APPENDIX

PART 1

Model 1

$$y_{ijk} \sim \mathrm{N}(XB, \Omega)$$

$$y_{ijk} = \beta_{0ijk} x_{0} + \beta_{1} x_{1ijk}$$

$$\beta_{0ijk} = \beta_{0} + v_{0k} + u_{0jk} + e_{0ijk}$$

$$\begin{bmatrix} v_{0k} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_v) \ :\ \Omega_v = \begin{bmatrix} \sigma^2_{v0} \end{bmatrix}$$

$$\begin{bmatrix} u_{0jk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_u) \ :\ \Omega_u = \begin{bmatrix} \sigma^2_{u0} \end{bmatrix}$$

$$\begin{bmatrix} e_{0ijk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_e) \ :\ \Omega_e = \begin{bmatrix} \sigma^2_{e0} \end{bmatrix}$$

$$-2*log(like) = 187634.400$$

Model 2

$$y_{ijk} \sim \mathrm{N}(XB, \Omega)$$

$$y_{ijk} = \beta_{0ijk} x_{0} + \beta_{1jk} x_{1ijk}$$

$$\beta_{0ijk} = \beta_{0} + v_{0k} + u_{0jk} + e_{0ijk}$$

$$\beta_{1jk} = \beta_{1} + v_{1k} + u_{1jk}$$

$$\begin{bmatrix} v_{0k} \\ v_{1k} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_v) \ :\ \Omega_v = \begin{bmatrix} \sigma^2_{v0} & \\ \sigma_{v10} & \sigma^2_{v1} \end{bmatrix}$$

$$\begin{bmatrix} u_{0jk} \\ u_{1jk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_u) \ :\ \Omega_u = \begin{bmatrix} \sigma^2_{u0} & \\ \sigma_{u10} & \sigma^2_{u1} \end{bmatrix}$$

$$\begin{bmatrix} e_{0ijk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_e) \ :\ \Omega_e = \begin{bmatrix} \sigma^2_{e0} \end{bmatrix}$$

$$-2*log(like) = 186879.600$$

Model 3

$$y_{ijk} \sim \mathrm{N}(XB, \Omega)$$

$$y_{ijk} = \beta_{0ijk} x_{0} + \beta_{1jk} x_{1ijk} + \beta_{2} x_{2jk}$$

$$\beta_{0ijk} = \beta_{0} + v_{0k} + u_{0jk} + e_{0ijk}$$

$$\beta_{1jk} = \beta_{1} + v_{1k} + u_{1jk}$$

$$\begin{bmatrix} v_{0k} \\ v_{1k} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{v}) \ :\ \Omega_{v} = \begin{bmatrix} \sigma^{2}_{v0} & \\ \sigma_{v10} & \sigma^{2}_{v1} \end{bmatrix}$$

$$\begin{bmatrix} u_{0jk} \\ u_{1jk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{u}) \ :\ \Omega_{u} = \begin{bmatrix} \sigma^{2}_{u0} & \\ \sigma_{u10} & \sigma^{2}_{u1} \end{bmatrix}$$

$$\begin{bmatrix} e_{0ijk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{e}) \ :\ \Omega_{e} = \begin{bmatrix} \sigma^{2}_{e0} \end{bmatrix}$$

$$-2*log(like) = 186771.400$$

Model 4

$$y_{ijk} \sim \mathrm{N}(XB, \Omega)$$

$$y_{ijk} = \beta_{0ijk} x_{0} + \beta_{1jk} x_{1ijk} + \beta_{2} x_{2jk} + \beta_{3} x_{3ijk}$$

$$\beta_{0ijk} = \beta_{0} + v_{0k} + u_{0jk} + e_{0ijk}$$

$$\beta_{1jk} = \beta_{1} + v_{1k} + u_{1jk}$$

$$\begin{bmatrix} v_{0k} \\ v_{1k} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{v}) \ :\ \Omega_{v} = \begin{bmatrix} \sigma^{2}_{v0} & \\ \sigma_{v10} & \sigma^{2}_{v1} \end{bmatrix}$$

$$\begin{bmatrix} u_{0jk} \\ u_{1jk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{u}) \ :\ \Omega_{u} = \begin{bmatrix} \sigma^{2}_{u0} & \\ \sigma_{u10} & \sigma^{2}_{u1} \end{bmatrix}$$

