.e.)**

	Model 8	Model 9
Fixed:		
Constant	-0.779	-0.768
3rd-grade score	0.784 (0.005)	0.784 (0.005)
Type of school	0.554 (0.053)	0.543 (0.053)
Gender of student	-0.214 (0.004)	-0.214 (0.004)
Scientific Orientation 1	-0.036 (0.005)	-0.036 (0.005)
Scientific Orientation 2	0.057 (0.006)	0.057 (0.006)
Scientific Orientation 3	0.447 (0.004)	0.446 (0.004)
Year of the Exams	0.124 (0.031)	0.124 (0.031)
Random:		
σ^2_{v0} (between prefectures)	0.017 (0.004)	0.017 (0.004)
σ_{v10}	-0.002 (0.001)	-0.002 (0.001)
σ^2_{v1}	0.001 (0.000)	0.001 (0.000)
σ^2_{u0} (between schools)	0.111 (0.004)	0.123 (0.006)
σ_{u10}	-0.007 (0.001)	-0.008 (0.001)
σ^2_{u1}	0.006 (0.000)	0.006 (0.000)
σ_{u70}		-0.012 (0.004)
σ_{u71}		0.003 (0.002)
σ^2_{u7}		0
σ^2_{e0} (between students)	0.321 (0.002)	0.321 (0.002)
σ_{e30}	-0.031 (0.001)	-0.031 (0.001)
σ^2_{e3}	0	0
-2*log(likelihood)	174388.000	174379.100

On the other hand, the estimates of the terms of the level-2 and the level-3 variance remain immutable and, as was mentioned before, are quadratic functions of the 3rd-grade score having the following form

Total level-3 variance

$$\text{var}(v_{0k}x_0 + v_{1k}x_{1ijk}) = \sigma^2_{v0}x^2_0 + 2\sigma_{v01}x_0x_{1ijk} + \sigma^2_{v1}x^2_{1ijk}$$

Total level-2 variance

$$\text{var}(u_{0jk}x_0 + u_{1jk}x_{1ijk}) = \sigma^2_{u0}x^2_0 + 2\sigma_{u01}x_0x_{1ijk} + \sigma^2_{u1}x^2_{1ijk}$$

where, we remind that x_{1ijk} is the 3rd-grade score and x_0 is the constant term. Moreover, in this model the level-1 variance is also a quadratic function of an explanatory variable; the gender of the student. Thus, the level-1 variance is given by

Total level-1 variance

$$\text{var}(e_{0ijk}x_0 + e_{3ijk}x_{3ijk}) = \sigma^2_{e0}x^2_0 + 2\sigma_{e03}x_0x_{3ijk}$$

because we have constrained the variance of the gender coefficient to be zero. Consequently, for girls (x_{3ijk}=1) the level-1 variance is $\sigma^2_{e0} + 2\sigma_{e03}$ and for boys (x_{3ijk}=0) the level-1 variance is σ^2_{e0}. Furthermore, the difference of the deviances of this model and the model 6 is 560.4 and, if referred to the tables of the chi-squared distribution with one degree of freedom is found to be highly significant. Finally, the assumptions of normality and constant variance are checked for the level-1, the level-2 and the level-3 residuals and with a careful inspection of the plots presented in figures 4.4.37-4.4.42 we conclude that these assumptions are met.

Figure 4.4.37 **Figure 4.4.38**

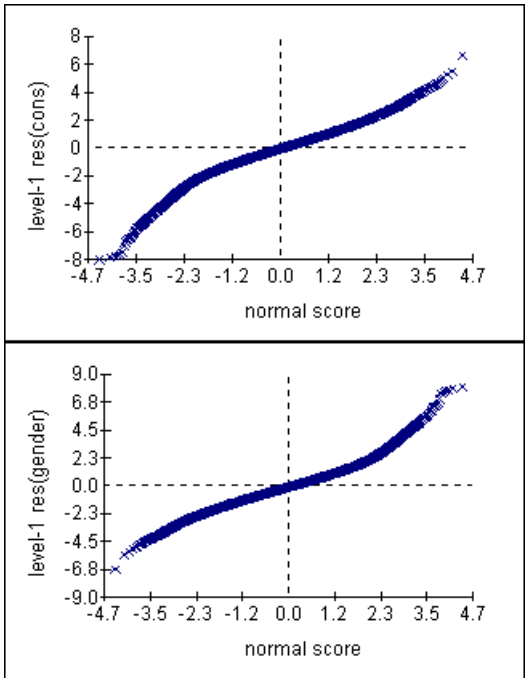


Figure 4.4.39

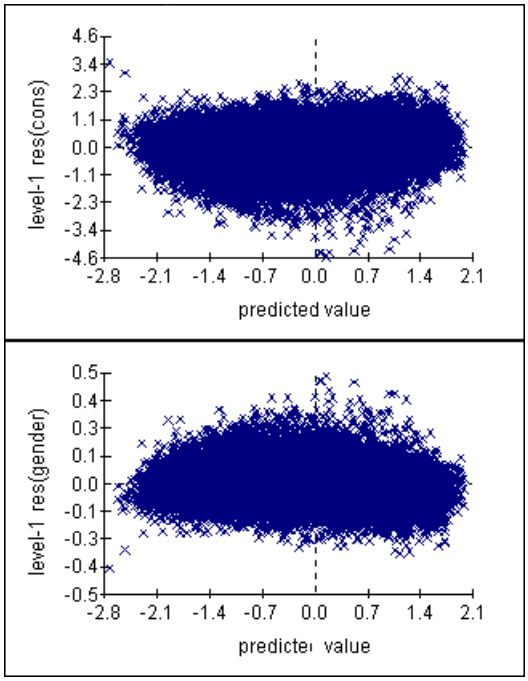


Figure 4.4.40

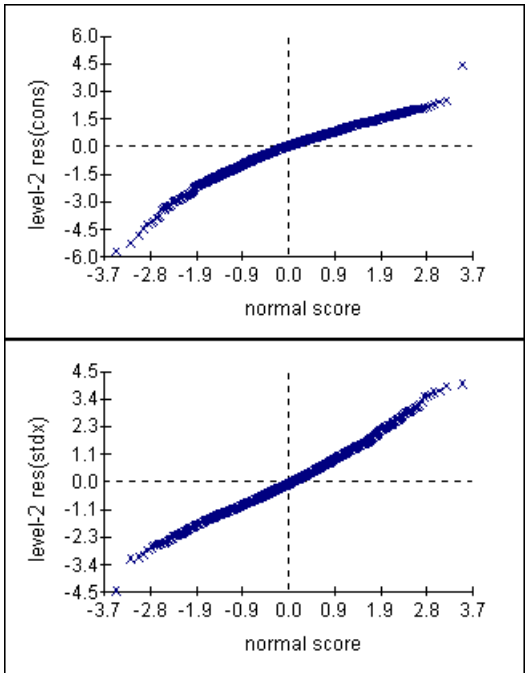


Figure 4.4.41

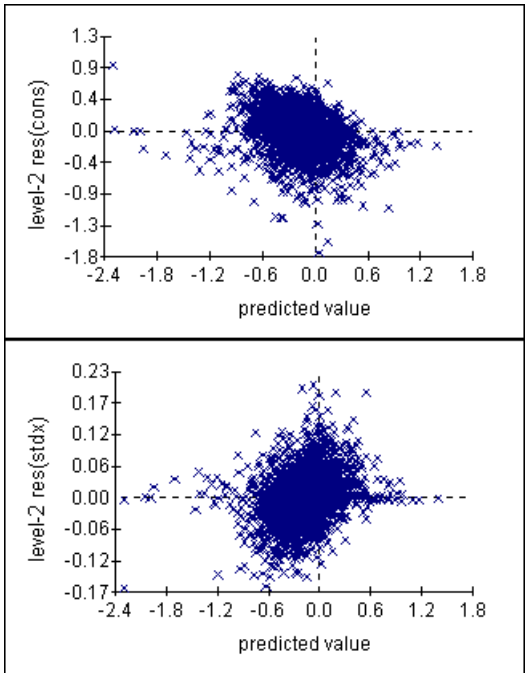
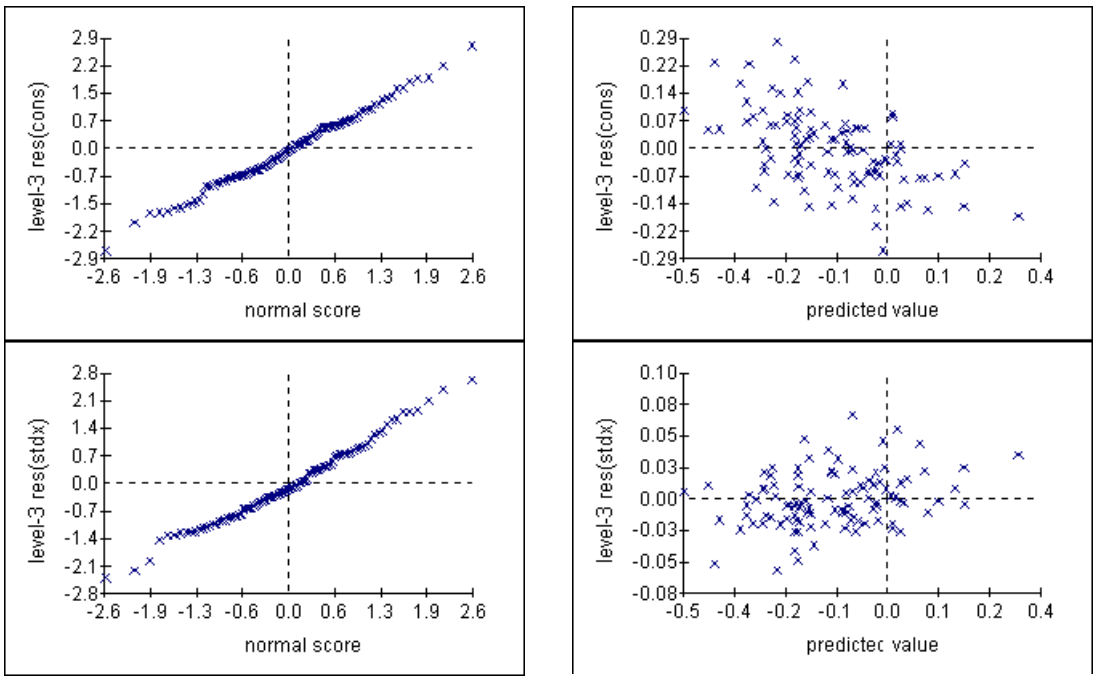


Figure 4.4.42



Next, we add another explanatory variable to the level-2 variance, except the 3rd-grade score, and this is the year of the Exams coefficient. In this case, the parameter estimates produced by this model are given in the second column in table 4.4.5. From the fixed parameters we observe that none of them has significantly changed. As far as the random parameters are concerned it is important to point out the form of the level-2 variance, which is

Total level-2 variance

$$\mathrm{var}(u_{0jk}x_0 + u_{1jk}x_{1ijk} + u_{7jk}x_{7k}) = \sigma^2_{u0}x_0^2 + 2\sigma_{u01}x_0x_{1ijk} + \sigma^2_{u1}x^2_{1ijk} + 2\sigma_{u07}x_0x_{7k} + 2\sigma_{u17}x_{1ijk}x_{7k}$$

where x_0 is the constant term, x_{1ijk} is the 3rd-grade score and x_{7k} is the year of the Exams coefficient. Besides, the level-1 and the level-3 variance is as presented in the previous model. In order to check how significant is the inclusion of the year of Exams coefficient in the level-2 variance we compare the current model with the previous one. The difference of the deviances of these models is 8.9 and, when referred to the tables of the chi-squared distribution with two degrees of freedom is found to be significant. With regard

to the assumptions of normality and of constant variance for the level-1, the level-2 and the level-3 residuals we conclude, by checking the corresponding plots in figures 4.4.43-4.4.48, that these assumptions are fulfilled.