$$\begin{bmatrix} e_{0ijk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{e}) \ :\ \Omega_{e} = \begin{bmatrix} \sigma^{2}_{e0} \end{bmatrix}$$

$$-2*log(like) = 185813.400$$

Model 5

$$y_{ijk} \sim \mathrm{N}(XB, \Omega)$$

$$y_{ijk} = \beta_{0ijk}x_{0} + \beta_{1jk}x_{1ijk} + \beta_{2}x_{2jk} + \beta_{3}x_{3ijk} + \beta_{4}x_{4ijk} + \beta_{5}x_{5ijk} + \beta_{6}x_{6ijk}$$

$$\beta_{0ijk} = \beta_{0} + v_{0k} + u_{0jk} + e_{0ijk}$$

$$\beta_{1jk} = \beta_{1} + v_{1k} + u_{1jk}$$

$$\begin{bmatrix} v_{0k} \\ v_{1k} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{v}) \ :\ \Omega_{v} = \begin{bmatrix} \sigma^{2}_{v\,0} & \\ \sigma_{v\,1\,0} & \sigma^{2}_{v\,1} \end{bmatrix}$$

$$\begin{bmatrix} u_{0jk} \\ u_{1jk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{u}) \ :\ \Omega_{u} = \begin{bmatrix} \sigma^{2}_{u\,0} & \\ \sigma_{u\,1\,0} & \sigma^{2}_{u\,1} \end{bmatrix}$$

$$\begin{bmatrix} e_{0ijk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{e}) \ :\ \Omega_{e} = \begin{bmatrix} \sigma^{2}_{e\,0} \end{bmatrix}$$

$$-2*log(like) = 174963.500$$

Model 6

$$y_{ijk} \sim \mathrm{N}(XB, \Omega)$$

$$y_{ijk} = \beta_{0ijk}x_{0} + \beta_{1jk}x_{1ijk} + \beta_{2}x_{2jk} + \beta_{3}x_{3ijk} + \beta_{4}x_{4ijk} + \beta_{5}x_{5ijk} + \beta_{6}x_{6ijk} + \beta_{7}x_{7k}$$

$$\beta_{0ijk} = \beta_{0} + v_{0k} + u_{0jk} + e_{0ijk}$$

$$\beta_{1jk} = \beta_{1} + v_{1k} + u_{1jk}$$

$$\begin{bmatrix} v_{0k} \\ v_{1k} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{v}) \ :\ \Omega_{v} = \begin{bmatrix} \sigma^{2}_{v0} & \\ \sigma_{v10} & \sigma^{2}_{v1} \end{bmatrix}$$

$$\begin{bmatrix} u_{0jk} \\ u_{1jk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{u}) \ :\ \Omega_{u} = \begin{bmatrix} \sigma^{2}_{u0} & \\ \sigma_{u10} & \sigma^{2}_{u1} \end{bmatrix}$$

$$\begin{bmatrix} e_{0ijk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{e}) \ :\ \Omega_{e} = \begin{bmatrix} \sigma^{2}_{e0} \end{bmatrix}$$

$$-2*log(like) = 174948.400$$

Model 7

$$y_{ijk} \sim \mathrm{N}(XB, \Omega)$$

$$y_{ijk} = \beta_{0ijk}x_{0} + \beta_{1}x_{1jk} + \beta_{2}x_{2ijk} + \beta_{3}x_{3ijk} + \beta_{4}x_{4ijk} + \beta_{5}x_{5ijk} + \beta_{6}x_{6k}$$

$$\beta_{0ijk} = \beta_{0} + v_{0k} + u_{0jk} + e_{0ijk}$$

$$\begin{bmatrix} v_{0k} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{v}) \ :\ \Omega_{v} = \begin{bmatrix} \sigma^{2}_{v0} \end{bmatrix}$$

$$\begin{bmatrix} u_{0jk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{u}) \ :\ \Omega_{u} = \begin{bmatrix} \sigma^{2}_{u0} \end{bmatrix}$$

$$\begin{bmatrix} e_{0ijk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{e}) \ :\ \Omega_{e} = \begin{bmatrix} \sigma^{2}_{e0} \end{bmatrix}$$

$$-2*log(like) = 276294.300$$

Model 8

$$y_{ijk} \sim \mathrm{N}(XB, \Omega)$$

$$y_{ijk} = \beta_{0ijk}x_{0} + \beta_{1jk}x_{1ijk} + \beta_{2}x_{2jk} + \beta_{3i}x_{3ijk} + \beta_{4}x_{4ijk} + \beta_{5}x_{5ijk} + \beta_{6}x_{6ijk} + \beta_{7}x_{7k}$$

$$\beta_{0ijk} = \beta_{0} + v_{0k} + u_{0jk} + e_{0ijk}$$

$$\beta_{1jk} = \beta_{1} + v_{1k} + u_{1jk}$$

$$\beta_{3i} = \beta_{3} + e_{3ijk}$$

$$\begin{bmatrix} v_{0k} \\ v_{1k} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{v}) \ :\ \Omega_{v} = \begin{bmatrix} \sigma^{2}_{v\,0} & \\ \sigma_{v\,1\,0} & \sigma^{2}_{v\,1} \end{bmatrix}$$

$$\begin{bmatrix} u_{0jk} \\ u_{1jk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{u}) \ :\ \Omega_{u} = \begin{bmatrix} \sigma^{2}_{u\,0} & \\ \sigma_{u\,1\,0} & \sigma^{2}_{u\,1} \end{bmatrix}$$

$$\begin{bmatrix} e_{0ijk} \\ e_{3ijk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{e}) \ :\ \Omega_{e} = \begin{bmatrix} \sigma^{2}_{e\,0} & \\ \sigma_{e\,3\,0} & \sigma^{2}_{e\,3} \end{bmatrix}$$

$$-2*log(like) = 174388.000$$

Model 9

$$y_{ijk} \sim \mathrm{N}(XB, \Omega)$$

$$y_{ijk} = \beta_{0ijk}x_{0} + \beta_{1jk}x_{1ijk} + \beta_{2}x_{2jk} + \beta_{3i}x_{3ijk} + \beta_{4}x_{4ijk} + \beta_{5}x_{5ijk} + \beta_{6}x_{6ijk} + \beta_{7j}x_{7k}$$

$$\beta_{0ijk} = \beta_{0} + v_{0k} + u_{0jk} + e_{0ijk}$$

$$\beta_{1jk} = \beta_{1} + v_{1k} + u_{1jk}$$

$$\begin{bmatrix} v_{0k} \\ v_{1k} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{v}) \ :\ \Omega_{v} = \begin{bmatrix} \sigma^{2}_{v\,0} & \\ \sigma_{v\,1\,0} & \sigma^{2}_{v\,1} \end{bmatrix}$$

$$\begin{bmatrix} u_{0jk} \\ u_{1jk} \\ u_{7jk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{u}) \ :\ \Omega_{u} = \begin{bmatrix} \sigma^{2}_{u\,0} & & \\ \sigma_{u\,1\,0} & \sigma^{2}_{u\,1} & \\ \sigma_{u\,7\,0} & \sigma_{u\,7\,1} & 0 \end{bmatrix}$$

$$\begin{bmatrix} e_{0ijk} \\ e_{3ijk} \end{bmatrix} \sim \mathrm{N}(0,\ \Omega_{e}) \ :\ \Omega_{e} = \begin{bmatrix} \sigma^{2}_{e\,0} & \\ \sigma_{e\,3\,0} & 0 \end{bmatrix}$$

$$-2*log(like) = 174379.100$$

PART 2

Table 1 Number of schools in each of the 51 Greek prefectures (Exams '90)

Prefectures	No of schools	Prefectures	No of schools
1	280	27	5
2	17	28	28
3	7	29	17
4	7	30	15
5	16	31	10
6	20	32	4
7	13	33	14
8	27	34	4
9	3	35	3
10	6	36	7
11	21	37	13
12	25	38	8
13	12	39	84
14	7	40	8
15	12	41	10
16	24	42	21
17	5	43	8
18	18	44	13
19	11	45	4
20	8	46	6
21	5	47	11
22	9	48	25
23	20	49	7
24	16	50	7
25	6	51	12
26	22		

Table 2 Number of students that took the 1990 National Entrance Exams in each prefecture of the 51 Greek prefectures