Figure 4.4.43

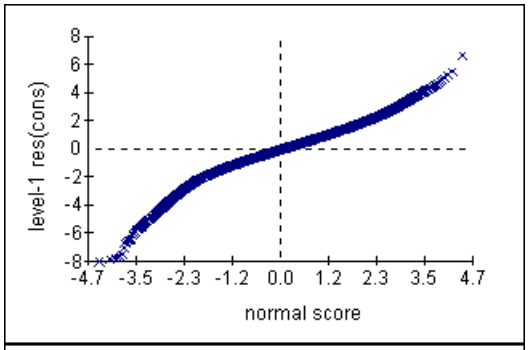


Figure 4.4.44

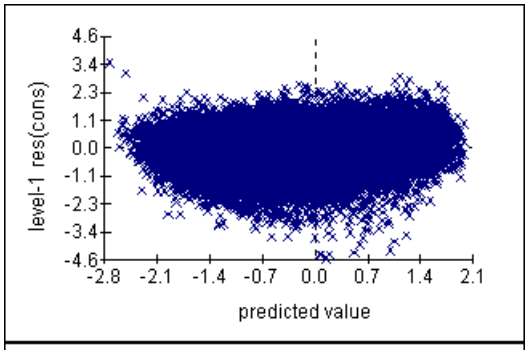


Figure 4.4.45

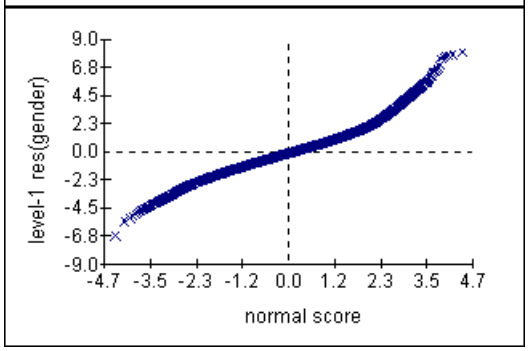
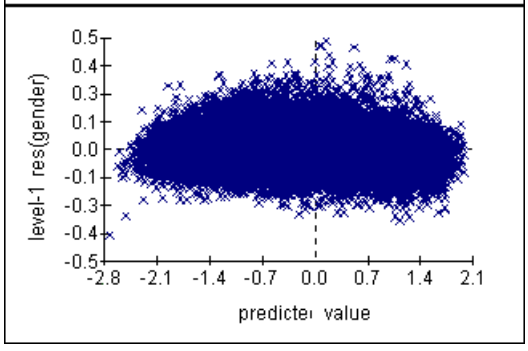