Prefectures	No of students	Prefectures	No of students
1	19,614	27	68
2	467	28	1,863
3	138	29	816
4	247	30	667
5	265	31	806
6	617	32	185
7	723	33	824
8	1,330	34	353
9	144	35	244
10	154	36	405
11	761	37	573
12	697	38	490
13	475	39	5,748
14	562	40	270
15	367	41	322
16	1,033	42	1,078
17	134	43	346
18	840	44	652
19	447	45	303
20	421	46	312
21	199	47	451
22	390	48	1,332
23	958	49	368
24	696	50	202
25	183	51	447
26	1,054		

Table 3a Descriptive statistics for the National Entrance Exams score for each prefecture (Exams ’90)

Prefectures	Mean	Std Dev	Minimum	Maximum	No of cases
1	10.21	4.73	0	19.66	19,614
2	10.51	4.71	0.75	19.38	467
3	9.29	4.56	1.47	18.06	138
4	11.58	4.21	2.13	19.41	247
5	9.06	4.42	1.38	18.94	265
6	10.27	4.90	0.06	18.81	617
7	11.33	4.57	0.06	19.47	723
8	10.30	4.92	0.06	19.47	1,330
9	10.63	4.62	2.69	18.44	144
10	10.05	4.61	0.53	18.66	154
11	10.38	4.70	0.88	19.50	761
12	9.11	4.98	0.06	19.25	697
13	11.19	4.73	0.63	19.19	475
14	10.24	4.85	0.06	19.41	562
15	9.52	4.69	0.28	18.94	367
16	9.76	4.70	0.28	19.09	1,033
17	9.42	4.57	1.38	19.16	134
18	10.82	5.07	0.06	19.34	840
19	9.95	5.03	0.13	19.25	447
20	10.06	4.86	0.06	19.63	421
21	9.91	4.79	0.06	19.03	199
22	9.50	4.46	1.06	19.09	390
23	9.81	4.77	0.09	19.25	958
24	10.07	4.85	0.06	18.97	696
25	10.23	4.51	0.03	19.53	183

Table 3b Descriptive statistics for the National Entrance Exams score for each prefecture (Exams '90)

Prefectures	Mean	Std Dev	Minimum	Maximum	No of cases
26	10.48	4.87	0.06	19.59	1,054
27	10.07	4.26	2.38	18.00	68
28	10.22	4.91	0.06	19.53	1,863
29	10.48	4.88	0.22	19.28	816
30	10.21	5.31	0.09	19.72	667
31	9.88	5.23	0.06	19.50	806
32	9.61	4.68	1.28	19.63	185
33	9.94	4.52	0.72	18.81	824
34	9.82	4.83	0.13	18.66	353
35	9.55	5.06	1.25	19.13	244
36	10.06	5.16	0.06	19.09	405
37	10.45	4.76	0	19.19	573
38	9.31	4.70	0.13	18.94	490
39	10.53	4.76	0.06	19.59	5,748
40	10.19	4.63	1.44	49.28	270
41	10.16	4.68	0.56	19.00	322
42	9.80	4.95	0.06	19.47	1,078
43	9.90	4.92	0.13	19.22	346
44	9.78	4.75	0.28	19.19	652
45	10.27	4.81	0.06	19.44	303
46	10.64	4.95	0.06	19.13	312
47	8.62	4.69	0.13	19.22	451
48	9.75	4.88	0.13	19.56	1,332
49	9.65	4.79	0.22	19.22	368
50	9.68	4.95	1.00	18.63	202
51	9.34	5.04	0.22	18.94	447

Table 4 Number of schools in each of the 51 Greek prefectures (Exams '91)

Prefectures	No of schools	Prefectures	No of schools
1	288	27	6
2	17	28	28
3	8	29	16
4	9	30	15
5	15	31	10
6	17	32	4
7	13	33	14
8	29	34	4
9	4	35	3
10	7	36	7
11	21	37	13
12	25	38	8
13	11	39	87
14	7	40	8
15	12	41	10
16	24	42	22
17	5	43	9
18	19	44	13
19	11	45	5
20	8	46	5
21	5	47	11
22	10	48	25
23	19	49	7
24	16	50	7
25	6	51	13
26	22		

Table 5 Number of students that took the 1991 National Entrance Exam in each of the 51 Greek prefectures

Prefectures	No of students	Prefectures	No of students
1	20,433	27	77
2	508	28	1,867
3	169	29	880
4	289	30	714
5	282	31	814
6	582	32	160
7	686	33	822
8	1,464	34	353
9	155	35	222
10	195	36	446
11	811	37	626
12	760	38	559
13	472	39	5,975
14	556	40	315
15	419	41	328
16	1,176	42	1,063
17	135	43	362
18	908	44	639
19	460	45	347
20	437	46	261
21	213	47	462
22	465	48	1,411
23	984	49	292
24	720	50	214
25	194	51	411
26	1,107		

Table 6a Descriptive statistics for the National Entrance Exams score for each prefecture (Exams '91)

Prefectures	Mean	Std Dev	Minimum	Maximum	No of cases
1	9.59	4.82	0	19.56	20,433
2	10.06	4.85	0.59	18.91	508
3	8.92	4.45	0.25	17.69	169
4	11.01	4.51	1.25	19.06	289
5	9.28	4.82	0.28	18.97	282
6	9.53	4.74	0.06	19.25	582
7	9.87	4.46	0.06	18.75	686
8	10.10	5.02	0	19.56	1,464
9	9.13	4.97	0.06	18.69	155
10	9.88	4.83	0.06	19.25	195
11	9.31	5.16	0	19.34	811
12	9.32	5.20	0.06	19.41	760
13	10.16	4.76	0	18.94	472
14	9.85	4.79	0.19	19.28	556
15	9.11	4.69	0.50	19.06	419
16	9.78	4.96	0.06	19.50	1,176
17	8.51	5.21	0.06	18.75	135
18	10.25	5.07	0	19.56	908
19	9.68	5.10	0.06	19.09	460
20	9.68	4.92	0.34	19.31	437
21	9.66	5.05	0.06	19.06	213
22	8.57	4.92	0	18.97	465
23	9.23	4.94	0.06	19.41	984
24	8.91	4.70	0.06	18.88	720
25	10.07	4.94	0.16	18.50	194

Table 6b Descriptive statistics for the National Entrance Exams score for each prefecture (Exams '91)

Prefectures	Mean	Std Dev	Minimum	Maximum	No of cases
26	9.94	5.18	0.06	19.44	1,107
27	7.44	4.63	0.66	18.19	77
28	10.21	5.03	0.06	19.47	1,867
29	9.90	4.97	0.06	19.38	880
30	9.19	5.35	0.06	19.56	714
31	10.39	5.48	0.06	19.59	814
32	8.89	4.71	0.06	18.91	160
33	9.18	4.66	0.06	19.25	822
34	8.51	4.91	0.13	19.13	353
35	9.34	5.01	0.41	19.22	222
36	10.36	4.99	0	19.31	446
37	9.41	4.96	0.19	19.22	626
38	9.13	5.04	0.06	19.19	559
39	9.76	4.96	0.06	19.53	5,975
40	8.87	4.89	0.13	19.13	315
41	8.74	4.73	0.13	18.72	328
42	9.47	5.17	0.06	19.41	1,063
43	9.44	4.90	0.06	18.97	362
44	9.14	5.02	0.06	19.06	639
45	9.24	4.95	0.88	19.25	347
46	10.12	4.77	0.75	18.94	261
47	8.45	4.90	0.06	18.47	462
48	8.78	4.95	0.06	19.22	1,411
49	9.31	4.91	0.72	19.16	292
50	9.15	4.91	0.06	19.41	214
51	8.70	4.70	0.06	19.28	411

Table 7 Greek Prefectures

	Prefectures		**Prefectures**
1	Attica	27	Evritania
2	Lesbos	28	Larisa
3	Samos	29	Magnesia
4	Chios	30	Carditsa
5	Cyclades	31	Trikala
6	Dodecanese	32	Grevena
7	Corinthia	33	Cozane
8	Achaia	34	Castoria
9	Zante	35	Florina
10	Kefallenia	36	Pieria
11	Ilia	37	Imathia
12	Messinia	38	Pella
13	Arcadia	39	Thessalonica
14	Argolis	40	Cilcis
15	Laconia	41	Halkidiki
16	Etoloacarnania	42	Serres
17	Leucada	43	Drama
18	Janina	44	Cavala
19	Arta	45	Xanthi
20	Preveza	46	Rodopi
21	Thesprotia	47	Evros
22	Kerkira	48	Iraklio
23	Euboea	49	Lasithio
24	Boeotia	50	Rethimno
25	Focida	51	Hania
26	Fthiotida		