Figure 4.4.46



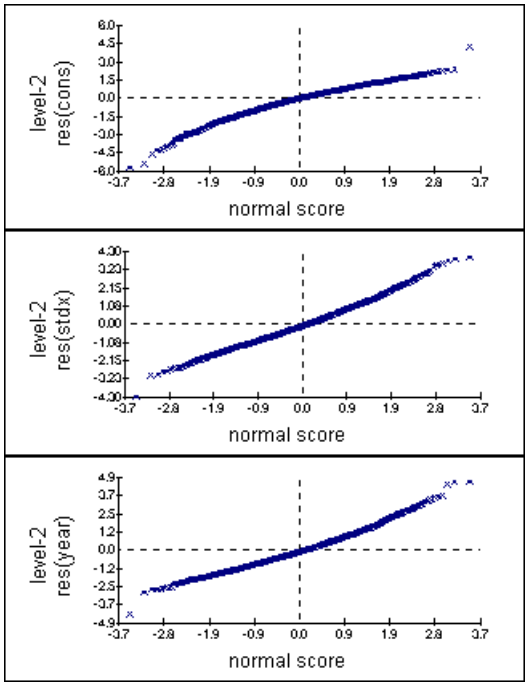


Figure 4.4.47

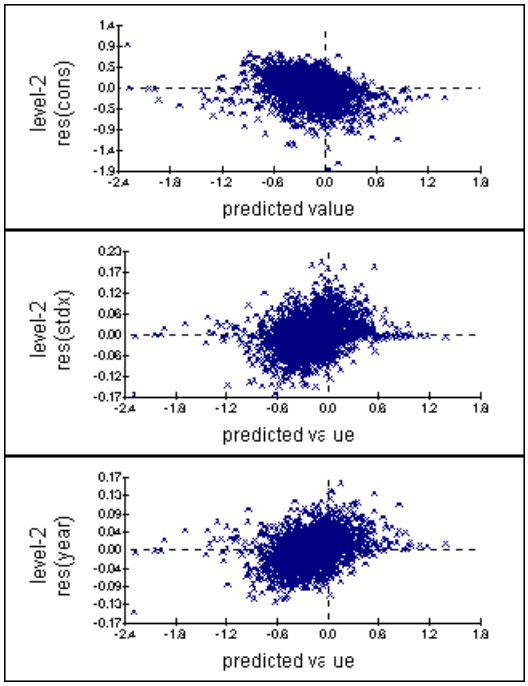
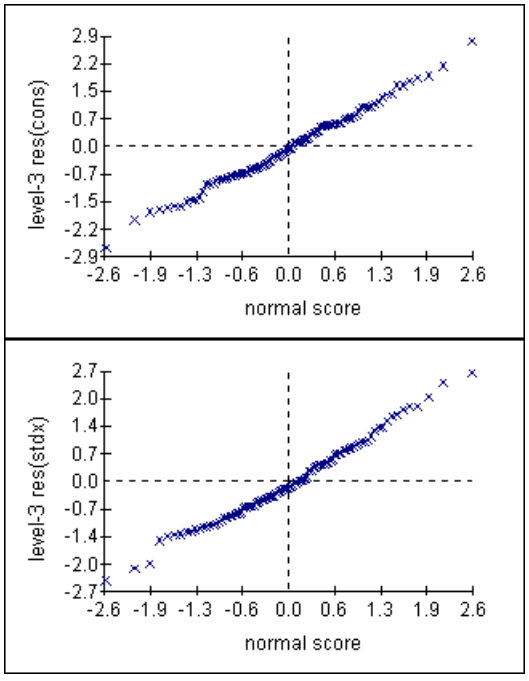
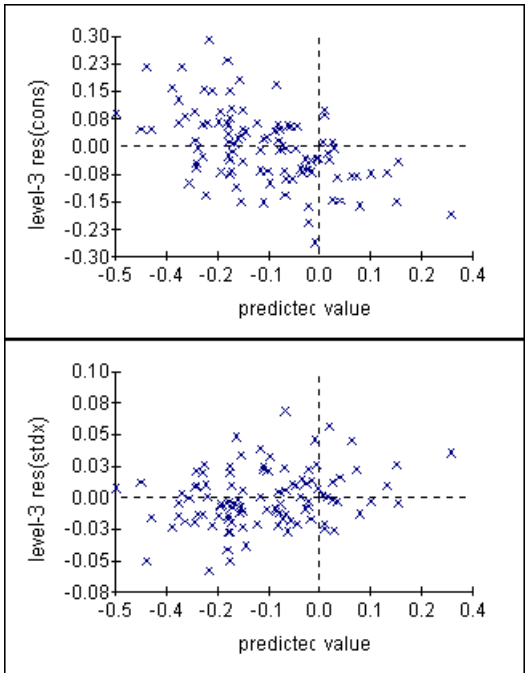


Figure 4.4.48





4.5 Results

The level-2 and level-3 residuals have been estimated for each school and each prefecture, respectively. The primary aim in studies of school effectiveness is to try to identify schools, or prefectures, with residuals which are substantially different. In order to do so, first, we order the residuals from smallest to largest and then we construct an interval about each residual so that the criterion for judging statistical significance at the (1-α)% level for any pair of residuals is whether their confidence intervals overlap. In the two figures presented below the confidence intervals for the level-2 residuals (in figure 4.4.49) and for the level-3 residuals (in figure 4.4.50) are presented. Two schools or two prefectures, respectively, are judged to have significantly different residuals, at the 5% level, if and only if their error bars do not overlap.

Figure 4.4.49

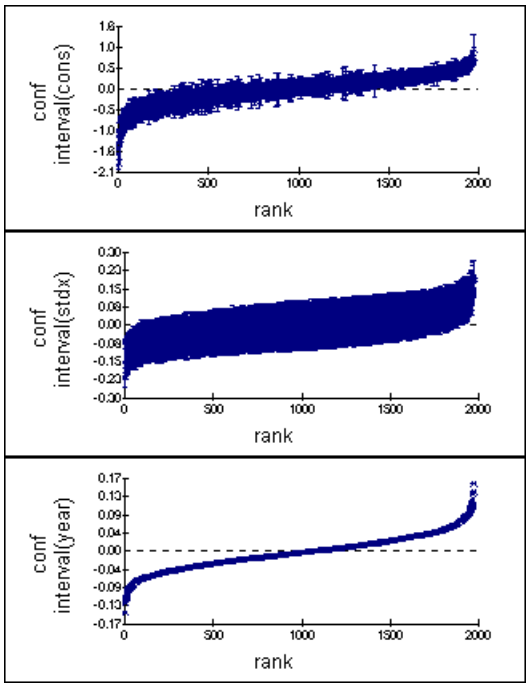
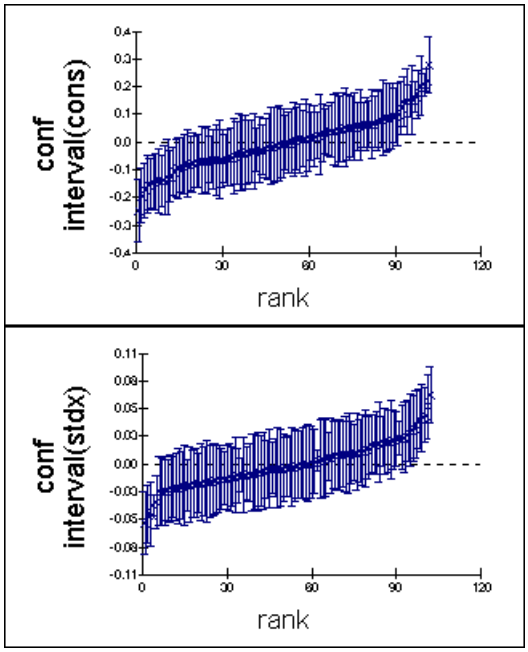


Figure 4.4.50



As we observe from the figures above there is substantial difference between some schools and between some prefectures also. As far as the prefectures are concerned, the one with the highest mean score, for both years, is the prefecture of Corinthia of the 1990 Greek National Entrance Exam. The second best prefecture is Attica again of the 1990 Exam. On the other hand,

prefecture 47 of the 1991 Exam has the lowest mean score for both years. The ranking of the prefectures according to the performance of the students in the Greek National Entrance Exam is presented in tables 4.4.6a and 4.4.6b. We stress again that: (a) two prefectures are judged to have significantly different residuals, at the 5% level, if and only if their error bars do not overlap and (b) the comparisons can be made only between two prefectures each time.

Table 4.4.6a Ranking of prefectures

	Prefectures	**Year of Exam**		**Prefectures**	**Year of Exam**
1	7	‘90	27	4	‘91

2	1	‘90	28	41	‘90
3	1	‘91	29	49	‘90
4	7	‘91	30	9	‘90
5	26	‘90	31	10	‘90
6	39	‘90	32	40	‘91
7	14	‘91	33	34	‘90
8	39	‘91	34	10	‘91
9	14	‘90	35	24	‘91
10	11	‘90	36	23	‘90
11	24	‘90	37	16	‘90
12	20	‘90	38	15	‘90
13	33	‘90	39	35	‘91
14	4	‘90	40	48	‘90
15	20	‘91	41	13	‘91
16	25	‘90	42	28	‘91
17	21	‘91	43	38	‘91
18	13	‘90	44	35	‘90
19	33	‘91	45	37	‘90
20	26	‘91	46	46	‘90
21	49	‘91	47	38	‘90
22	8	‘91	48	17	‘90
23	23	‘91	49	22	‘90
24	8	‘90	50	15	‘91
25	21	‘90	51	44	‘90
26	16	‘91			

Table 4.4.6b Ranking of prefectures

	Prefectures	**Year of Exam**		**Prefectures**	**Year of Exam**
52	36	‘91	78	43	‘91

53	32	‘90	79	43	‘90
54	25	‘91	80	50	‘90
55	45	‘91	81	6	‘90
56	34	‘91	82	11	‘91
57	40	‘90	83	31	‘90
58	19	‘90	84	3	‘91
59	12	‘91	85	3	‘90
60	36	‘90	86	44	‘91
61	28	‘90	87	6	‘91
62	46	‘91	88	51	‘91
63	31	‘91	89	30	‘91
64	41	‘91	90	48	‘91
65	27	‘90	91	42	‘91
66	45	‘90	92	27	‘91
67	32	‘91	93	29	‘90
68	19	‘91	94	30	‘90
69	17	‘91	95	22	‘91
70	5	‘91	96	2	‘91
71	29	‘91	97	18	‘91
72	42	‘90	98	18	‘90
73	51	‘90	99	47	‘90
74	9	‘91	100	2	‘90
75	50	‘91	101	5	‘90
76	37	‘91	102	47	‘91
77	12	‘90			